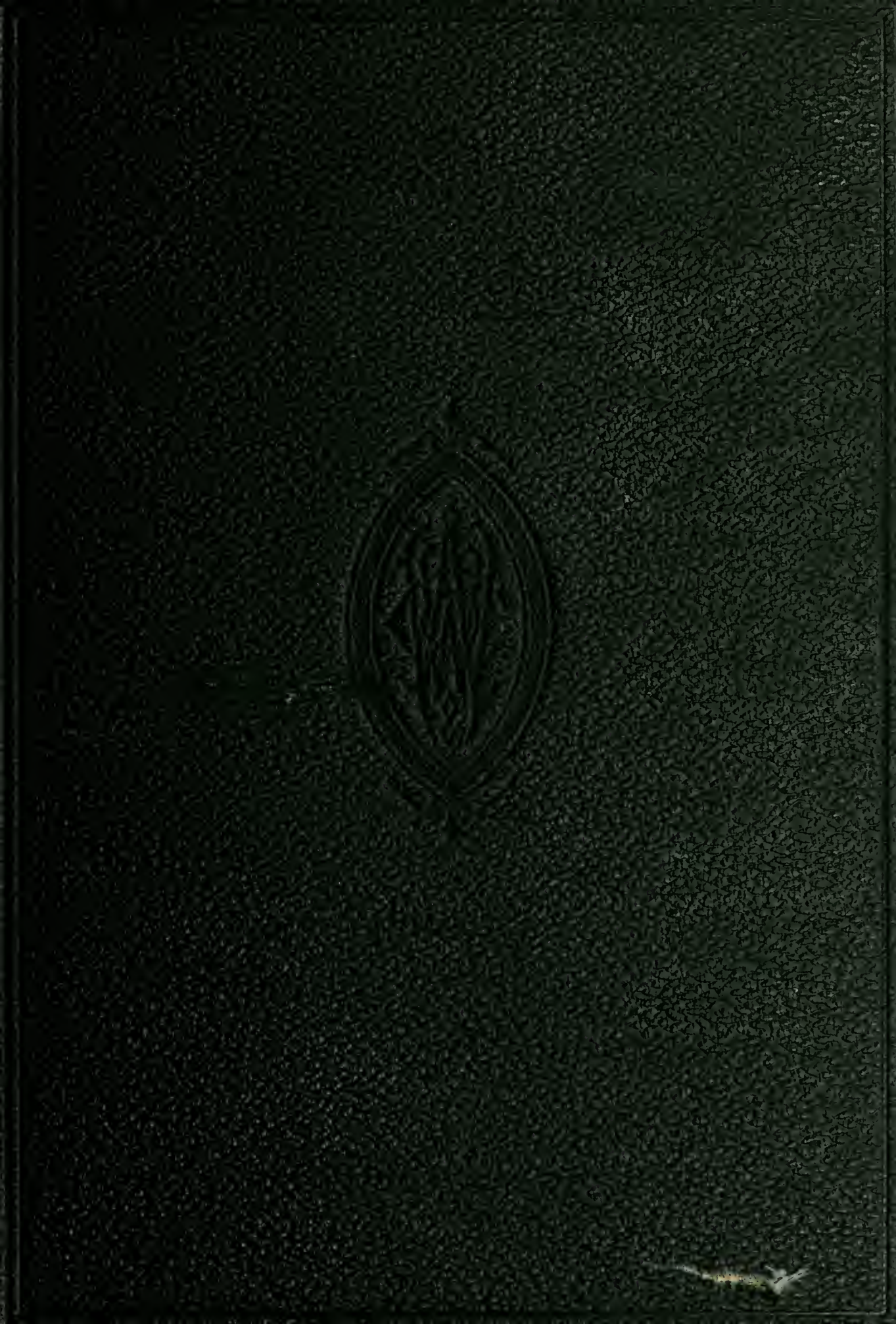

A Reference Handbook

OF

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SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

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Ligation of Arteries.—General Introduction.—Classical ligation of an artery is done most often for hemorrhage in the part supplied by the artery when the bleeding cannot be controlled by pressure or ligation at the site of injury by enlarging the wound. Sometimes ligation is needed for secondary hemorrhage after a distal ligation, sometimes as a preliminary to an operation on the part supplied by the artery, such as ligation of the linguals before excision of the tongue, sometimes to control nutrition and growth of a distal malignant neoplasm or non-malignant tumor, as in the case of goiters, sometimes to control the blood supply to an angioma or cirsoid aneurysm, and sometimes either distal or proximal to an aneurysm. When the ligation is done for aneurysm in a large vessel care must be taken to note that the vessel wall is sound before the ligature is placed.

At times it is desirable to close temporarily an artery during an operation by exposing the artery and compressing it with a tape the ends of which are held in a clamp, or kinking the artery by traction on a loop around the vessel, or even temporarily ligating the vessel. Such conditions arise in head operations where temporary control of one external carotid may suffice or that of both common carotids may be needed.

In ligating an artery the anatomy of the parts must be fully appreciated. The relations of the important landmarks and guides help to locate the vessel, while the knowledge of the nearness of the important structures such as nerves and terminal veins helps us to avoid them. The work should be methodical. The patient should be put into such a position as will best expose the line of the vessel. The incision should be long enough to give free access to the parts while later the parts should be so flexed as to relax the muscles and allow exposure of the vessel. The site of ligation should be far enough away from branches to allow of the formation of a clot in length about twice the diameter of the vessel to be tied. The vessel, as a rule, should be cleaned from veins and sheath and tied by itself. The artery in the main trunks can be distinguished from its sheath not merely by its pulsation, but also by its pinkish-white color and its smooth shining surface. Digital compression of the artery, of course, gives distal collapse of the vessel while compression of the vein gives proximal collapse. The ligature is to be tied tight enough to approximate completely the intima. In the larger vessels it is wise to apply two independent ligatures. The ligature should remain efficient until the clot is organized. It should be proportionate to the size of the vessel ligated. In a vessel the size of a man's axillary artery nothing less than chromic catgut number two, doubled and twisted, should be used, and twisted silk of a proportionate size might well be used.

Radial Artery on the Back of the Wrist.—Line.—From a point on the flexor surface of the wrist just to the ulnar side of the styloid process of the radius to a point on the back of the wrist between the heads of the metacarpal bones of the thumb and the index-finger.

Relations.—Superficial: skin, fascia, branches of the radial and the musculocutaneous nerves, tendons of the three extensor muscles of the thumb. Deep: carpal ligament, styloid process of radius and trapezius.

Operation.—Position: arm resting on its ulnar margin, assistant holding fingers and moving thumb to make evident the three thumb tendons. Incision, one and a quarter inches long in the line of the artery, avoiding radial vein. Separate tendons, go through deep fascia and deep fatty tissue, feel artery on ligaments and deep between heads of metacarpal bones. Pass ligature from either side. Injury to tendons and joints must be avoided.

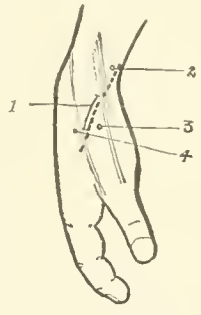

Fig. 3733.—Radial at Back of Wrist. Line of artery dotted; position of tendons shown in double lines. 1, Incision; 2, styloid process of radius; 3, head of metacarpal bone of thumb; 4, head of metacarpal bone of index-finger.

Radial Artery in the Forearm.—Line.—From a point in the bend of the elbow midway between the external and the internal epicondyles (to the inner side of the biceps tendon) to a point just to the ulnar side of the styloid process of the radius, following the ulnar margin of the supinator longus.

Relations.—Superficial: skin, fascia, musculoconnective fascia, branches of musculocutaneous nerve, supinator longus. Deep: biceps, supinator brevis, pronator radii teres, flexor sublimis digitorum, flexor longus pollicis, pronator quadratus, radius. On radial side: supinator longus, radial nerve. On ulnar side: pronator radii teres, flexor carpi radialis.

Operation.—*In Lower Third.*—Position: complete supination, wrist extended. Incision, one and a half inches long its lower end a quarter inch above the carpal skin crease, in the line of the artery (midway between the tendon of the supinator longus and that of the flexor carpi radialis) going through skin and fascia avoiding a large branch of the radial vein that crosses the artery. Flex the wrist to relax the tendons, and pick up the artery.

In Middle Third.—Position: complete supination, wrist extended. Incision, two inches long in line of artery (along ulnar border of the supinator longus) carried through skin and fasciæ. Pull supinator longus toward radial border of arm open fascia that binds artery to supinator longus and pronator radii teres. The radial nerve lies to the radial side of the artery and somewhat deeper. Bend the wrist to relax the flexor muscles and pass the ligature from the radial toward the ulnar side under the artery.

In Upper Third.—Position: complete supination. Incision, two and a half inches long in the line of the artery at the upper third of the forearm through skin and superficial fascia. The deep fascia is opened in the line between the supinator longus and the pronator radii teres which can be identified by noting the direction of the muscle fibers of the supinator longus running straight down the radius, and those of the pronator which run obliquely downward and outward to the center of the radius. Relax the muscles by bending the elbow and the wrist, separate the muscles and feel the artery, pass the ligature from the radial toward the ulnar side. The radial nerve lies sufficiently distant to the radial side so that it rarely comes into view.

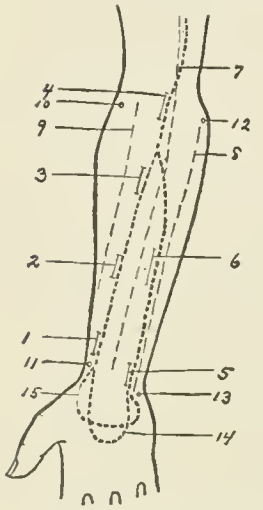

Fig. 3734.—Arteries of the Forearm. Lines of arteries dotted. 1, Incision for radial in lower third; 2, incision for radial in middle third; 3, incision for radial in upper third; 4, incision for brachial at bend of elbow; 5, incision for ulnar in lower third; 6, incision for ulnar in middle third; 7, median nerve; 8, ulnar nerve; 9, radial nerve; 10, external epicondyle; 11, styloid process of radius; 12, internal epicondyle; 13, pisiform bone; 14, superficial palmar arch; 15, deep palmar arch.

Ulnar Artery.—Line.—Obliquely inward from a point in the bend of the elbow midway between the internal and the external epicondyles (to the inner side of the biceps tendon) to a point on the ulnar side of the arm midway between the pisiform bone and the internal condyle. Then down to the wrist in a line from the tip of the internal condyle to the radial side of the pisiform bone (along the radial side of the flexor carpi ulnaris).

Relations.—Superficial: skin, fasciæ, ulnar and internal cutaneous nerves, anterior ulnar veins, median nerve, pronator radii teres, flexor carpi radialis, palmaris longus, flexor sublimis digitorum. Deep: brachialis anticus and flexor profundus digitorum. On the radial side: flexor sublimis digitorum; on ulnar side: flexor carpi ulnaris and ulnar nerve.

Operation.—*In Lower Third of Forearm.*—Position: hand supinated. Incision, one and a half inches in length in the line of the artery (along the radial border of the flexor carpi ulnaris), beginning just above the pisiform bone going through the skin and deep fascia. Flex the wrist, retract flexor carpi ulnaris to ulnar side; separate the artery from its veins pull the ulnar nerve, if it appears, to the ulnar side and pass ligature from ulnar side.

In Middle Third of Forearm.—Position: hand supinated. Incision, three inches long in line of artery (internal condyle to pisiform) beginning midway between these bony landmarks and extending toward the wrist. Cut through the skin and fascia. Locate the intermuscular septum between the flexor carpi ulnaris and the flexor sublimis (the intermuscular septum nearest to the line of the artery), at times identified by a sulcus in place of a white line, or by a muscular branch of the artery that comes up through the septum and leads directly to the ulnar artery. Relax muscles by bending wrist and elbow, insert retractors to pull muscles well apart using stronger retraction on the radial side as the artery lies covered by the flexor sublimis digitorum. The nerve and artery are looked for at the bottom of the wound. The nerve lies to the ulnar side of the artery and may be seen first, then further retraction to the radial side will expose the artery. The ligature is passed from the ulnar toward the radial side. There is often difficulty in identifying the correct intermuscular septum. The desired septum should be the one nearest to the line of the incision. The interval next in the radial direction is that between the flexor sublimis digitorum and the palmaris longus. At the middle point in the forearm the palmaris longus can be identified because it is tendinous not muscular. The septum next to the one desired on the ulnar side is that between the flexor carpi ulnaris and the flexor profundus digitorum, and is well around the ulnar border of the forearm.

Brachial Artery at the Bend of the Elbow.—Line.—To ulnar side of biceps tendon.

Relations.—Superficial: skin fascia, bicipital fascia, median basilic vein, internal and external cutaneous nerves. Deep: brachialis anticus; Radial side: biceps tendon; Ulnar side: median nerve.

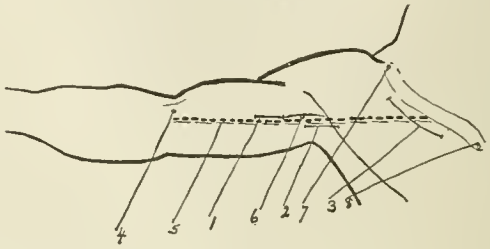

Fig. 3735.—Arteries of the Arm. Line of artery dotted. 1, Incision for brachial in arm; 2, incision for third part of axillary; 3, incision for first part of axillary; 4, biceps tendon; 5, median nerve; 6, coracobrachialis; 7, acromioclavicular joint; 8, sternoclavicular joint.

Operation.—Position: supination, elbow slightly flexed. Incision, two inches long in the line of the artery through the deep fascia and the semilunar aponeurosis of biceps tendon. Retract tendon to radial side. Ligature passed from ulnar side to avoid catching median nerve. Close bicipital fascia and deep fascia separately. Injury to the vein and to the artery at the same spot might lead to an arteriovenous aneurysm.

Brachial Artery in Middle of Arm.—Line.—From junction of middle and anterior thirds of axilla along inner edge of coracobrachialis and biceps to the middle of the elbow triangle.

Relations.—Superficial: skin, fascia, internal and external cutaneous nerves, median nerve in center of arm. Deep: triceps, coracobrachialis, brachialis anticus, musculospiral nerve, and superior profunda artery. Outside: coracobrachialis, biceps. Inside: ulnar nerve, internal cutaneous nerve, basilic vein.

Operation.—Position: arm extended and abducted from side, elbow flexed and supported. Incision, two and a half inches long at the inner border of the biceps in the middle of the arm through skin, fascia, retract biceps outward and median nerve inward. Ligature passed from inside out taking care to avoid the veins, and nerves.

Axillary Artery in the Axilla.—Line.—When the arm is perpendicular to the body and the palm up the artery lies in a line from the center of the clavicle to the axillary margin of the coracobrachialis.

Relations.—Superficial: skin, fascia, and pectoralis major. Deep: subscapularis, latissimus dorsi, teres major, circumflex nerve. Axillary side: internal cutaneous nerve, median nerve. Outer border: coracobrachialis.

Operation.—Position: arm perpendicular to body, hand in mid pronation. Incision, three inches long at axillary border of coracobrachialis, beginning near apex of axilla and extending across insertion of the latissimus dorsi into the humerus. Cut through skin

and fascia, and expose the border of the coracobrachialis, the axillary vein and the median nerve. Retract vein and smaller nerves toward the triceps. Retract median nerve and coracobrachialis with its perforating musculocutaneous nerve toward the biceps. Pass ligature from the triceps side toward the biceps avoiding the vicinity of the large branches of the axillary artery, such as the subscapular and the circumflex.

Axillary Artery under the Clavicle.—Line.—As in the axilla.

Relations.—Superficial: skin, fascia, platysma, supraclavicular nerves, pectoralis major, costocoracoid membrane, acromiothoracic vessels, cephalic vein. Deep: serratus magnus, first intercostal muscle posterior thoracic nerve. Acromial side: outer and inner cords of brachial plexus. Chest side: axillary vein.

Operation.—Position: arm perpendicular to trunk. Incision, curved with convexity downward one-half inch below clavicle and nearly the full length of that bone reaching from just outside the sternoclavicular joint to the coracoid process. Divide skin, fascia platysma and clavicular origin of the pectoralis major. Separate fascia and locate the pectoralis minor. Draw its inner border downward and outward and cut through the costocoracoid membrane close to the coracoid process avoiding the cephalic vein and acromiothoracic vessels. Adduct the arm to relax the muscles and feel for the vessel in the bottom of the wound. Pass ligature from below up toward the clavicle to avoid the vein. Suture the muscle carefully in closure. A temporary weakening of the arm is almost sure to occur.

Subclavian Artery, Third Part.—Line.—A curve convex toward the head starting at the sternoclavicular joint and going to the junction of the inner and middle thirds of the clavicle (just beyond the outer margin of the sternomastoid muscle).

Relations.—*Third Part:* Superficial: skin, fascia, platysma, cutaneous nerves from the cervical plexus, transverse cervical and suprascapular arteries, subclavian vein. Deep: first rib; above, omohyoid and brachial plexus. *Second Part:* Superficial: skin, fascia, platysma, sternomastoid, scalenus anticus, and phrenic nerve. Deep: scalenus medius. Below: pleura. Above: brachial plexus.

Operation.—Position: sand bag under shoulder to be operated on, face turned toward opposite side, arm and shoulder pulled down by traction on hand, arm at side. Incision; draw skin down over clavicle. Make clean cut through skin, fascia, and platysma down to bone in an incision three inches long from clavicular insertion of trapezius across that of the sternomastoid but avoiding the external jugular vein. Let skin glide upward to expose the tissues a half inch above the clavicle. It may be necessary to incise the skin upward from the inner end of the clavicular incision and also to cut the muscles in order to get sufficient exposure. The deep fascia is opened at the inner end of the incision and the outer edge of the scalenus anticus sought directly under the clavicular edge of the sternomastoid. The large vessels in the venous plexus are to be tied. The suprascapular artery below the incision and the transverse cervical artery above the incision are avoided and saved if possible. The outer edge of the scalenus anticus being identified it is followed down to the scalene tubercle on the first rib. The artery lies immediately above and behind this tubercle. The subclavian vein lies in front and below the tubercle. One of the cords of the brachial plexus lies in contact with the artery and must be separated before the vessel is tied. The ligature is passed very carefully from above downward, and from behind forward keeping the point of the ligature carrier closely in contact with the vessel wall in order to avoid injury to the accompanying vein and nerve and the closely adjacent pleura. In cases of aneurysm the quality of the vessel wall must be carefully inspected for disease before tying the ligature. After the ligature is applied and the wound carefully tied, the entire arm must be bandaged, supported, and the return circulation watched for. If the transverse cervical and suprascapular arteries have been injured during the operation the collateral circulation is very apt to be interfered with. Injury to the subclavian vein, the pleura, the brachial plexus, the phrenic nerve, and the nerve to the subclavius muscle (which has a phrenic branch) add complications.

Subclavian Artery, First Part.—Line.—The right subclavian artery starts behind the sternoclavicular articulation at the bifurcation of the innominate artery. The left subclavian artery starts from the arch of the aorta, behind the first intercostal space and ascends nearly vertically to the inner margin of the scalenus anticus.

Relations.—*On the right side:* Superficial: skin, fascia, sternomastoid, sternohyoid, sternothyroid muscles, internal jugular, and vertebral veins, the vagus, phrenic, and cardiac nerves. Deep: recurrent laryngeal and sympathetic nerves, the longus colli muscle, and the pleura.

On the left side in addition to the relations of the right side are added: Superficial: the pleura and lung and the left common carotid artery. Deep: the esophagus and the thoracic duct. To the median side are the trachea, esophagus, and the thoracic duct; and to the outer side, the pleura.

Operation.—*On the right side:* Position: patient on his back with a small low pillow under the middle of the back, face turned to opposite side. Incision

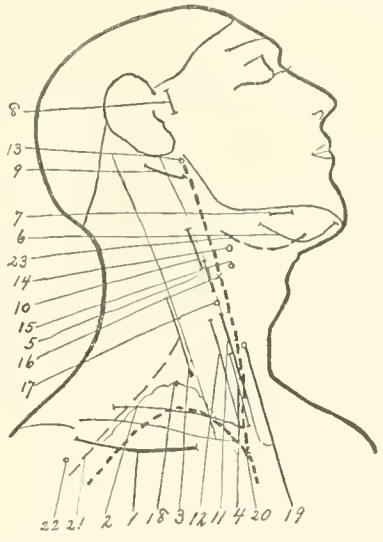

Fig. 3736.—Arteries of Head and Neck. Line of larger arteries dotted. 1, Incision for third part of axillary; 2, incision for first and third parts of subclavian and for innominate; 3, incision for vertebral along posterior border of sternomastoid muscle; 4, incision for inferior thyroid; 5, incision for superior thyroid; 6, incision for lingual; 7, incision for facial; 8, incision for temporal; 9, incision for occipital; 10, incision for external and internal carotids; 11, incision for common carotid above omohyoid; 12, incision for common carotid below omohyoid; 13, transverse process of atlas; 14, greater cornu of hyoid bone; 15, upper border of thyroid cartilage; 16, bifurcation of common carotid; 17, carotid tubercle under middle point on anterior border of sternomastoid muscle; 18, apex of lung; 19, cricoid cartilage; 20, bifurcation of innominate artery; 21, brachial plexus; 22, coracoid process; 23, hypoglossal nerve.

along the internal border of the sternomastoid and then along the upper border of the clavicle each limb of the incision being about two and a half inches long. The sternomastoid is cut through; the external and

the anterior jugular veins tied and cut, the sternohyoid muscle is also cut through and the common carotid artery identified as it runs longitudinally down the neck behind the sternothyroid which is pushed inward free from the common carotid. The underlying muscular layer of the cervical fascia is torn through and the common carotid artery traced downward and with the internal jugular vein pulled outward. The head and neck are bent forward to relax the muscles. The finger pressed down and back in the lower angle of the wound feels the subclavian artery just above the clavicle and can compress it against the spinal column. The vessel is cleaned and the ligature on an aneurysm needle with its point kept close to the vessel is passed from below back and up, while the pleura is pushed down with the other hand and great care taken to avoid injury to the recurrent laryngeal and phrenic nerves. The vagus nerve and the internal jugular vein are retracted outward. The ligature must not be placed too close to the origin of the vessel at the bifurcation of the innominate artery and not near enough to the anterior border of the scalenus anticus to risk including in the ligature the phrenic and the recurrent laryngeal nerves. The origin of the vertebral artery must also be noted and if necessary to give holding room for the clot it may be wise to ligate the vertebral through the same incision, and at the same time, by pulling the jugular vein inward and identifying the vertebral artery in the groove between the longus colli and the scaleni muscles at the point where the artery enters the foramen in the transverse process of the sixth cervical vertebra. In ligating the vertebral care must be taken not to mistake the inferior thyroid for the vessel sought. The inferior thyroid lies external to the vertebral and is considerably smaller.

On the left side of the neck the most important additional relation is that of the thoracic duct as it crosses from the body of the fourth vertebra above the arch of the subclavian artery in front of the vertebral artery and the common carotid sheath to the subclavian vein at the inner border of the scalenus anticus muscle. Passing the ligature from below and keeping close to the subclavian artery should avoid the thoracic duct. On the left side of the neck too there is more space for the adherence of the clot and therefore less probability of need to ligate the vertebral artery. Naturally the ligature should be strong and wide. The operative difficulties from possible injury to the pleura, sympathetic, vagus, phrenic, and recurrent laryngeal nerves, the thoracic duct and the large veins, as well as the chances of secondary hemorrhage either venous or arterial make the operation a very serious one.

Innominate Artery.—Line.—From the middle of the junction of the manubrium and the body of the sternum to the right sternoclavicular joint.

Relations.—Superficial: skin, fasciæ, sternum, sternohyoid and sternothyroid muscles, the left innominate vein, right inferior thyroid vein, cervical branch of right vagus nerve. Deep: trachea. Right: right innominate vein, right vagus nerve, pleura. Left: left carotid artery.

Operation.—Position: sand bag under back, raising sternum and right shoulder, arm pulled down, head turned face to left. Incision, along inner third of clavicle and up the anterior border of the sternomastoid each limb of the incision three and a half inches long, carried through skin and fascia. Sternomastoid cut through above clavicle. The sternohyoid and the sternothyroid also cut above sternum. The inner end of the clavicle is disarticulated and an inch and a half sawed off. The common carotid artery is felt in its sheath which is opened and the artery ligated with double chromic catgut. It is then traced down to its origin at the bifurcation of the innominate great care being taken of the internal jugular and the two innominate veins, of the vagus and phrenic nerves and the pleura. The right innominate vein, and the vagus nerve are retracted to the right and the left innominate vein pulled downward. The vessel is ligatured twice a half inch apart and three-fourths of an inch from the aorta. Twisted silk is probably the best material for the ligature which is tightened until distal pulsation is gone. The wound is closed carefully a rubber tissue drain left in the wound. The right arm is wrapped in cotton and secured to the patient's side. Enough morphine is given after operation to prevent cough and restlessness until the clots in the big vessels have become adherent. In spite of the magnitude of the operation fourteen recoveries in fifty-three cases operated on have been reported.

Vertebral Artery.—Line.—Parallel to spine on either side of neck from sternoclavicular articulation up through the transverse processes of the vertebræ.

Relations.—Superficial: skin, fasciæ, sternomastoid, internal jugular vein, inferior thyroid artery, vertebral vein, sympathetic nerve plexus (thoracic duct on left side of neck). Deep: cervical nerves, sympathetic nerve plexus; external, scalenus anticus and phrenic nerve. Internal: longus colli muscle.

Operation.—Position: head raised and turned slightly to opposite side; incision, three inches long at outer border of sternomastoid up from clavicle and one inch along the upper border of the clavicle. Cut through the skin, fascia, platysma, avoid the external jugular vein, retract sternomastoid and external jugular vein toward the median line, detach some of the fibers of the sternomastoid from the clavicle, clean the interspace between the scalenus anticus and the longus colli retracting the scalenus internally with the sternomastoid. Rotate head back into median line and flex slightly, identify and avoid phrenic nerve on the scalenus, avoid pleura, internal jugular vein, inferior thyroid artery, vertebral vein (thoracic duct on left side of neck), retracting all. Find the vertebral artery just below the anterior tubercle of the transverse process of the sixth cervical vertebra as it runs lengthwise of the neck and passes into the foramen in the transverse process of the vertebra. Pass ligature from without inward. Temporary paralysis of the cervical sympathetic is almost sure to follow with contraction of the pupil of the eye on the same side.

Inferior Thyroid Artery.—Line.—Tortuous ascent from sternoclavicular joint to the transverse process of the sixth cervical vertebra then inward to cricoid cartilage.

Relations.—Superficial: skin, fasciæ, platysma, carotid sheath and vessels, cervical sympathetic ganglion, thyroid gland, recurrent laryngeal nerve (thoracic duct on left side of neck). Deep: vertebral artery, longus colli.

Operation.—Incision three inches long at anterior border of sternomastoid down to clavicle. Cut through skin, fascia, platysma, retract sternomastoid and carotid sheath outward. Flex head and feel carotid tubercle (tubercle on transverse process of sixth cervical vertebra) and artery running across the neck from just below the tubercle to the cricoid cartilage. Ligate close to the carotid to avoid recurrent laryngeal nerve.

Superior Thyroid Artery.—Line.—From a quarter inch below the tip of the greater cornu of hyoid bone up slightly, then down and in, to upper pole of thyroid gland.

Relations.—Superficial: skin, fascia, platysma, depressor muscles of hyoid bone and sternothyroid. Deep: pharynx. External: external and common carotid arteries.

Operation.—Position: head raised, face turned to opposite side. Incision two inches long at inner border of sternomastoid its center at the upper border of the thyroid cartilage. Cut through skin, fascia, platysma, retract sternomastoid and large vessels

outward and the omohyoid downward. Artery felt between larynx, and carotid artery.

Lingual Artery.—Line.—Just above and parallel to the greater cornu of the hyoid bone.

Relations.—Superficial: skin, fascia, platysma, hypoglossus muscle part of the mylohyoid muscle, hypoglossal nerve, and submaxillary gland. Deep: middle constrictor of pharynx.

Operation.—Position: face to opposite side, mouth closed. Incision, curved, two and a half inches long, convex downward, extending from symphysis menti down and back toward angle of jaw. Cut through skin, fascia, platysma, deep fascia; turn submaxillary gland toward the jaw bone and the hypoglossal nerve will be seen running parallel to the line of the artery. The glistening tendon of the digastric muscle is seen at its attachment to the hyoid bone. Both of these structures are superficial to the hyoglossus muscle which covers the lingual artery. The fibers of the hyoglossus are separated in the triangle between the hypoglossal nerve, the hyoid bone, and the digastric muscle and the artery felt and ligatured. If the artery should be exposed behind the digastric muscle instead of in the given triangle, it might be easily confused with the facial artery with which it not unfrequently arises in common.

Facial Artery.—Line.—Straight across the lower border of the jaw bone at anterior border of masseter muscle.

Relations.—Superficial: skin, fascia, platysma. Deep: jaw bone.

Operation.—Position: head extended, face to opposite side. Incision, an inch and a quarter long parallel to and just below the border of the jaw its center at the anterior border of the masseter muscle. Cut through skin, fascia, and platysma and pick up artery.

Temporal Artery.—Line.—Parallel to and a quarter inch in front of anterior border of external ear.

Relations.—Superficial: skin, fascia. Deep: roots of zygoma.

Operation.—Incision one inch long in line of artery its center in front of the tragus. Cut through skin and fascia, retract vein backward and the auriculotemporal branch of the trifacial nerve forward. Feel and ligate artery.

Occipital Artery.—Line.—Parallel to the posterior border of the mastoid process.

Relations.—Superficial: skin, fascia, sternomastoid, splenius capitis, trachelomastoid and digastric muscles. Deep: rectus lateralis, superior oblique and complexus muscles. Anteriorly and above: the occipital groove in the mastoid process.

Operation.—Incision two inches long parallel to posterior border of mastoid process beginning a half inch below its apex. Divide skin, fascia, sternomastoid, and splenius capitis. Feel for digastric groove on mastoid process and at that point divide the fascia on the deep surface of the splenius. Feel the artery there and ligate.

External Carotid Artery.—Line.—Along anterior border of sternomastoid muscle above the hyoid bone to a point between the external auditory meatus and the condyle of the jaw.

Relations.—Superficial: skin, fascia, platysma, cervical and facial nerves, digastric and stylohyoid muscles, parotid gland. Deep: parotid gland, styloglossus and stylopharyngeus muscles, superior laryngeal and glossopharyngeal nerves. Internal: pharynx, hyoid bone, jaw bone, and parotid gland. External: parotid gland and cervical veins.

Operation.—Below the digastric muscle. Position: shoulders slightly raised, face turned toward opposite side. Incision three inches long at anterior border of sternomastoid from angle of jaw to upper border of thyroid cartilage. Cut through skin, fascia, platysma, retract sternomastoid outward, identify digastric muscle, and hypoglossal nerve, feel artery and determine that it is the external carotid by its position in front of the internal carotid artery, by its having branches and by its relation to the hypoglossal nerve which descends immediately in front of the external carotid and turns inward to the tongue around the lingual artery as it branches from the external carotid. Ligate the external carotid as far as possible from its branches. If it is not possible to find a stretch of vessel three-quarters of an inch long that is free from branches it will probably be well to ligate at the same time and by the same incision, the superior thyroid artery to give additional space for the clot to hold. Permanent ligation should be done with chromic catgut that will last at least ten days.

Internal Carotid Artery.—Line.—Same as external carotid (anterior border of sternomastoid above hyoid bone). Internal lies outside and behind external at its origin which is the only part accessible for ligation.

Relations.—Superficial: skin, fascia, platysma, sternomastoid styloglossus, stylopharyngeus, glossopharyngeal nerve, parotid gland. Deep: rectus capitis anticus major, superior laryngeal nerve. External: internal jugular vein, vagus nerve. Internal: pharynx, ascending pharyngeal artery, tonsil.

Operation.—Position: shoulders slightly raised, face turned to opposite side. Incision three inches long at the anterior border of the sternomastoid its center half an inch above the upper border of the thyroid cartilage. Cut through skin, fascia, platysma. Identify the anterior border of the sternomastoid and retract it outward, pull the external carotid inward, the digastric muscle upward, the internal jugular vein and the vagus nerve are seen and retracted outward, and the ligature passed from the outside in. Great care being taken to avoid the internal jugular vein and the vagus nerve.

Common Carotid Artery.—Line.—From sternoclavicular joint along the anterior border of the sternomastoid to the middle point of a line between the angle of the jaw and the tip of the mastoid.

Relations.—Superficial: skin, fascia and platysma, sternomastoid, sternohyoid, sternothyroid, omohyoid muscles, the descending hypoglossal nerve, and the anterior jugular vein. Deep: rectus capitis anticus, longus colli, sympathetic, vagus, and recurrent laryngeal nerves inferior thyroid artery. External: internal jugular vein. Internal: pharynx, larynx, trachea, thyroid gland, recurrent laryngeal nerve.

Operation.—*Above omohyoid* (site of election). Position: elevate shoulder and turn face to opposite side. Incision three inches long at anterior border of sternomastoid its center opposite the cricoid cartilage. Cut through the skin fascia, platysma; find the omohyoid muscle and draw it down. Retract the sternomastoid outward, the larynx forward and feel for pulsation of artery above the depressed omohyoid. Cut the sternomastoid artery and the thyroid vein and open the carotid sheath avoiding the descendens hypoglossi nerve and the internal jugular vein by opening the sheath well to the inner side; feel the artery and clean it carefully. Flex the neck, depress the chin to relax the muscles. Pass the ligature from the outside keeping the point of the ligature carrier close to the vessel to avoid injury to the vagus nerve. One of the complications that must be anticipated in about a quarter of the cases is cerebral softening which comes on early after the operation. This, of course, is avoided by temporary ligation or partial ligation followed by complete occlusion of the artery. To this are added the dangers from injury to the hypoglossal nerve, the vagus, and the sympathetic, the internal jugular vein, and the thyroid gland.

In the lower triangle of the neck. Here the artery is deeper than at the site of election, the recurrent laryngeal nerve is behind it, and on the left side of the neck the internal jugular vein lies close against the artery. On the right side of the neck there is much more space between the two vessels. Position: same as for ligation above the omohyoid (shoulder elevated, face turned to opposite side). Incision three inches long at anterior border of sternomastoid from below the cricoid cartilage to the sternoclavicular joint, the sternomastoid is retracted outward, a few of its fibers divided if necessary, and the sternohyoid and sternothyroid pulled inward. The carotid is felt and cleaned by opening its sheath well to the inner side and a ligature passed from without in, avoiding the internal jugular vein and the recurrent laryngeal nerve.

Ligation of the iliac arteries, common, internal, and external, is most conveniently done by the transperitoneal route. A laparotomy is done first and then with the patient in the Trendelenburg posture and the intestines packed away the posterior layer of the peritoneum is opened at the site of ligation and the ligature passed with due care for the ureter, large veins and nerves that are in close relation to the vessels. In some special cases it may be desirable to do an extraperitoneal operation and then the older special operations will have to be relied upon.

Common Iliac Artery.—Line.—From a point over the body of the fourth lumbar vertebra (an inch and a half below and a half inch to the left of the umbilicus) down and out to the sacroiliac joint (toward the middle of Poupart's ligament), being slightly convex outward.

Relations.—*Right artery.* Front: ureter, sympathetic nerve, peritoneum, and contents of abdominal cavity and abdominal wall. Behind: fourth and fifth lumbar vertebræ, right and left common iliac veins, sympathetic nerve. External: psoas muscle, inferior vena cava, right common iliac vein. Internal: right and left common iliac veins.

Left artery. Front: sympathetic nerve, ureter, superior hemorrhoidal artery, peritoneum, etc. Behind: left common iliac vein. External: psoas muscle. Internal: left common iliac vein.

Operation.—Extraperitoneal. Position: patient lying on back turned slightly to rest on the opposite side. Incision five inches long from twelfth rib to ilium at anterior-superior spine cutting muscles somewhat from spine of ilium. Elevate peritoneum and with it the ureter as it crosses the vessels is lifted up. Pass a double ligature of heavy chromic catgut or better two independent ligatures a half inch apart each of twisted chromic catgut, and tie each separately.

Internal Iliac Artery.—Line.—From a point an inch and a half below and a half inch to the left of the umbilicus to the center of Poupart's ligament. Intraabdominal line from lumbosacral joint to upper border of great sciatic notch.

Relations.—Front: ureter through its whole length, peritoneum, rectum over the left artery and ileum over the right artery. Deep: internal iliac vein, common iliac vein, lumbosacral cord, and sacrum. External: external iliac vein, psoas, and obturat ornerve. Internal: pyriformis and sacral nerves.

Operation.—Extraperitoneal. Position: patient lying on his back. Incision four inches long parallel to and about an inch above the outer half of Poupart's ligament. Cut through skin, fasciæ, and abdominal muscles, lift peritoneum up and retract it with the abdominal muscles toward the median line. The chest is elevated and the hips flexed to give relaxation of the muscles. The external iliac vessel is felt and traced up to the bifurcation of the common iliac where the internal iliac is found. This is now separated, avoiding the vein, the psoas muscle, and the lumbosacral cord. The ureter is lifted up with the peritoneum. The ligature is then passed and tied.

External Iliac.—Line.—Same as internal iliac (lower half of line from a point an inch and a half below and a half inch to the left of the umbilicus to the middle of Poupart's ligament.)

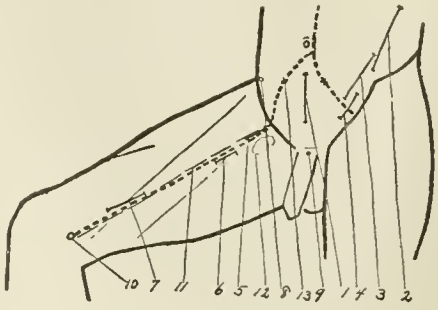

Fig. 3737.—Arteries of Pelvis and Thigh. Line of main arteries dotted. 1, Incision for transperitoneal ligation of all iliac arteries; 2, incision for extraperitoneal ligation of common iliac; 3, incision for extraperitoneal ligation of internal iliac; 4, incision for extraperitoneal ligation of external iliac; 5, incision for ligation of common femoral; 6, incision for ligation of superficial femoral in Scarpa's triangle; 7, incision for ligation of superficial femoral in Hunter's canal; 8, anterior-superior spine of ilium; 9, symphysis pubis; 10, adductor tubercle; 11, anterior crural nerve; 12, saphenous opening; 13, bifurcation of common iliac.

Relations.—In front: peritoneum and small intestines, iliac fascia, genitocrural nerve, spermatic vessels. Deep: iliac fascia, external iliac vein, psoas muscle. External: psoas. Internal: external iliac vein.

Operation.—Extraperitoneal. Position: lying on back. Incision three inches long parallel to and an inch above the outer half of Poupart's ligament. Cut through skin and fasciæ. Split the external oblique in the line of its fibers and the internal oblique and transversalis in the line of their fibers some of them being cut if necessary. Incise the transversalis fascia in the line of the incision and retract the lower edge of the peritoneum strongly toward the umbilicus. This exposes the artery and vein and a ligature can be passed from without in. In closing, the muscle and aponeurosis layers will be made as secure as in a hernia operation.

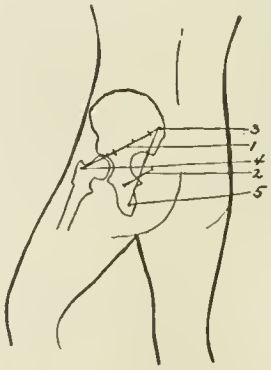

Fig. 3738.—Arteries of Gluteal Region. 1, Incision for ligation of gluteal artery; 2, incision for ligation of sciatic and internal pudic arteries; 3, posterior-superior spine of ilium; 4, great trochanter of femur; 5, tuber ischi.

Gluteal Artery.—Line.—From the posterior superior spine of the ilium to the great trochanter when the limb is slightly flexed and rotated inward. The junction of the upper and middle thirds of this line is the point of emergence of the artery from the pelvis.

Operation.—The patient is put in the Sims or reversed Sims position and an incision five inches long is made in the line from the posterior-superior spine of the ilium to the upper and outer part of the great trochanter parallel to the fibers of the gluteus maximus, the center of the incision being over the point of emergence of the artery. The muscular branch of the artery is found and followed back to the gluteal artery separating the fibers of the muscle. The artery

will be found deep beneath the gluteus maximus between the gluteus medius and the pyriformis. It should be traced as far as possible within the sciatic notch and there ligated.

Sciatic Artery.—Line.—From the posterior superior spine of the ilium to the ischial tuberosity with its point of emergence at the junction of the middle and lower thirds of that line.

Relations.—The artery emerges from the sciatic notch below the pyriformis.

Operation.—Position: Sims or reverse Sims. Incision in line parallel to fibers of gluteus maximus its center crossing the line of the artery at its point of emergence. The muscle fibers are separated, and the margin of the notch felt for or the great sciatic nerve seen and followed. The artery lies just to the outer side of the great sciatic nerve at its emergence from the pelvis.

Internal Pudic Artery.—Line and operation very similar to those for ligation of the sciatic. The pudic artery lies just to the outer side of the sciatic as it passes under the border of the pyriformis muscle.

Common Femoral Artery.—Line.—From a point midway between the anterior-superior spine of the ilium and the symphysis pubis to the adductor tubercle on the internal condyle of the femur.

Relations.—Superficial: skin, fascia, crural branch of genitocrural nerve. Deep: psoas muscle. External: anterior crural nerve. Internal: femoral vein.

Operation.—Position: limb abducted and rotated outward. Incision, two and a half inches long in line of artery beginning at Poupart's ligament. Divide skin and fascia, retract lymph nodes. Open deep fascia over vessel after it is felt. Pass ligature from within outward to avoid the vein that lies just to its inner side. Avoid also the genitocrural nerve that lies over the artery and the anterior crural nerve that lies just to the outer side of the artery. Care in the operation also must be taken not to open unwittingly a hernial sac and to preserve the saphenous vein. After the operation the limb must be cared for with the utmost caution until it is determined that there will be sufficient collateral circulation to prevent gangrene of the leg.

Superficial Femoral.—*In Scarpa's Triangle.*—Line.—Along inner border of sartorius muscle.

Relations.—Superficial: skin, fascia, crural branch of genitocrural nerve, middle cutaneous and internal cutaneous nerves, fascia lata, sartorius. Deep: psoas, pectineus and adductor longus muscles, femoral vein (below), profunda artery and vein, nerve to pectineus muscle. Internal: femoral vein (above). External: anterior crural nerve, femoral vein (below).

Operation.—Position: knee and hip slightly flexed, thigh abducted and everted, knee supported on pillow. Incision, three inches long in line of artery beginning two and a half inches below Poupart's ligament and extending down below apex of Scarpa's triangle. Divide skin, superficial fascia, deep fascia. Retract sartorius outward. Feel artery. Nerves over the sheath are seen and avoided. Open sheath freely on its outer side and pass stout ligature from within outward, avoiding most carefully the vein which lies very close to the artery. If the incision is too far internal the saphenous vein is apt to be injured and lead to edema of the leg. Puncture to the femoral vein occurs also not infrequently at the time of trying to pass the ligature around the artery. If such an accident should happen then desist from the attempt to pass the ligature at that point and ligate with greater care either above or below that spot. The venous bleeding will stop when the artery has been tied.

In Hunter's Canal.—Line.—Same as the preceding.

Relations.—Similar to those in Scarpa's triangle but the nerves are no longer in relation to the artery while the artery is covered with an aponeurosis between the vastus internus and the adductors.

Operation.—Position: knee and hip flexed, limb abducted and rotated outward. Incision three inches long in the line of the artery at the middle third of the thigh. Cut through the skin superficial and deep fasciæ retract the saphenous vein. The sartorius muscle is recognized by the direction of its fibers downward and inward (the adductor fibers run straight down) and retracted to the inner side (depressed). The aponeurotic roof of Hunter's canal is cut through, the vessel carefully cleaned and ligated.

Popliteal Artery.—Line.—From a point just inside the inner hamstring down to the center of the lower part of the popliteal space.

Relations.—Superficial: skin, fascia, small sciatic nerve, short saphenous vein, external saphenous nerve, semimembranosus above, and gastrocnemius and soleus below, internal popliteal nerve, and popliteal vein outside above and inside below, branch of obturator nerve. Deep: popliteus muscle, posterior ligament of knee, femur.

Operation.—Position: patient rolled two-thirds on face, limb extended. Incision, three inches long in line of vessel (along outer margin of inner hamstring). Pull small sciatic nerve toward median line of leg, open fascia freely and feel vessel. The internal popliteal nerve and the popliteal vein are pulled also toward the median line of the leg and the ligature passed from the vein toward the hamstring muscle.

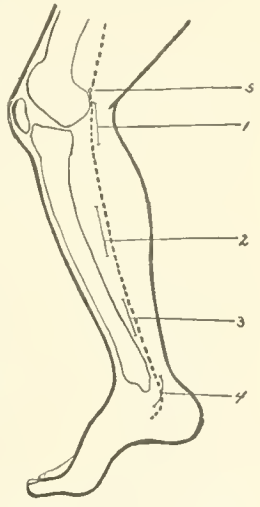

Fig. 3739.—Arteries of Inner Side of Leg. Line of posterior tibial artery dotted. 1, Incision for ligation of popliteal artery; 2, incision for ligation of posterior tibial in middle third of leg; 3, incision for ligation of posterior tibial in lower third of leg; 4, incision for ligation of posterior tibial at ankle; 5, adductor tubercle.

Posterior Tiblial Artery.—Line.—From the lower angle of the popliteal space to a point midway between the tendo Achillis and the internal malleolus.

Relations.—In *middle third* of leg. Superficial: skin, fascia, short saphenous vein, gastrocnemius, soleus, plantaris. Deep: flexor longus digitorum tibialis posticus. External: posterior tibial nerve (below). Internal: posterior tibial nerve (above).

Operation.—In *middle third* of leg. Position: patient lying on his back, hip abducted, knee flexed, and a sand-bag under the knee. Incision three and a half inches long parallel with inner border of tibia and from a half to three-quarters of an inch behind it, cut through skin superficial and deep fascia at inner edge of gastrocnemius. This is retracted exposing the soleus. The soleus is cut free from its tibial origin at least a half inch from the tibia. The special intermuscular fascia between the bones of the leg is then opened and the posterior tibial artery and nerve seen. The nerve will probably be seen first as the artery lies further from the tibia. Flexion of the knee and plantar flexion of the foot relax the muscles and allow space to pass the ligature.

Relations.—In *lower third* of leg. Superficial: skin, fascia superficial veins and cutaneous nerves. Deep: flexor longus digitorum, tibia. External: posterior tibial nerve, tendo Achillis.

Operation.—In *lower third* of leg. Position: patient lying on back knee flexed and supported on sand bag. Incision, two and a half inches long parallel to inner

border of tibia midway between the bone and the tendo Achillis in the lower third of the leg. Cut through skin, fasciæ and extra layer of fascia that binds down the deep flexor tendons. Artery felt between flexor longus digitorum and flexor longus hallucis. The posterior tibial nerve lies on the outer side of the artery and the ligature is passed from the nerve.

At the Ankle.—Relation.—Superficial: skin, fascia, branches of the internal saphenous vein, and nerve, internal annular ligament. Deep: internal lateral ligament of the ankle. External: flexor longus hallucis, posterior tibial nerve. Internal: flexor longus digitorum, tibialis posticus.

Operation.—Incision curved, convex posteriorly, two inches long, three-quarters of an inch behind the internal malleolus. Cut through skin fascia internal lateral ligament. Artery is found surrounded by veins. The nerve lies posterior to the artery. The ligature is passed from the side next to the tendo Achillis toward the internal malleolus.

Anterior Tibial Artery.—Line.—From a point midway between head of the fibula and the outer tuberosity of the tibia to the center of ankle-joint in front.

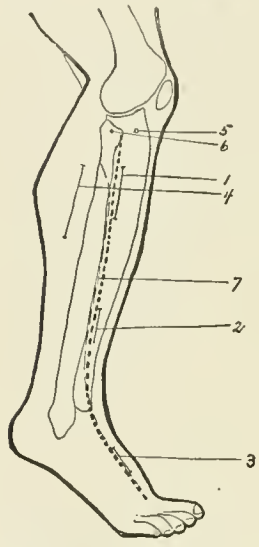

Fig. 3740.—Arteries of Outer Side of Leg. Line of anterior tibial artery dotted. 1, Incision for ligation of anterior tibial in upper half of leg; 2, incision for ligation of anterior tibial in lower half of leg; 3, incision for ligation of the dorsalis pedis artery; 4, incision for ligation of peroneal artery; 5, outer tuberosity of tibia; 6, head of fibula; 7, anterior tibial nerve.

Relations.—Superficial: skin, fascia, saphenous veins, and nerves, musculocutaneous nerve, tibialis anticus, extensor longus digitorum, extensor longus hallucis. Deep: interosseous membrane. External: extensor longus digitorum, extensor longus hallucis, anterior tibial nerve. Internal: tibialis anticus.

Operation.—In *upper half.* Position: patient on his back, hip adducted, knee flexed and supported on its inner side. Incision in line of artery (corresponding to outer edge of tibialis anticus which can be brought out by muscular action), beginning two inches below the head of the tibia. Cut through the skin and fascia and define the first intermuscular septum from the crest of the tibia; (usually about three-quarters of an inch away from the bone and not so well marked as the next intermuscular septum which is between the extensors and the peronei). Separate the muscle bellies of the tibialis anticus and the extensor longus digitorum. Frequently a muscular branch of the artery comes up through this space. The muscles are separated, retracted, the knee flexed and the foot put in dorsal flexion to give additional space. The artery is felt at the bottom of the space on the interosseous membrane. The nerve lies to the fibular side of the artery but crosses in front of the artery in the middle of the leg. The ligature is passed after drawing the nerve to the outer side.

In *lower half.* Incision in line of artery, about an inch to the outer side of the tibia, through skin and fascia. Separate tibialis anticus and extensor proprius hallucis. The nerve lies nearer to the artery than above, but still to its outer side. Ligature passed from the fibular side.

Dorsalis Pedis Artery.—Line.—From the center of the front of the ankle-joint to the upper part of the first interosseous space.

Relations.—Superficial: skin, fascia, musculocutaneous and anterior tibial nerves, Extensor brevis digitorum. Deep: bones of tarsus. External: anterior tibial nerve and extensor longus digitorum. Internal: extensor longus hallucis.

Operation. Position: foot held in plantar flexion. Incision one and a half inches long in line of artery beginning an inch and a half below the ankle-joint. Cut through the skin fascia and sheath that binds down the tendons. The artery is felt and the ligature passed from the outside inward.

Peroneal Artery.—Line.—Parallel to the fibula in the middle third of the leg and just to its tibial side.

Relations.—Superficial: skin, fascia, soleus. Deep: tibialis posticus and interosseous membrane.

Operation.—Position: patient on back, knee, flexed and leg adducted supported on the opposite leg. Incision three inches long by the posterior border of the fibula its center at the junction of the upper and middle thirds of the leg. The gastrocnemius is retracted, the soleus separated from its attachment to the fibula, the deep muscle fascia opened and the artery felt close to the fibula, where the ligature is tied.

Truman Abbe.

Ligatures.—See *Dressings, Surgical.*

Lignin may be regarded as a cellulose-like body occurring in the older cells of the walls of plants.

F. P. U.

Lily of the Valley.—See *Convallaria.*

Lime.—See *Calx* and *Citrus.*

Limnæa.—A genus of fresh-water snails. These molluscs have a rather slender conical shell, coiled to the right. They serve as intermediate hosts for some of the liver flukes. See *Trematoda.* A. S. P.

Limnatis.—A genus of leeches found in tropical countries. Several species are known. These annelids sometimes get into the mouth or nose when persons are drinking and cause serious trouble. See *Hirudinea.* A. S. P.

Limo.—Lemon (see also *Citrus*). The lemon is a large, evergreen, fragrant shrub or small tree, two or three meters or more in height, with numerous straggling grayish branches and green or reddish spiny twigs. The scattering leaves are, like those of the orange, articulated to the petiole; they are ovate, rather narrow, pointed, slightly serrate, the petioles not at all, or very narrowly, winged. The deliciously sweet flowers have the same structure as those of the orange, but are rose-colored or purplish externally. The juice of the lemon, as commonly known, is excessively sour, but there are numerous varieties which are deliciously sweet. The peel, *Limonis Cortex* and its volatile oil *Oleum Limonis*, and the juice, *Limonis Succus*, are official. The first named, for medicinal use, is pared or grated off with a knife in thin ribbons, so as to include but little more than the oleiferous zone and, according to the U. S. P., must be used fresh. It has a fragrant, pleasant odor, and a bitterish aromatic taste. Lemon juice is prepared by simple expression of the pulp, and straining if there are any evident shreds of the pulp or partitions in it, as these will make it bitter upon standing. It is a slightly turbid, yellow, nearly odorless, pleasantly but intensely acid liquid, of specific gravity about 1.030. Besides these, which are prepared extemporaneously from

commercial lemons, the oil of lemon, imported from the south of Europe, is also in extensive use as an elegant and popular flavor. This oil, like that of orange peel, is to be obtained from the fresh peel by expression.

Composition.—Lemons contain three distinct leading constituents, in as many distinct anatomical parts of the fruit: The *essential oil*, in a zone of large spherical glands situated just beneath the outer surface of the peel, is a pale-yellow, fragrant liquid, of an aromatic, bitterish taste and a neutral reaction; soluble in two parts of common alcohol, and in one or two thousand parts of water. It keeps badly, becoming thicker by age, and acquiring a disagreeable turpentine-like odor. The white spongy part of the peel and the partitions have a bitterish taste, due to the crystalline neutral substance *aurantia-amarin*, common also to the other fruits of the genus. It is not used in medicine. The pulp owes its acidity to five or six per cent. of, mostly free, *citric acid* (of which lemons, limes, and sour oranges are the principal sources), and to a little *malic acid*.

Uses.—Lemons are mostly used as an agreeable and wholesome flavor for food and drink. Their medicinal value is slight, and consists in their antiscorbutic quality. As a grateful refrigerant drink in fevers, and especially in rheumatism, lemonade has no equal. The oil has the properties of the aromatic oils in general, but is used only as a flavor.

Administration.—Spirit of Lemon (*Spiritus Limonis*, formerly official, the Essence of Lemon of the kitchen) contains six parts of oil of lemon, four of lemon peel, and enough alcohol to make a hundred; macerate and filter. The Syrup of Lemon (*Syrupus Limonis*) was made of: lemon juice, 40 parts; fresh lemon peel, 2 parts; sugar, 60 parts; and water enough to make 100 parts. Boil the juice, add the peel, and, when cold, filter, adding water enough to make 40 parts; finally put in and dissolve the sugar. The Syrup of Citric Acid (*Syrupus Acidi Citrici*, U. S. P.) keeps better and is almost invariably substituted for this by the apothecaries. It contains: one per cent. each of citric acid, distilled water, and tincture of fresh lemon peel in syrup. The mixture of citrate of potassium (neutral mixture, *Mistura Potassii Citratis*, an old fever mixture not much used at present) lemon juice neutralized by bicarbonate of potassium. Lemon juice is frequently added to the alkaline carbonates to form an effervescing draught.

H. H. Rusby.

Limp, Diagnostic Significance of.—By the term limp we understand a noticeable inequality in the gait. Inasmuch as the two lower extremities are often of unequal length, and usually of unequal musculature, it follows that the gait of a normal person is not absolutely even. He will make a longer step with one foot than with the other, but he is not said therefore to limp, because the inequality is not noticeable. Again, with a marked difference in length in the two extremities or with a pathological lesion in one of them so marked as to cause a distinct inequality in the gait, a person by the exercise of his will, and by training, can accustom himself to walk with approximately equal steps, so that no noticeable inequality of gait, no limp, results. An absence of limp therefore is not an indication of perfect function or of symmetry.

The causes of limp are manifold, and broadly include injury or disease of (1) the nerve apparatus from the cerebral cortex to the nerve terminals in the lower extremity, (2) the bones and joints of the lower extremity, (3) the muscles and other soft tissues of the lower extremity. In a word they include all unilateral injuries and diseases of the motor apparatus of the lower extremity, and unequal bilateral lesions.

In the first class would fall especially the limp occasioned by hemiplegias and by anterior poliomyelitis. The limp of hemiplegia differs somewhat as the age of the patient. In the limp following hemorrhage into the internal capsule in the adult, the foot drop is the most noticeable peculiarity, and causes the patient to swing his foot outward through the arc of a circle in walking. The upper extremity and the face on the same side are paralyzed also. The hemiplegias dating from birth or from shortly after (Little's disease) have a characteristic spastic element that enables one to recognize them almost at a glance. The intelligence may be impaired markedly in addition. The limp of anterior poliomyelitis is essentially a limp of weakness. It is caused by the paralysis of one muscle or of a group of muscles, and by the resulting contracture of their antagonists. It varies greatly according to the identity of the paralyzed muscles.

All sorts of injuries and diseases of the bones and joints, can give rise to a limp. In most injuries and diseases of the joints, the element of pain and stiffness enters into the causation, rather than the element of weakness, as in nerve lesions. It is not necessary that a joint disease should be active in order to cause a limp. If a joint be limited in its motion as the result of a healed arthritis, a limp will result. The shaft of a bone may be badly diseased without causing a limp, but the least disturbance of the mechanics of a joint will be noticeable in the gait. The psoas contraction of Pott's disease occasionally causes limp. In unilateral congenital dislocation the limp is essentially one of weakness rather than of stiffness, and may be described best as a "lurch." In bilateral dislocation the gait shows a waddle rather than a limp. In each case the peculiarity will have been present since the patient began to walk, thereby differing from the gait of practically every other joint lesion. The limp of coxa vara is a limp of stiffness, and usually makes its appearance in adolescence. An inflamed bunion or a painful flat foot can cause limping. Neglected club foot is fairly frequent.

Division of muscles or of tendons gives rise to a limp that is practically the same as that of divided nerves or of anterior poliomyelitis. Inflamed corns, and the injuries to the feet caused by improper shoes are probably responsible for more cases of limping than is anything else.

The diagnostic significance of a limp varies greatly with the acumen of the observer. To attempt to make a diagnosis as to the cause of a peculiarity of the gait by observing its possessor is an interesting exercise, but too much reliance must not be placed upon the conclusions thus reached. A person with an artificial limb usually has a peculiar "sag," and makes a "clumping" sound. A hemiplegic has a droop in one side of his face, carries his forearm across his chest, with his hand drooping, and swings out his foot, as described above. A person with a Charcot joint may walk with a bad limp, and with a "wobbling" joint, but without the slightest manifestation of pain or of stiffness. The flexed hip of old hip-joint disease causes a limp with not only a lateral motion of the body but also a forward and backward motion. A stiff knee can usually be recognized easily: The owner rises on his other toe as he swings his stiff leg forward. Knock-knees and ordinary flat feet cause a shambling gait rather than a limp. A painful flat foot however may occasion a severe limp. The man with a "gonorrheal foot" usually walks as if he were treading on eggs. Not only by the stiffness in the gait can one tell whether a limp is painful or not; the face betrays the feelings even better.

Leonard W. Ely.

Limping, Intermittent.—See *Claudication Intermittent*.

Linacre, Thomas.—Founder of the Royal College of Physicians, England, and a famous Greek scholar. He was, probably, born at Canterbury, about the year 1460. He received his early education at the cathedral school of Canterbury, then under the direction of William Celling, an ardent scholar, and one of the earliest in England who cultivated Greek learning. He entered Oxford about the year 1480, and in 1484 was elected a Fellow of All Souls' College. Shortly afterward he visited Italy, and became the pupil of Angelo Poliziano, at Bologna. Later, he shared the instruction which that great scholar imparted to the sons of Lorenzo de'Medici, at Florence. Linacre took the degree of Doctor of Medicine with great distinction at the University of Padua. While in Italy he gained the friendship of many distinguished scholars, and—among the number—of Aldus Romanus the famour printer of Venice.

About the year 1501 Linacre was called to the Court as tutor of the young prince Arthur. In 1509, on the accession of Henry VIII., he was appointed physician to the king, and for a number of years afterward he practised medicine in London, most of the great statesmen and prelates of the time—Cardinal Wolsey, Archbishop Warham, and Bishop Fox—being among his patients. About this time he rendered very great service to the Medical Profession and to the cause of science by procuring the foundation, by royal charter, of the College of Physicians in London. He was chosen its first president. He died October 20, 1524.

Linacre's only medical works were his Latin translations of Greek writings. The more important of these are the following (all of them from Galen): "De sanitate tuenda," Paris, 1517; "Methodus medendi," Paris, 1519; "De temperamentis etc.," Cambridge, 1521; "De naturalibus facultatibus," London, 1523; "De symptomatum differentiis et causis," London, 1524; and "De pulsuum usu," London—no date given. "The accuracy of these translations and their elegance of style were universally admitted. They have been generally accepted as the standard versions of those parts of Galen's writings, and frequently reprinted." (Encyclopedia Britannica.) A. H. B.

Linden Flowers.—*Lime Flowers, Tilia Flowers.* The flowers of several species of *Tilia* (fam. *Tiliaceæ*). This article, though still extensively employed among the common people of Europe, and to some extent in this country, is of so little medicinal importance that it may be dismissed with brief mention. It contains a very small amount of volatile oil, with gum, sugar, and a little tannin. It is very mildly antispasmodic and emollient, and, given in the form of a copious warm draught, becomes diaphoretic.

Henry H. Rusby.

Lineville Mineral Springs.—Mercer County, Missouri.

Post-office.—Lineville Springs. Hotel.

These springs are located about four miles southwest of Lineville, a thriving town on the southwestern branch of the Chicago, Rock Island and Pacific Railroad. The Mineral Springs Hotel is a large, convenient, and commodious structure, picturesquely situated amid the hills bordering the Grand River. The scenery is diversified and interesting, and the atmospheric conditions are of a salubrious and invigorating character. Everything has been done to render the house and surrounding grounds pleasant, comfortable, and homelike. The sanitary arrangements are excellent, and, with pure air and the presence of the mineral springs, with hot and cold water, the place offers many inducements to the seeker after health or recreation. The water is brought from a point 150 feet below the surface by means of pipes to the interior of the hotel. It is clear and sparkling, and very pleasant to the palate. The following analysis was made by Mr. A. E. Woodward, former assistant geologist of the State of Missouri.

One United States Gallon Contains:

Solids.	Grains.
Silica	0.11
Alumina	.28
Calcium sulphate	1.90
Magnesium sulphate	3.18
Sodium sulphate	180.30
Potassium sulphate	1.74
Sodium chloride	15.07
Total	202.58

This is a valuable purgative water. It is useful in dropsical affections due to renal disorders. It has also produced excellent results in cases of chronic constipation, functional disturbances of the liver, certain cutaneous diseases, and other affections.

Emma E. Walker.

Ling, Peter Henrik.—Born in Sweden in 1766. He originated and introduced into Sweden a system of gymnastics called the "Swedish Movement Cure," which could be performed without the aid of apparatus or charts. This method of physical culture was intended to be used by those in good physical condition as well as to provide a means of benefit for the sick and deformed.

In 1813 the Royal Central Institution was established at Stockholm in order that Ling might teach his system and practise among his patients. His exercises have been adopted by the physical culturists of other countries, and are in use in the English Navy. While Ling originated this system named after him, the basis of his work was supposed to have been taken from the Hindoo and Chinese systems. He died in 1839. E. L. J.

Linguatula.—*Pentastoma.* A genus of peculiar worm-like arachnids. The body is depressed, rounded dorsally, and with crenate margins. *L. serrata* lives in the nasal cavity and frontal sinus of the dog, wolf, fox, and rarely in the horse, mule, sheep, goat, and man. The larvæ become encysted in sheep, oxen, horses, dogs, cats, and man but are later active and pass out through the bronchial passages. See *Arachnida.* A. S. P.

Linguatulidæ.—Parasitic arachnids with ringed, elongated vermiform bodies. These animals usually occur in man in the larval condition, causing obscure abdominal or pulmonary symptoms, but the adults are often present in the nasal cavities, frontal sinuses, or lungs. Two genera are known: *Linguatula* (*Pentastoma*) and *Porocephalus.* See *Arachnida.* A. S. P.

Lingulinæ.—A subfamily of tapeworms. The eggs are operculate; the ovary forms a rosette. A single genus *Braumia* is known to occur in man. See *Cestoda.* A. S. P.

Linimenta.—A liniment (*linimentum*) is a mixture or solution of one or more substances in an oily or alcoholic liquid, intended for external application; and it is generally applied to the skin with a certain amount of friction. There are eight liniments in the United States Pharmacopœia, fifteen in the

British Pharmacopœia, and eleven in the National Formulary.

		Composition.
Linimentum Aconiti (Liniment of aconite).	B. P.	Aconite root, 20 ounces; camphor, 1 ounce; alcohol to 30 ounces.
Linimentum Aconiti et Chloroformi (Liniment of aconite and chloroform).	N. F.	Fluid extract of aconite, 45; alcohol, 80; chloroform, 125; soap liniment, 750.
Linimentum Ammoniæ (Ammonia liniment).	U. S. P.	Ammonia water, 350; alcohol, 50; cotton seed oil, 570; oleic acid, 30.
Linimentum Ammoniæ (Liniment of ammonia).	B. P.	Solution of ammonia, 1 ounce; almond oil, 1 ounce; olive oil, 2 ounces.
Linimentum Ammonii Iodidi (Liniment of ammonium iodide).	N. F.	Iodine, 4; oil of rosemary, 15; oil of lavender, 15; camphor, 32; ammonium water (U. S. P.) 110; alcohol, to 1,000.
Linimentum Belladonnæ (Belladonna liniment).	U. S. P.	Camphor, 50; fluidextract of belladonna root, to 1,000.
Linimentum Belladonnæ (Liniment of belladonna).	B. P.	Liquid extract of belladonna, 10 ounces; camphor, 1 ounce; distilled water, 2 ounces; alcohol to 20 ounces.
Linimentum Calcis (Lime liniment).	U. S. P.	Lime water, 500; linseed oil, 500.
Linimentum Calcis (Liniment of lime).	B. P.	Solution of lime, 2 ounces; olive oil, 2 ounces.
Linimentum Camphoræ (Camphor liniment).	U. S. P.	Camphor, 200; cotton seed oil, 800.
Linimentum Camphoræ (Liniment of camphor; camphorated oil).	B. P.	Camphor, in flowers, 1 ounce; olive oil, 4 ounces.
Linimentum Camphoræ Ammoniatum (Ammoniated liniment of camphor; Compound Liniment of camphor).	B. P.	Camphor, 2½ ounces; oil of lavender, 1 dram; strong solution of ammonia, 5 ounces; alcohol (90 per cent.), to 20 ounces.
linimentum Cantharidis (Cantharides liniment).	N. F.	Cantharides, 150; oil of turpentine, to 1,000.
Linimentum Chloroformi (Chloroform liniment).	U. S. P.	Chloroform, 300; soap liniment, 700.
Linimentum Chloroformi (Liniment of chloroform).	B. P.	Chloroform, 2 ounces; liniment of camphor, 2 ounces.
Linimentum Crotonis (Liniment of croton oil).	B. P.	Croton oil, 1 ounce; oil of cajuput, 3½ ounces; alcohol (90 per cent.), 3½ ounces.
Linimentum Hydrargyri (Liniment of mercury).	B. P.	Ointment of mercury, 1 ounce; strong solution of ammonia, 160 minims; liniment of camphor to 1½ ounces.
Linimentum Iodi (Iodine liniment).	N. F.	Iodine, 125; potassium iodide, 50; glycerin, 35; water, 65; alcohol, to 1,000.
Linimentum Opii (Liniment of opium).	B. P.	Tincture of opium, 2 ounces; liniment of soap, 2 ounces.
Linimentum Opii Compositum (Compound liniment of opium; Canada liniment).	N. F.	Tincture of opium (U. S. P.), 100; camphor, 17.5; alcohol, 250; oil of peppermint, 25, ammonia water (U. S. P.), 375; oil of turpentine, to 1,000.
Linimentum Plumbi Subacetatis (Liniment of lead subacetate).	N. F.	Solution of lead subacetate, 350; cotton seed oil, 650.
Linimentum Potassii Iodidi cum Sapone (Liniment of potassium iodide with soap).	B. P.	Curd soap (recent shavings), 2 ounces; potassium iodide, 1½ ounces; glycerin, 1 ounce; oil of lemon, 1 dram; distilled water, 10 ounces.
Linimentum Saponato-Camphoratum (Camphorated soap liniment; opodeldoc; solid opodeldoc).	N. F.	White castile soap, 75; camphor, 25 alcohol, 950; oil of thyme, 3; oil of rosemary, 6; stronger ammonia water (U. S. P.), 50.
Linimentum Saponis (Soap liniment).	U. S. P.	Soap, 60; camphor, 45; oil of rosemary, 10; alcohol, 725; water, to 1,000.
Linimentum Saponis (Liniment of soap).	B. P.	Soap soft, 2 ounces; camphor, 1 ounce; oil of rosemary, 3 drams; alcohol (90 per cent.), 16 ounces; distilled water, 4 ounces.
Linimentum Saponis Mollis (Liniment of soft soap).	U. S. P.	Soft soap, 650; oil of lavender flowers, 20; alcohol, to 1,000.
Linimentum Sinapis (Liniment of mustard).	B. P.	Volatile oil of mustard, 1½ drams; camphor, 120 grains; castor oil, 5 drams; alcohol (90 per cent.), 4 ounces.
Linimentum Sinapis Compositum (Compound liniment of mustard).	N. F.	Volatile oil of mustard, 30; fluidextract of mezereum, 200; camphor, 60; castor oil, 150; alcohol to, 1,000.
Linimentum Terebinthinæ (Turpentine liniment).	U. S. P.	Rosin cerate, 650; oil of turpentine, 350.
Linimentum Terebinthinæ (Liniment of turpentine).	B. P.	Soft soap, 1½ ounces; distilled water, 5 ounces; camphor, 1 ounce; oil of turpentine, 13 ounces.
Linimentum Terebinthinæ Aceticum (Liniment of turpentine and acetic acid).	B. P.	Oil of turpentine, 4 ounces; glacial acetic acid, 1 ounce; liniment of camphor, 4 ounces.
Linimentum Terebinthinæ Aceticum (Acetic turpentine liniment; linimentum album; Stokes' liniment).	N. F.	Oil of turpentine, 100; fresh egg, 1; oil of lemon, 4; acetic acid (U. S. P.), 20; rose water (U. S. P.), 85.
Linimentum Tiglii (Liniment of croton oil).	N. F.	Same as Linimentum Crotonis (B. P.), *q.v.*
Linimentum Tiglii Compositum. (Compound croton oil liniment).	N. F.	Croton oil, 20; oil of sassafras, 20; oil of turpentine, 20; olive oil, 40.

R. J. E. Scott.

Linseed.—See *Linum*.

Lint.—A loose, soft, and fine mat or fabric of linen fiber, used as an application to wounds, to check hemorrhage by the mechanical action of the fiber, to serve as packing or padding and as an absorbent vehicle for the application of medicinal substances. The best is the "patent" or woven lint. It is a soft, loosely woven cloth, with a heavy flocculent nap on one side, beautifully bleached and clean, and so tender that it can be easily torn in either direction or pulled into woolly bits. Picked, scraped, and ravelled lints, made, as their names indicate, from old linen cloths, are now mostly of domestic employment, having been superseded in the hands of physicians by the lint just mentioned and the now beautifully prepared "absorbent cotton."

Very similar substances are *tow* and *oakum*. The former is the tangled fibers heckled out in the production of linen fiber. The latter is the former soaked in tar, and adds antiseptic to the mechanical properties of the tow. Henry H. Rusby.

Linum.—Linseed. Flaxseed. "The seed of *Linum usitatissimum* L. (fam. *Linaceæ*)" (U. S. P.). The universally known and cultivated flax is a slender, blue-flowered annual, its bark contributing the extremely tough fibers from which linen is made. It is a native of the Old World, but has been in cultivation so long that its wild state is wholly unknown. There is no plant of which the proofs of its ancient use are so substantial; linen coverings are folded around Egyptian mummies more than twenty-five centuries old. It has also been found in the relics of the prehistoric Lake Dwellers of Switzerland. It is frequently mentioned in the Bible, and has been known

from the earliest times of ancient Greece and Rome. The employment of the seeds is also of very ancient origin.

The plants being collected for their fiber, and dried, the seeds are combed off from them, and constitute the article under consideration. Since the plants are pulled up, considerable dirt is apt to get into the seed. This is increased by the seeds of many weeds, and these impurities are often very imperfectly winnowed out. In trade, the relative amount of this foreign matter is roughly estimated by shaking up the seeds in an inverted conical bag, which carries the impurities to the bottom, or tip of the cone. The character of this matter, furthermore, conveys to the expert an idea of the geographical source of the product.

The following is the official description of flaxseed. "About four or five millimeters long, oblong-ovate, flattened, obliquely pointed at one end, brown, glossy, covered with a transparent, mucilaginous epithelium, which swells considerably in water; the embryo whitish or pale greenish, with two large, oily, plano-convex cotyledons, and a thin perisperm; inodorous; taste mucilaginous, oily and bitter. *Ground linseed* (linseed meal, or flaxseed meal), for medicinal purposes, should be recently prepared and free from unpleasant or rancid odor. When extracted with carbon disulphide, it should yield not less than twenty-five per cent. of fixed oil. The filtered infusion of ground linseed, prepared with boiling water and allowed to cool, has an insipid, mucilaginous taste, and should not be colored blue by iodine T. S. (absence of starch)." The British Pharmacopœia requires a yield of thirty per cent. of oil, and, as a matter of fact, nearly thirty-five per cent. should be yielded. There are about fifteen per cent. of gum, twenty-five per cent. of albuminous matter, a little resin, and a trace of amygdalin, which gives the bitter taste. The ash should not exceed five per cent. The chief adulterants are starch, and the use of a meal made from the ground cake left after the expression of the oil.

Uses.—Linseed is chiefly, if not entirely, used in medicine as the material of which poultices are made, for which, by its elasticity, its low conducting power for heat, and its retaining qualities for water, it is exceedingly well adapted. The addition of camphor, as a preservative and antiseptic, is common, and gives a stimulant tendency to the poultice.

Oleum Lini.—*Flaxseed Oil.* "A fixed oil expressed from linseed. Boiled linseed oil should not be employed in medicine. A yellowish, or yellow, oily liquid, having a slight, peculiar odor, and a bland taste. When exposed to the air it gradually thickens, and acquires a strong odor and taste; and if spread, in a thin layer, on a glass plate, and allowed to stand in a warm place, it is gradually converted into a hard, transparent, resin-like mass (absence of *non-drying oils*).

"Specific gravity: 0.925 to 0.935 at 25° C. (77° F.).

"It does not congeal above −20° C. (−4° F.).

"Soluble in about ten parts of absolute alcohol, and, in all proportions, in ether, chloroform, benzin, carbon disulphide, or oil of turpentine.

"It should not more than slightly redden blue litmus paper previously moistened with alcohol (limit of *free acid*).

It should be completely saponifiable with alcoholic potassium hydroxide T. S., and the resulting soap should be completely soluble in water without leaving an oily residue (absence of *mineral oils* and *rosin oil*).

If 2 c.c. of the oil be warmed and shaken in a test-tube with an equal volume of glacial acetic acid, and if to this mixture, after cooling, one drop of sulphuric acid be added, a greenish color should be produced (a violet color under these circumstances indicates the presence of *rosin* or *rosin oils*).

Linseed oil saponified by alcoholic potassium hydroxide T. S. should show a saponification value of from 187 to 195.

If 0.15 gram of linseed oil be dissolved in 10 c.c. of chloroform in a 250 c.c. flask, and 25 c.c. of a mixture of equal volumes of alcoholic iodine T. S. and alcoholic mercuric chloride T. S. added, and if, after standing for sixteen hours protected from the light, 20 c.c. of potassium iodide T. S. be introduced and the mixture diluted with 50 c.c. of water, on titrating the excess of iodine with tenth-normal sodium thiosulphate V. S., an iodine value of not less than 170 should be obtained.

This differs from most other fixed oils in its large percentage of albuminous matter, though this imparts no special medicinal properties. Rancidity and septic contamination should be guarded against. Its chief use in medicine is in the formation of the official *Linimentum Calcis*, Lime Liniment or Carron Oil, consisting of equal parts of this and lime water, a favorite application to burns, as is the oil itself. The oil is used upon an immense scale in the arts.

Henry H. Rusby.

Lipase.—The enzyme possessing the power to transform fats into fatty acids and glycerin is called lipase. It has a widespread distribution throughout the body wherever fat deposits may occur. Its most obvious presence is in the alimentary canal, in the pancreatic juice. There is at the present time a good deal of controversy as to its occurrence in gastric juice.

F. P. U.

Lipemia, Traumatic.—The presence of fat in the blood occurs physiologically in nursing infants, in adults after a heavy fat meal, and in some pregnant women. Pathologically it is found in diabetes, obesity, chronic alcoholism, pancreatitis, tuberculosis, acute fevers, pneumonia, malaria, cholera, hepatic, and renal disease, in poisoning with potassium chlorate, phosphorus, or carbon monoxide, in splenitis, menstrual suppression, general carcinomatosis and sarcomatosis, and as the result of injuries to the adipose tissues of the body, particularly the fatty marrow. In the great majority of cases the amount of fat in the blood is small, and leads to no important results. In severe forms of diabetes the fat may be greatly increased above the normal amount (0.75–0.85 per cent.), running as high as eighteen per cent. and over. The embolism produced in such cases of lipemia appears, however, to be unimportant clinically. The one form of lipemia that does become of great clinical importance is that resulting from injury to the fatty tissues of the body (traumatic lipemia).

The entrance of free liquid fat into the blood stream as a result of trauma affecting the bone marrow or the panniculi has become, through the freedom from infection gained by modern surgical technique, the most serious complication attending such injuries. It is also of very common occurrence, as it is highly probable that in every case of amputation or fracture of the long bones some fat is set free from the ruptured fat cells and, either directly or by way of the lymphatics, gains entrance into the blood stream to cause a fat embolism in the pulmonary capillaries, or, passing the lungs, in the capillaries of some other organ. When the amount of fat liberated is small, as it is in the majority of cases of bone injuries, the results of such a fat embolism may be unimportant and unnoticed; but it is evident that the seriousness of the condition will depend upon the anatomical importance of the capillaries blocked by the fat emboli. A very small amount of fat passing through the lung capillaries to lodge in certain capillaries of the brain may cause severe or even fatal disturbances. On the other hand, a relatively large amount of fat can

lodge in the pulmonary capillaries without causing great damage.

Etiology.—The free fat liberated into the blood stream is often of almost incredible amount, single sections of all the organs and tissues of the body showing on microscopical examination numerous emboli; and it would seem that the total amount of fat contained in the emboli must far exceed the fat content of the injured bone. In some cases of this kind, when the whole circulatory system is apparently flooded with fat the injury to the bone and bone marrow may apparently be very slight, although usually in these severe cases one or more comminuted fractures is present. Concussions, amputations, even when most carefully and perfectly performed, incomplete fractures, acute periostitis or osteomyelitis, crushing or infection of the subcutaneous panniculi, laceration of fat tissue by dislocations or efforts at replacing dislocated bones, redressement, brisement forcé, pressure upon atrophic bones, injuries to adipose tissue during labor, crushing of fat cells of the panniculi during surgical operations, rupture of a fatty liver, purulent inflammation of fatty tissues, burns of the skin, etc., are the chief etiological factors of traumatic lipemia in addition to the more direct lesions of the marrow resulting from complete fractures. The lipemia and fat embolism resulting from any one of these causes may be slight or marked, without symptoms or with severe ones, terminating favorably or fatally. There is no clinical correspondence between the apparent injury and the degree of the resulting lipemia. Injuries apparently indentical may in one individual be followed by a fatal lipemia, while in another not the slightest disturbance attributable to fatty embolism can be made out.

Pathology.—From the study of the literature, the examination of my own cases, and the experimental work with animals the following statements concerning the pathology of fat embolism can be made with some confidence that they represent the true nature of the condition.

1. *Entrance of the Fat into the Circulation.*—At the site of the bone injury there is often found a mixture of liquid fat and blood, or fat and pus. Fat droplets may be seen in the discharges from the wound or from the incisions. In the case of osteoporotic bones cystoid cavities filled with liquid fat are found. From the broken fat cells and fat spaces the fat enters the open veins of the bone, the tension at the site of the injury usually being greater than that in the veins, so that the fat is readily forced into or taken up into the venous circulation. This may occur immediately after the injury, or the taking up of fat may proceed for some time, as long as there is free fat at the seat of injury or until coagulation occurs. In addition to the fat taken up by the blood-vessels there is also an entrance of fat into the lymphatics, occurring later than the direct entrance of fat into the circulation. The fat droplets pass the regional lymph nodes and enter the thoracic duct, and thence through the venous circulation into the lungs. This entrance of fat through the thoracic duct occurs usually some time after the embolism of the pulmonary vessels from the fat gaining direct access to the veins. Hence an exacerbation of the symptoms is noted when this second supply of fat reaches the lungs, and if the patient survived the first embolism he may succumb to the second blocking-up of the pulmonary and cerebral vessels. As the fat passes into the arterial system it may be forced through the systemic capillaries back into the veins, giving rise to a definite cycle of symptoms.

2. The *tissue lesions* in fatty embolism and the consequent symptoms are dependent wholly upon the amount and distribution of the fat gaining entrance to the circulation. It is evident that the latter factor is the more important. Three times as much fat might be poured into the blood stream of one individual with less effect than one-third as much put into the circulation of another person. The result depends largely upon the destination of the emboli. It is, of course, evident that the larger the amount of fat in the blood, the more likely are important regions to be visited by the fat. There are evidently both individual and local factors that serve to determine the course of the fat and its effects upon the organism.

It is evident that the body, even the brain, can stand a relatively large amount of fat in its capillaries before the final limit of obstruction is reached and damage to the tissues ensues. In all cases of fatty embolism of the lungs some fat reaches the kidneys and is excreted. It must also reach the brain and, temporarily at least, lodge in some of its capillaries. But miliary hemorrhagic infarctions of the brain occur only when there is a marked degree of obstruction, stasis, and secondary thrombosis. The same thing is true of all the other organs of the body.

There is not a single organ or tissue in the body—be it thyroid, pancreas, adrenal, testis, or skeletal muscle—that does not get some fat in its capillaries during a fatty embolism. Anatomical considerations and the peculiar organization of tissues will determine the result. As the fat enters the venous circulation first, the heart and lungs first bear the brunt of it. When the fat suddenly enters the blood stream in large amounts, the effect upon the heart may be the same as air embolism. The cardiac contractions are insufficient to drive the fat on into the lungs, and it remains in the right ventricle, increasing perhaps in amount, and exciting the formation of fibrin. The heart may gradually be exhausted, delirium may ensue, and sudden death. It is extremely likely that many of the cases of death within twenty-four hours after an injury are the result of cardiac paralysis.

The heart is further impeded in its action by emboli within its own vessels. A vicious circle may thus be set up, and the organ become more and more embarrassed. With the formation of fat emboli in the coronaries local infarctions of the heart muscle are likely to occur, and these serve to bring about the final break in cardiac efficiency. In such cases there is a great fall in arterial pressure, and a corresponding rise in the venous; the heart rate is very rapid and irregular. It is, therefore, proper to speak of a *cardiac symptom-complex* in fatty embolism. The importance of this has been strangely overlooked before. Colley and a few other observers are the only ones who have regarded the part played by the heart as of any consequence.

In all cases the pulmonary capillaries get the greater share of the fat emboli, but the lung is better able than any other organ to withstand this condition. Nevertheless, as not infrequently happens, the lung is overflooded, and so many of its passageways are blocked that a *respiratory symptom- and lesion-complex* arises, as shown by cyanosis, dyspnea, pulmonary edema, hemorrhage, and hemorrhagic infarction. Beyond the lung, in the systemic circulation, any one organ may receive the greatest damage from the emboli. If it is the brain, then there occurs a *cerebral symptom- and lesion-complex*, easily recognized clinically and at autopsy. Congestion, stasis, thrombosis, hemorrhage, hemorrhagic infarction, and areas of degeneration characterize the cerebral lesions. Headache, vomiting, restlessness, apathy, clouded sensorium, diminished reflexes, low or high temperature, delirium, paralysis, coma, convulsions, and death result from these lesions. Yet, if not too severe, recovery may take place.

The blocking of the glomerular capillaries of the *kidney* does not produce any appreciable lesion in this

organ. Slight hemorrhages, congestion, stasis, etc., are occasionally seen, but no marked degenerative lesion.

In the *adrenals* there may be extensive blocking, hemorrhagic infarction, and fatty degeneration. We cannot yet recognize clinically such an *adrenal symptom-complex*, and we do not know what part these lesions may play in the cardiac disturbance. The extreme fatty change in the *liver* may be in part a protective function.

Likewise in the *pancreas* the islands of Langerhans may be blocked with fat emboli, and the cells of the islands be markedly infiltrated with fatty granules. What disturbances may be caused by this we do not yet know. The same thing is true of the *thyroid*. There is extensive blocking of the capillaries of this organ in fatty embolism, but we cannot recognize any effects, although some functional disturbance must occur.

Fatty change in the *diaphragm* may be associated with disturbances of circulation and respiration. In the skeletal muscles numerous areas of fatty degeneration and embolism may account for some of the general malaise and fever. In all of these minute damaged areas protein change must be going on, and various intoxications may be secondary to the embolism. Emboli occur also in the capillaries of the *stomach, intestine, bladder, lymph nodes, thymus, blood spaces, spleen*, etc., without causing recognizable tissue changes.

The action upon the blood must always be borne in mind. In some cases an active hemolysis takes place, and a large amount of blood may be lost. Blood-pigment casts may be present in the urine.

3. The minute areas of tissue infarcted by the fatty emboli show in certain organs, such as the heart, skeletal muscles and diaphragm, liver, adrenals, pancreas, and spleen, an especial tendency on the part of the injured parenchymatous cells to take up fat droplets. This tendency is not similarly shown by the thyroid, kidneys, brain, salivary glands, testis, etc. There must exist some especial attraction between the fat of the emboli and the injured protoplasm of these cells. In the case of the liver it is worth noting that this "fatty degeneration" or agonal fatty infiltration occurs chiefly about the emboli in the capillaries which flow into the central veins, but may also be found anywhere in the lobule and at the periphery.

4. The *excretion* of the fat is chiefly through the kidneys, in periodic cycles, in accordance with the movement of the fat from the arterial to the venous side and back again. The passage into the tubules is accomplished in the glomeruli, and not in the epithelial cell of the tubules. Phagocytes also convey the fat droplets out of the body in great numbers, especially in the sputum, feces, and bile. No doubt much of the fat is utilized by such organs as the liver.

Symptomatology.—The symptoms of fatty embolism vary greatly, accordingly as the brain, lungs, or heart receives the greatest number of emboli, and show a corresponding disturbance of circulation. The earlier observers concerned themselves with fatty embolism of the lungs alone, and failed to examine the brain or to consider the possibility of a fatal cerebral fatty embolism. Not until Scriba's paper was the importance of fatty embolism of the brain recognized. His dictum that the fatal outcome of any case of fatty embolism is always due to a plugging of the cerebral vessels was generally accepted for a time, and led to more careful examinations of all the organs and tissues after death from fatty embolism. As a result of the more recent studies Scriba's view was shown to be incorrect; and, while the great importance of cerebral fatty embolism is recognized, two clinical types of fatty embolism are distinguished: a *pulmonary* and a *cerebral*.

Pulmonary Fatty Embolism.—This is clinically less characteristic in its symptoms and course than the cerebral; and the diagnosis is correspondingly more difficult. The chief symptoms are respiratory: dyspnea, cough, cyanosis, pulmonary edema, and hemorrhage. These symptoms may develop immediately after the bone injury (apoplectiform cases), or the development may be very slow. The respiratory symptoms may or may not predominate. In many cases it is impossible to make a diagnosis until the autopsy is performed. Death may take place almost immediately, or the patient may live for several weeks. There may be an initial free interval before the respiratory symptoms appear. Restlessness, headache, and stupor may be the first symptoms; or a respiratory difficulty may suddenly develop, and the patient suffer a most severe air hunger. The heart rate is increased, the rhythm irregular and the tension low. Precordial or epigastric pain may be felt. The right heart especially is dilated. The temperature may be low or high, more frequently it is low at the very first, to rise gradually after the first few hours. The respiratory rhythm may be irregular; the resonance is slightly diminished and becomes somewhat tympanitic in character. Moist râles are heard over the base and there are the usual signs of a marked pulmonary edema, the sputum often running from the mouth in a foamy mass. It is often blood stained, and free fat can be demonstrated in it by staining with Scharlach R. Fat appears also in the urine.

In the fatal cases asphyxia may rapidly develop, following very closely upon the trauma, and the patient dies in apparent collapse. Between the fatal and the non-fatal cases there is no sharp line; nor is there such between the respiratory and cerebral form. The first form usually comes on early after the trauma but may be delayed, while the cerebral variety develops later although it may also develop within a few hours. In the respiratory form cerebral symptoms may develop as the result of the anemia of the brain and carbonic acid increase in the blood.

The *cerebral* form usually manifests itself after an interval period, often three to eight days, but may come on within a few hours. In these cases the pulmonary lesion is less prominent than the blocking of the cerebral vessels. The patient's first symptoms are uneasiness or headache, sleepiness, disturbance of mind, stupor; there is sometimes vomiting, often hallucinations or delirium passing into a somnolent or comatose condition. The skin is pale and may show petechial hemorrhages, and the lips bluish. Reflex excitability is gradually lost, and there may be definite spasms, tremors, convulsions, or paralysis (even hemiplegia). While signs of cortical irritation are usually present, those of increased intracerebral pressure such as choked disc, slow pulse, and rigidity of neck are always absent. The respirations are greatly increased and the cyanosis and dyspnea may be marked. Symptoms of the respiratory form are usually added to those of the cerebral. Cheyne-Stokes phenomenon is often present. The pulse becomes very rapid, weak, and irregular. At the beginning the temperature may fall, and may remain subnormal to the end, more frequently there is a rising temperature curve reaching to 104–5° before death, and sometimes persisting at this height for several hours postmortem. In many cases the symptoms show three distinct stages: the free interval, the soporific stage and the comatose. In the cases that recover there may be only the first two stages.

In both forms free fat may appear in the urine but is most abundant in the cerebral form, giving evidence of the flooding of the arterial system with fat. It appears periodically, as described above. It

may form a definite layer on the surface of the urine, or a small number of fat droplets alone may be seen floating on the surface. Associated with the fat there may be red blood cells, casts of different types, particularly blood casts containing fat droplets. Albumin may or may not be present. If pulmonary edema is present fat droplets will be found in the sputum. The blood may also be examined for fat droplets.

It is evident that in all cases in which there is fat in the urine some fat must also reach the brain. The occurrence of cerebral symptoms is dependent upon the amount of fat reaching that organ. It is highly probable that in all cases of fatty embolism some fat must get into the cerebral circulation. If the amount is small, and if the capillaries are not blocked for a long distance so that serious disturbances of the nutrition of the part is not produced, it is not likely that there will be any serious cerebral symptoms, or at most only transitory ones. The normal lung can bear a great deal of fatty embolism without damage; and the same is true in a lesser degree of the brain.

Diagnosis.—Fatty embolism may be mistaken for shock, collapse, commotio cerebri, contusio cerebri, compressio cerebri, hysteria, intracranial hemorrhage or inflammation, acute or chronic alcoholism, delirium tremens, sunstroke or heat exhaustion, diabetic or uremic coma, septicopyemia, etc. At times the diagnosis may be easy; at other times it is extremely difficult to differentiate between fatty embolism and some of these conditions, notably intracranial hemorrhages. When the patient has received injuries about the head the difficulty of differentiation becomes greater. Considerations of temperature, heart's action, pulse, respiratory, and cerebral symptoms become of little avail, as practically all the clinical phenomena characterize these various conditions in common, so that it is impossible to separate them. The occurrence of a free interval in many of the cases of fatty embolism will distinguish it from shock, commotio cerebri, and contusio cerebri. In the case of meningeal hemorrhages and compressio cerebri the differential diagnosis is very difficult at times. In fatty embolism the cerebral symptoms are more diffuse, the centers are not affected regularly or as a part of a definite system. Choked disc and the other signs of increased intracranial pressure are not seen.

In general the diagnosis of fatty embolism should rest upon those considerations that are peculiar to it alone. In the first place, it should always be looked for after any damage to bones containing fatty marrow, no matter how mild this injury or concussion may appear to be, also after orthopedic manipulations of atrophic bones. If after such operations or injuries symptoms of restlessness, sleepiness, and coma develop, with dyspnea, cough, and signs of pulmonary edema, then the diagnosis of fatty embolism is very probable and the objective signs of this condition—*fat in the urine* and *fat in the sputum*—should be positively determined. The presence of fat in the blood may also be determined by examination of the retinal vessels, or by removal of a large amount of venous blood.

Fat in Urine.—Riedel and Scriba were the first to show that fat droplets appear in the urine after the majority of bone injuries. Other writers have reported negative findings. It must be borne in mind that the lipuria is often delayed for several hours or days, and that the patient may die before it occurs; also that the lipuria is usually intermittent. There may be a large layer of fat on the surface of the urine, or the surface may show only large fat drops.

Fat in the Sputum.—The presence of free fat droplets and of numerous phagocytes containing many fat granules in the sputum is here put forth as a new and extremely valuable diagnostic aid. In 1906, I began to teach to my classes the importance of fat in the sputum as an important and early sign of fatty embolism of the lungs, basing my belief upon a case I had seen in which an old man after a fracture of his femur showed a sputum containing blood and large numbers of fat droplets. Carrington (1908) quoted by Le Conte and Stewart is the only other writer who, as far as I have been able to discover, mentions this sign. He is quoted as having found it in six cases. I have confirmed my finding in all recent cases of fatty embolism seen by me, and hence regard it as a most valuable sign. Fat escapes by rupture from the dilated capillaries of the lungs before it passes from the kidneys. If the pulmonary obstruction is at all marked there will be an increase in the amount of sputum and in this sputum there will be free fat droplets and alveolar cells containing large fat droplets. Stain fresh unfixed sputum under cover-glass with Sudan III. Occasional cells containing fine fat granules are found in ordinary sputum, after a pneumonia they are more numerous and small fat droplets may then be found free. They are never so large or numerous as in fatty embolism.

The differential diagnosis of fatty embolism will depend, therefore, upon the following chief factors: (1) Injury to bone marrow or adipose tissue. (2) A cardiac, pulmonary, or cerebral complex, or these combined. (3) Free fat droplets in sputum: Fat-containing alveolar cells in sputum. (4) Free fat droplets in urine. (5) Examination of eye-grounds for evidences of fat in circulating blood. (6) Examination of venous blood for fat droplets. (7) Increase of temperature, rather than a lowered temperature, as reported by Scriba, and quoted in the text-books.

Course.—The course of fatty embolism may be rapid or slow. The cases are described as *apoplectiform*, with fatal result at once or within a few hours; or the symptoms and signs may last for several days or weeks, to terminate then fatally or in recovery. In the apoplectiform cases the diagnosis may be possible only through the autopsy, as there may be no time for the development of a clinical picture presenting characteristic symptoms.

Prognosis.—The prognosis in well-developed cases of fatty embolism with recognizable signs and symptoms is grave. The majority die; the number of reported recoveries is small. It is very pobable, however, that the literature upon this condition cannot be taken as a criterion of its prognosis. The cases that recover are probably not recognized as fatty embolism; but pass under the diagnoses of shock, collapse, concussion, etc. It is my own belief that there are many more cases of fatty embolism that do recover. A more careful observation of the condition of patients suffering from fractured bones will, I am sure, support this contention.

Treatment.—The treatment of fatty embolism is both prophylactic and therapeutic. The *preventive* treatment in the case of fractured bones is absolute rest and the avoidance of all unnecessary moving of the patient. Particularly is transportation over rough roads, or in a jolting vehicle, or even transportation for a long distance contraindicated, because of the fatal cases apparently induced by such conditions, as reported in the literature. Likewise, massage and the use of tight bandages are dangerous in increasing the tension at the site of the injury and promoting the entrance of fat into the veins and lymphatics. In the case of orthopedic operations, particularly when there is disuse atrophy and osteoporosis of the bones, should the employment of direct force upon the atrophic spongiosa, either by the use of the chisel, by crushing, or by direct pressure upon the bones, be avoided. The saw should be used rather than the chisel in all operations upon osteoporotic bones. Concussion of such bones should

be avoided in all possible ways. The slow removal of the Esmarch bandage is also recommended by von Aberle, Grondahl, and others.

Reiner advises the puncture of the femoral vein, or the insertion of a cannula through the saphenous into the femoral after bloodless orthopedic operations, so that when the Esmarch bandage is removed slowly the wave of blood flowing into the veins will wash out any fat that may be in the vessels. Other writers are not enthusiastic over this method.

Lexer states that the most important prophylactic method against the occurrence of fatty embolism in orthopedic operations is the avoidance of the chisel in operations upon the spongiosa. He advises that a saw should always be employed in such operations, as the separation of the bone may be secured without any crushing or concussion. Further, he warns against the employment of pressure upon the articular ends of the bones, in the case of operations upon crooked limbs, particularly when the ends are atrophic and softened.

The ligature of the veins above the injury or seat of operation is also recommended as a preventive measure, as in the case of thrombophlebitis for the prevention of infected emboli. It is not considered a practical measure by some surgical writers.

Free incision and drainage of the fat in case of comminuted fractures, also incision and removal of stitches to relieve the tension, are recommended as preventive measures.

Therapeutic Measures.—After fatty embolism has occurred the treatment consists of measures to get rid of the fat in the blood stream by proper stimulants. Among the methods advised for the removal or neutralization of the fat in the blood stream are the following:

1. *Injections of Two Per Cent. Sodium Carbonate Solution.*—Czerny's experiments with this method were fruitless so far as saving the life of the animal was concerned, although the dyspnea seemed temporarily lessened. In one human case in which I have seen this method employed there was great improvement of the air hunger, but the patient died. Minnich regards this treatment as useless. It needs, however, a more thorough trial than has yet been given it.

2. *Venesection* was recommended by Czerny to lessen the venous congestion, and this writer also advised the injection of the sodium carbonate solution after the bleeding. Temporary benefit at least may be obtained in this way.

3. *Injections of physiological salt solution* into the veins are recommended by Schanz (1910). Eight out of ten cases of fatty embolism following orthopedic manipulations were treated by saline infusions, the salt solution being injected at several points in order to accomplish most effectually the desired dilatation and flushing out of the veins. In the case of severe symptoms the saline solution should be injected directly into the large veins. The earlier the injection and the larger the amount of salt solution injected the better the result. Schanz's success with this method is very promising and it should be given a thorough trial. At least it is easily carried out and can do no great harm.

4. *Drainage of Thoracic Duct.*—In 1910, Wilms recommended the establishment of a thoracic-duct fistula in the treatment of fatty embolism, on the ground that more fat is added to that in the blood by absorption through the lymphatics, the fat passing the lymph nodes and reaching the thoracic duct, whence it passes into the venous circulation some time after the fat that gained immediate entrance into the veins. This accession of fat may be the final straw in bringing about the fatal termination, and if this increase in the fat in the blood stream can be prevented the patient survives. Wilms carried out this operation successfully in one case of fatty embolism in a patient who had fallen from a window. The risk of the operation itself is slight, and the consequences negligible. On the other hand, as so few cases of fatty embolism diagnosed *intra vitam* live, the risk of the operation is nothing compared to that of the condition of fatty embolism itself. As Gröndahl says, this method of treatment is certainly theoretically a good one, and surgeons should be urged to carry it out whenever there are indications of cerebral fatty embolism.

A combination of venesection, saline injection and thoracic-duct fistula may then be advised as offering at the present time some hope in the treatment of fatty embolism. All other treatment must be directed toward the prevention of further entrance of fat into the blood stream, and the relief of the dyspnea by lessening the work thrown upon the lungs and heart. Cardiac stimulants, the use of oxygen, artificial respiration, etc., are chief among other measures that must be tried.

Medicolegal Significance.—The medicolegal significance of fatty embolism has been considered by Wintritz, Puppe, Westenhoeffer, Burger, Grondahl, and others. Many points of great interest are associated with this question. From the literature the following points may be taken as having authority:

1. Fatty embolism of lungs, brain, and kidneys is always an intravital phenomenon. It will not occur in the capillaries of these organs after death, although putrefactive gas emphysema may cause the entrance of fat into the large vessels, it cannot push it into the small vessels of these organs. Nor can burning after death cause this.

2. The occurrence of fatty embolism in the lungs, brain, or kidneys of a person whose body has been burned must be taken as evidence that there was previous to death some injury to fat tissues or bone marrow or severe concussion of the bones.

3. Fatty embolism as a cause of death after trauma must be excluded by autopsy examination before a diagnosis of death from acute alcoholism, intracranial hemorrhage, meningitis, insanity, hysteria, shock, etc., is given. Particularly when there is any suspicion of foul play should this condition be looked for and considered as a cause of death. In one of my cases a fatal case of fatty embolism in a man who was thought to have been pushed downstairs was diagnosed as "acute alcoholism" by the coroner, and no investigation was ever made.

4. Fatty embolism is of medicolegal importance, therefore, as a cause of death, also as a means of determining whether a burned body had been injured in any other way before the burning. The criminal and insurance aspects are obvious.

For complete bibliography of traumatic lipemia see monograph by Warthin in the "International Clinics," vol. iv., 1913, from which this article is compiled. Aldred Scott Warthin.

Lipochromes.—See *Luteins*.

Lipoids.—The lipoids are substances that closely resemble fats in solubility and solvent power but which chemically are not necessarily related to the fats. Lipoids cannot be defined from a chemical standpoint as the nature of certain of them is still only indefinitely known. They include such bodies as lecithin (the phosphatides especially) and cholesterole. The lipoids undoubtedly play a significant rôle in metabolic processes by altering osmotic pressure hence influencing absorption and secretion and by their presence or absence changing the character of cell membranes which are assumed to be impregnated with lipoids.

F. P. U.

Lipoma (Lipoblastoma, adipoma, steatoma) is a tumor consisting essentially of adipose tissue. Such growths belong to the mature connective-tissue tumors, and have for their physiological prototype

the adipose tissue found beneath the skin and serous membranes. Between normal adipose tissue and the fat tissue of lipomata there are no essential differences of structure. In the majority of lipomata the fat cells as well as the fat lobules are usually larger than those of normal adipose tissue (the former three to four times as large); but this difference does not hold good to such an extent that it can be used as a point in differential diagnosis. In general, a lipoma presents the structural characteristics of a localized mass of fat differing in no essential respect from normal subcutaneous fat. The chemical reactions of the fat contained in lipomas likewise correspond to those of normal fat except that some lipomas show a deficiency in lecithin. Lipomas are hydrolyzed by trypsin as readily as normal fat. The lipase of lipomas hydrolyzes fat and esters in the same manner as the lipase of normal adipose tissue. No chemical reason has been yet found for the apparent independent fat metabolism of many lipomas.

Since the resemblance in structure to normal adipose tissue is so very close, it may sometimes be difficult to draw a line between a simple hypertrophy of adipose tissue and a lipoma. Both general and local hyperplasias of adipose tissue occur which are not classed with lipomata (general lipomatosis, lipomatous elephantiasis, the deposit of fat about an atrophic kidney or between the bundles of atrophic muscles); but other local hyperplasias of a similar nature have by various authors been styled lipomata. Thus the hyperplasia of the fatty capsule of the mammary gland which occurs sometimes in scirrhous carcinoma of this organ or in chronic interstitial mastitis has been called *lipoma capsulare*, an excessive deposit of fat beneath the epicardium has been styled *lipoma cordis capsulare*, and the deposit of fat in the villous fringes of the joints is known as *lipoma arborescens*, although analogous to the fatty hyperplasia so frequently seen in the epiploic appendages of the large intestine. Such local fatty hyperplasias may be styled *pseudolipomata*. An exact use of the term lipoma would limit its application to those formations of adipose tissue alone in which an actual new formation of fat tissue occurs. Such a criterion has, however, but little practical value, since in the fully developed growth of fat tissue it may be impossible to say whether the latter has arisen from a circumscribed hyperplasia or represents a true neoplasia. This difficulty is increased by the fact that lipomata are usually found in those parts of the body in which there is normally more or less fat tissue. A more practical guide will therefore be found in the principle that the term lipoma should be applied to *circumscribed proliferations of adipose tissue which show a certain anatomical and physiological independence of the neighboring tissue, even when the latter is fat tissue.*

The application of the term lipoma made by some writers to tumors other than connective tissue, the cells of which have undergone fatty degeneration or contain an abundance of fat, is wholly incorrect. The true lipomata belong to the mature connective-tissue tumors—that is, the tissue of which they are composed is of the type of adipose tissue.

Histogenesis.—The histogenesis of lipomata is not yet definitely known. Their very frequent development in regions where fat tissue is normally found has led to the belief that the majority arise from a hyperplastic proliferation of adipose tissue with new formation of fat cells and fat lobules. Such an explanation would hold good even for the lipomata which are sometimes found in the submucosa of the gastrointestinal tract, since in well-nourished individuals fat cells are usually present in small numbers in this region, and from these a lipoma could take its origin. Another view is that lipomata arise from undifferentiated embryonal cells which have persisted from fetal life, or are formed by the proliferation of connective-tissue cells. The development of fat tissue from these follows the same course as that of the normal development of fat cells from fetal myxomatous tissue. It is not improbable that undifferentiated "primitive fat organs" (developing fat lobules in the fetal mesenchyma) may persist quiescent until adult life and later resume active proliferation, giving rise to localized growths of fat tissue which in their development would be more or less independent of the normal laws of nutrition and cell growth. Such lipomas differ in histological structure from the ordinary lipoma, consisting of cells showing minute fat droplets scattered through the cell instead of one large fat droplet as in mature fat tissue. Such lipomas corresponding in their structure to primitive fat lobules I have repeatedly seen and have for a number of years called them "primitive fat-lobule lipomas," regarding them as arising from the primitive fat tissue. Support is given to this theory by the fact that some lipomata in their growth appear to be entirely independent of the laws governing the general nutrition of the body, since they continue to increase in size or at least do not become smaller under conditions of cachexia, etc., when the normal fat tissue is being reduced in amount. The fact that a combination of myxomatous tissue and adipose tissue is frequently found under pathological conditions may also be taken as an indication of the close histogenetic relations of these tissues. In many lipomata areas of myxomatous tissue occur, and occasionally the appearances presented suggest the development of the fat tissue out of the myxomatous. Moreover, there are rare forms of lipomata in which the fat cells resemble those of embryonic adipose tissue, in that the fat droplets are of small size and do not coalesce into larger drops filling the entire cell.

A further origin for lipomata may be found in atrophic lymphadenoid tissue, a physiological paradigm being found in the development of fatty marrow from the lymphoid marrow, and the fatty transformation of the thymus, and later in old age that of the lymphatic glands. The relationship between lymphoid tissue and adipose tissue is very close. In the fetus the development of the lymph glands is either coincident with that of the primitive fat organs or follows it; in the latter case the lymphadenoid structures (both ordinary lymphatic and hemolymph nodes) developing out of the fat organs. In adult life under certain conditions a new formation of lymph glands takes place from adipose tissue, and in old age the lymph glands become to a large extent replaced by fat tissue. Throughout life it is very probable that there is a constant cycle of alternation between lymphoid tissue and adipose tissue. As the result of some disturbance of these processes it is possible that lipomata may arise, either from atrophic lymph glands or from anlage of undifferentiated cells. Askanazy traces the origin of multiple lipomata in particular to a replacement of lymph glands by fatty tissue.

The lipomata of the uterus, kidney-cortex, brain, spinal cord, etc., are to be referred to misplacements of anlage of fat tissue or of fibrous connective tissue which later undergoes a fatty metaplasia. Such lipomata are to be classed with the heterotopous teratomata. It should be borne in mind also that lipomatous masses not infrequently form the bulk of teratomata found in other regions as well.

Etiology.—As in the case of the other true neoplasms but little is known of the etiology of lipomata. Some of them may arise as the results of trauma or chronic inflammation. Such an origin has been ascribed to the fatty tumors sometimes found in the hands of working people in the parts most exposed to injury. In other cases fatty tumors have been found developing from scars. In such cases the trauma has only the significance of an exciting factor

acting upon an intrinsic predisposition. The fatty growths in the villi of the joints are usually associated with a chronic arthritis. There also seems to be some association between multiple lipomata and rheumatoid affections. In the case of the multiple and symmetrical lipomata a nervous or trophic origin is assumed by many writers. In such cases other symptoms suggesting a neuropathic origin are not infrequently present. According to Grosch, multiple lipomata of the skin arise from a disturbance of fat secretion by the skin glands due to a trophoneurosis. A connection between lipomata and disease of the thyroid and hypophysis has also been assumed by some authors. In the majority of cases it is very probable that lipomata are to be regarded as congenital, that is, they arise from misplaced anlage. A tendency to the development of lipomata appears also to be inherited in some families.

Gross Appearances.—All lipomata possess a more or less definite capsule. In the sharply circumscribed forms the capsule may be well defined, of varying thickness; in the diffuse forms the capsule is not perfect and often sends prolongations of connective tissue into the surrounding tissues, which if not removed may lead to a recurrence of the growth. The size of lipomata varies greatly; in the kidney, submucosa of the intestinal tract, etc., they may be very small, while in the subcutaneous tissues of the shoulder and back and in the retroperitoneal tissues they may give rise to tumors weighing fifty pounds or more. As a rule, they do not exceed ten pounds in weight. They usually form lobulated growths of more or less regular contour. A subdivision of the larger lobules into smaller ones gives the growth a tuberous appearance. Lipomata are not infrequently pedunculated, particularly those found in the submucosa of the alimentary tract, though even in the skin the tumor may occasionally possess a relatively long and narrow pedicle (*lipoma pendulans*). Through the twisting of the pedicle the lipoma may undergo cystic softening, and appear as a cystic tumor covered with folds of skin (*dermatocele lipomatosa*). Accessory nodules are rarely seen about the main growth. In the majority of cases lipomata are solitary. Occasionally they are multiple, and in such cases the tumors may be symmetrically distributed over the body. As a rule, lipomata are soft, elastic, and may give a sensation of fluctuation. Puncture with a trocar yields no fluid except in those cases in which extensive retrograde changes have taken place. The absence of fluid on aspiration may therefore have a certain diagnostic value. The occurrence of retrograde changes may render the growth either harder or softer. As a rule, the cut section of a lipoma presents a yellowish or whitish, glistening, lobulated surface, having the characteristic appearances of adipose tissue.

Microscopical Appearances.—As stated above, the minute structure of lipomata corresponds in general with that of normal subcutaneous fat. Other varieties of tissue may take part in the make-up of the growth. If the fibrous trabeculæ are developed to such an extent that they form a prominent feature of the tumor the latter may be styled a *fibrolipoma*. As the result of the increased consistence of such tumors they are also called *lipoma durum* or *steotoma*. A combination of myxomatous tissue with fatty tissue gives rise to a *myxolipoma*. *Osteolipomata*, *chondrolipomata*, and *myolipomata* have also been described. An abundant blood supply with overdevelopment and dilatation of the blood-vessels gives rise to the form known as *telangiectatic lipoma;* the formation of blood spaces resembling those of erectile tissue to the variety known as *lipoma cavernosum*. The soft form of fibroma may also be combined with a lipoma. To very cellular varieties of a sarcomatous nature the term *liposarcoma* may be applied. Such forms are rare, sarcoma developing less frequently in lipoma than in any other benign connective-tissue tumor. In rare cases an excessive formation of fat of lipomatous nature may be combined with sarcoma or carcinoma. Lipomatous formations are not uncommon in teratomata, and may form the bulk of the tumor. The presence of other histological elements such as epithelial and nervous tissues gives a basis for differential diagnosis. Varieties of lipomata have also been described in which the fat tissue presented the appearances of embryonic adipose tissue ("primitive fat-lobule lipoma"). Such tumors consist of lobules of cells containing many fine vacuoles of fat instead of one large droplet as in the ordinary lipoma, and which are precisely like the fat cells of the "primitive fat tissue" seen in the human fetus and which persists in certain regions in extrauterine life. The writer has seen a number of such "primitive fat-lobule lipomas." Shattock has described the same form of lipoma under the term of "glandular lipoma," and regards the cells of which they are composed as homologous with the fat cells of the hibernating gland of lower animals. Such "primitive fat-lobule lipomas" are found not only in the neck and axillæ, but also in the mediastinum, kidney capsule, retroperitoneal tissues, and elsewhere. The largest one seen by the writer came from the sacral region. If such primitive fat tissue represents hibernating gland tissue it occurs in many regions of the human body. Hemolymph nodes are especially associated with this form of fat tissue.

Evidences of the growth of the lipoma may be found either in the capsule or in centers of growth which are scattered throughout the tumor. The new formation of adipose tissue may therefore take place peripherally or at different places in the tumor. A fibrous connective tissue is usually first formed, and this later undergoes metaplasia into fat tissue.

Manner of Growth.—Lipomas grow by expansion, and as a rule slowly. They do not set up metastases. According to their manner of development lipomata may be classed as *solitary, multiple, circumscribed, diffuse, symmetrical,* etc. The diffuse and multiple forms are closely related on the one hand to the simple hyperplasias of fatty tissue resulting from anomalies of metabolism, overeating, etc.; and, upon the other hand, to the multiple fibromata, chondromata, osteomata, etc., which are congenital or develop from misplaced anlage.

The *diffuse* and *multiple* lipomata, particularly the *symmetrical* forms, have in recent years attracted much attention, and various hypotheses have been advanced in explanation of their origin. In certain cases there appears to be some definite connection between disturbances of the nervous system and the development of multiple lipomata. Numerous clinical observations show the coincidence of occurrence of multiple lipomata and nervous conditions. The development of symmetrical lipomata in association with disturbances of sensation and motion has been seen in the lower extremities after injury to the spinal column. Neuralgias, trophic disturbances of the skin, etc., have been observed in connection with multiple and symmetrical lipomata. It is probable of course that in some of these cases the nervous disturbances may be the result of pressure by the tumor. Lipomata which are themselves painful are also seen. In such tumors there may be a new formation of nerve fibers, or the tumor may spring from the connective-tissue sheaths of the nerve trunks, or the symptoms may be the result of pressure. An exact anatomical distribution of the tumors to accord with the peripheral nerves cannot always be made out. Multiple lipomata may also be inherited. Blaschko reports the case of a family in which the male members developed multiple lipomata at the age of puberty, while the females were not affected. The coinci-

dence of multiple lipomata with rheumatoid affections has already been mentioned.

Broca has reported an extraordinary case of multiple lipomata. In a man of the age of twenty-five years there appeared on the right thigh a small fatty tumor which in six years attained a large size. It was excised, found to weigh five pounds, and to consist of ordinary adipose tissue. The patient remained well for five months when there occurred an eruption of hundreds of small fatty tumors all over the body, fresh ones developing from time to time during a period of forty years. At the age of seventy the man came under Broca's care for treatment for dysphagia. Two thousand and eighty tumors in size from that of a pea to that of a walnut were counted over the body, more minute ones not being included. The original scar showed no signs of disease. The microscopical examination of portions of the growths removed during life gave the appearance of lipofibroma. Increase of dysphagia caused emaciation to set in. This at first did not affect the tumors, but after several weeks the emaciation became extreme and the tumors diminished. The patient finally died of starvation. At autopsy no trace of fat was found in the normal fat depots. A large fatty tumor surrounded the esophagus for the greater part of its extent, occluding the lumen; the pylorus was surrounded by a similar growth. Fatty growths were found in the valves of the heart, in the deep tissues of the neck, in the sheath of the carotid vessels, and in the sheaths of the muscles, as well as in the normal fat regions. Many of the tumors had lost their fat, they consisted of fibrous tissue; the others presented the appearances of fibrolipomata.

Site.—Lipomata are found most frequently in those parts of the body where fat tissue is most abundant normally: in the subcutaneous, subserous, and submucous fat, and the intermuscular connective tissue, and less frequently in the kidney, periosteum, joints, tendon sheaths, meninges, etc.

Subcutaneous.—Circumscribed lipomata are found more frequently in the subcutaneous tissues than elsewhere, appearing as movable, lobulated, elastic tumors. The neck, back, gluteal region, thighs, axillæ, anterior abdominal wall, arms, hands, and feet are mentioned in the order of frequency of involvement. Lipomata of the scalp and face are rare. The palms of the hands are more often the seat of fatty tumors than the soles of the feet. In the hands lobules of fat may extend from the main mass of the tumor underneath the palmar fascia. Small lipomata may be found occasionally on the fingers. The fat of subcutaneous lipomas may in some cases resemble that of "primitive fat lobules." This is particularly likely to be the case in lipomas of the back of the neck, axillæ, and back. Subcutaneous lipomas are sometimes associated with angiomatous formations, hemolymph-node tissue or nerve elements. In a remarkable case seen by the writer there were hundreds of small subcutaneous tumors. Microscopic examination of these showed them to be varying stages of angiomas becoming converted into lipomas. In regions where the skin is loose the lipoma may become pedunculated. Subcutaneous fatty tumors may reach a very large size. They are sometimes painful and may be associated with nervous symptoms. Ordinarily they are painless. Over the large ones the skin may be stretched to such an extent that it may become very atrophic or may undergo ulceration. In this way the tumor itself may become infected. The loose nature of the fatty tissue and the low resistance of the surrounding tissue make such an infection dangerous, as it is very likely to become phlegmonous.

The diffuse pseudolipoma of the subcutaneous tissue of the neck may be mentioned here. It is in reality a diffuse fatty hyperplasia and gives rise to the condition known as "fatty collar." The deeper fascia may also be involved, and the lipomatosis may spread over the back, shoulder, and trunk. Similar fatty hyperplasias may occur in the subcutaneous tissue in other parts of the body. In some cases they are symmetrically arranged. In the majority of these cases there seems to be a definite connection between the condition and chronic alcoholism. Under changed conditions the fatty deposits become smaller. The diffuse, multiple, and symmetrical fatty deposits are therefore better classed as pseudolipomata.

Subserous.—Small lipomata are not rare in the subserous tissues. Polypoid fatty growths are occasionally seen in the peritoneum, pericardium, pleura, and the synovial membranes. When possessing a definite pedicle the latter may become twisted and atrophy, or may tear, setting the tumor free into the serous cavity where it appears as a free mass of fat showing more or less calcification. The subserous lipomata may reach a large size, particularly in the retroperitoneal region, and may become dangerous through the pressure exerted upon important organs. Adami has discussed at length the subject of retroperitoneal lipoma, collecting forty cases from the literature and reporting several of his own. As a rule, the fatty tumors of this region are slowly growing, but may attain a very large size. They are usually situated more to one side than to the other, and are usually crossed by some portion of the large intestine. Since they give fluctuation they are generally at first mistaken for cystic tumors, but puncture with the trocar yields no fluid. This fact is the most important point in the differential diagnosis. Small fatty tumors are sometimes seen in connection with femoral and inguinal hernias, but these are more of the nature of local hyperplasias of fat tissue than of true neoplasms. Such hyperplasias may in themselves constitute the hernia, and may drag the intestine down into the sac (hernial lipomata). Similar hyperplasias of the epiploic appendages may present the appearance of pedicled lipomata. Subserous lipomata of the anterior abdominal wall may sometimes appear as subcutaneous tumors as the result of the atrophy or displacement of the abdominal muscles. Large fatty tumors of the omentum have also been reported; in several instances the growth presented the character of a myxolipoma.

Submucous.—Small pedicled lipomata of the gastrointestinal submucosa are occasionally found. They are usually of small size, and rarely give rise to symptoms. In a few cases they have been of the size of a man's fist, and when situated at the pylorus or ileocecal valve, caused obstruction. In other cases they have led to intussusception. In the submucosa of the respiratory tract fatty tumors are more rare. Fatty polypi are sometimes seen in the laryngeal and nasal mucosa.

Intermuscular.—Fatty tumors are occasionally found between the muscles, arising in the intermuscular connective tissue. They may reach a very large size. The myxolipoma is the most common form, and is characterized by a tendency to become sarcomatous. They are found most frequently in the gluteal folds, thigh muscles, and muscles of the neck. Congenital lipomata have been found in the muscle of the anterior abdominal wall. Enlargement of the sucking disc may give rise to a lipomatous tumor.

Periosteum.—Lipomata of the periosteum are rather rare. As a rule, they also contain striped muscles fibers, and are therefore to be regarded as heterotopous teratomata. In some cases parosteal lipomata have been observed at birth.

Joints.—A diffuse subserous hyperplasia of fatty tissue is not uncommon in the synovial membranes of the joints, the knee- and shoulder-joints being most frequently affected. The hyperplasia of the villous fringes gives rise to an arborescent appearance (*lipoma arborescens*). The movements of the joints may be

affected. These conditions are not to be classed with the true lipomata.

Internal Organs.—Lipomata are found more frequently in the kidneys than in any other of the internal organs. The tumors may arise either from the fatty or fibrous capsule, or from the interstitial connective tissue of the cortex and medullary pyramids. They are usually of small size, but occasionally become so large as to be of clinical importance. In the capsule the tumors may represent local fatty hyperplasias or metaplasias; in the kidney cortex they are probably heterotopous teratomata, though it is possible that they arise in some cases directly from the interstitial connective tissue of the organ or represent a metaplasia of a fibroma or of a mass of scar tissue. Many growths described as kidney lipomata were in reality "adrenal rests." The writer has reported a

Fig. 3741.—Fibrolipoma of the Kidney. (Warthin.)

unique case of fibrolipoma of this organ which was so large as to cause serious clinical symptoms and to require operative interference. The growth, of which an illustration is here given (Fig. 5188), was a lobulated mass fourteen inches long, eight inches wide, and six inches in thickness, weighing two pounds. It completely filled the enormously dilated pelvis of the left kidney, and sent a round cord-like prolongation down into the dilated ureter. The only remains of kidney tissue were found microscopically in the cyst wall enclosing the tumor, which was entirely free except for a pedicled attachment posteriorly. At this point the tissues of the tumor passed into those of the cyst wall. Microscopically the tumor presented the structure of an edematous fibrolipoma, its surface being covered with a layer of atrophic transitional epithelium derived from the kidney pelvis.

Lipomata of the *heart* are very rare. The majority of cases reported as such were most probably conditions of excessive fatty infiltration. According to Orth, small lipomata are sometimes found under the epicardium near the apex. Albers, Banti, Handford, Pasini, and others have reported the occurrence of lipomata airsing in the intermuscular connective tissue. The cases described as lipomata of the *liver* and *spleen* are very doubtful. Those found upon the capsule of these organs probably represent portions of omentum or epiploic appendages that have become loosened. A formation of adipose tissue may occur also in old adhesions. Lipomata of the *ovary* have apparently not yet been observed. In the *uterus* tumors of the nature of lipomyoma or fibrolipoma have been seen in a few cases. Fatty tumors of the *broad ligament* are very rare. Very large lipomata are occasionally seen in the *vulva*. They may increase in size during pregnancy. Small ones are found rarely beneath the skin of the *scrotum*. Connected with the *spermatic cord* there are found sometimes lipomata of considerable size. Some of the smaller tumors of the cord described as lipomata may have been adrenal tissue (adrenals of Marchand). In the *central nervous system* lipomata are found rarely. They arise usually from the meninges, but fatty tumors have been found in the substance of both brain and cord. In the case of the brain, they appear to be found most commonly in connection with the corpus callosum. They are probably of the nature of heterotopous teratomata. In the complex teratoma of the nervous system a large part of the tumor may be made up of fat tissue. Fatty tumors also may be found in the sacral and lumbar regions with spina bifida occulta. With these *teratoid lipomas* should be mentioned the congenital lipomatous formations that form a part of the tail-like appendages of man (*"pseudotail," "fat-tail"*).

Retrograde Changes.—According to Virchow, it is not rare to find in lipomata isolated cavities the contents of which are partly fluid and partly saponified. Saponifying necrosis of lipomata has been reported by a number of observers ("soap cysts," "butter cysts"). The necrotic areas appear whitish, opaque, and of a cheesy consistence. Lime salts may be deposited in such necrotic areas, and in this way there may be formed calcareous nodules throughout the growth. A deposit of lime salts may occur also within the stroma of the tumor. In some cases the entire growth may become calcified (*lipoma petrificans*). Ossification has also been reported as occurring within lipomata (*lipoma ossificans*). Liquefaction of portions of the fat tissue may occur. Through the rupture and confluence of fat cells pseudocysts filled with oil may be formed (oil cysts). The twisting of the pedicle of a polypoid lipoma may lead to the necrosis and sloughing of the entire tumor. Self-healing may result in this way. In some cases a serous atrophy of the fat tissue takes place, the tumor assuming the character of an edema and partial liquefaction of the fat tissue. The fat may be removed from the cells and the lipoma changed into a fibroma. Myxomatous degeneration converts the tumor into a myxolipoma (*lipoma myxomatodes, collenema*). This is the most common retrograde change occurring in fatty tumors; and is of the nature of a metaplasia. Retrograde changes are most common in the lipomata of the skin, since in this location the tumors are most exposed to injury and to the possibility of infection.

Diagnosis.—The nature of the gross appearances, the clinical history, etc., make the diagnosis easy in those cases in which the tumor can be seen and directly palpated. The subcutaneous lipomata are slowly growing, lobulated, movable tumors, and give pseudofluctuation. In the case of large lipomata of the internal organs the negative results of aspiration in the

case of a fluctuating tumor would lead to the suspicion of lipoma, particularly in the case of retroperitoneal tumors. The presence of inflammatory changes and the development of cachexia are suggestive of sarcomatous change. Neuralgic pains may be associated with lipomata. The symptoms in general are dependent upon the position and size. Lipomata of internal organs may give rise to important pressure symptoms. In the great majority of cases, however, the chief effect of lipomata is a cosmetic one. In spite of the great size to which they frequently attain, lipomata do not usually influence the general metabolism of the body.

Prognosis.—The prognosis in lipoma is favorable. Since this form of tumor produces no metastases it must be classed with the benign neoplasms. Sarcoma may develop in a lipoma, but this occurrence is very rare, more so than in the case of any other of the benign connective-tissue tumors. Sarcomatous change appears to be more common in the case of tumors containing both adipose and myxomatous tissue (myxolipoma), the resulting sarcoma being of the nature of a myxosarcoma. This change occurs most frequently in lipomata of the intermuscular connective tissue. The cases reported in the literature as metastatic lipomata are undoubtedly examples of sarcomata containing fat tissue. No evidence exists of the metastasis of a pure lipoma. As a rule, the growth of a lipoma is gradual and slow, with periods of apparent quiescence. In the case of infected lipomata, particularly those of the skin, the prognosis is more grave, since the conditions favor the occurrence of phlegmonous inflammations with resulting septicemia or pyemia. Such complications are, however, on the whole rare. In the case of large lipomata of internal organs the prognosis depends upon the location of the growth, the extent of the pressure symptoms, the organs thus involved, etc. The removal of a lipoma usually results in a cure, recurrence being very rare.

Treatment.—The treatment is purely surgical. In the case of subcutaneous lipomata local anesthesia is usually sufficient. It should be borne in mind that the capsule should be removed in all cases of lipoma, since very often the new formation of fat tissue proceeds from the fibrous capsule. In the case of the diffuse forms the prolongations of fatty and fibrous tissue extending into the surrounding tissues should be dissected out, as from these a recurrence may take place. In those cases in which the tumors are covered by atrophic or inflamed skin the incision is best made at the base of the growth and not over it. Tearing should be carefully avoided. Drainage is not necessary. The strictest aseptic precautions should be observed during the operation and afterward, since the condition of the tissues about the growth favors infection and the occurrence of phlegmonous inflammations. Aldred Scott Warthin.

Lip-reading.—Lip-reading, or speech reading, as Dr. John Bulwer said in 1648, is "that subtile Art which may enable one with an Observant Eye to Hear what any man Speaks by the moving of his Lips." This art has, indeed, possibilities of great value as a substitute for or as an aid to hearing in the great majority of cases of deafness of whatever degree, though, like any other substitute, it has its limitations. Old as the art would seem to be from the quotation by Dr. Bulwer, it is nevertheless, as far as its general use among all classes of the deaf is concerned, hardly out of its infancy. It is only within the last fifty years that any systemic attempt has been made in the United States to teach lip-reading to deaf children, and only within the last twenty years that it has been taught in any measure to the adult deaf. At the present time it is taught to about three-quarters of the children in the special schools for the deaf, but the proportion of those becoming deaf in youth or adult life who have been taught lip-reading is very small as compared with the great total who might be so helped. In the special report on the deaf for the census of 1900, Dr. Alexander Graham Bell says: "Most of those who lost hearing in adult life have not apparently yet learned of this important means of ameliorating their condition. They fly to hearing trumpets and speaking tubes for relief, but rarely think of 'lip-reading' in this connection. Many of them have never even heard the word, or have associated lip-reading with the 'deaf and dumb' rather than with themselves."

In this census of 1900 the endeavor was made to include only those who could not hear loudly shouted conversation, and a total of 89,287 were so returned. Subsequent correspondence revealed, however, that 51,861 could hear loudly shouted conversation, and 37,426 could not. The latter were then classified as totally deaf, and the former as partially deaf, "although of course," the report adds, "the cases reported constitute only a small fraction of the partially deaf of the country." Of the totally deaf, 14,474 were reported as being able to read the lips, 13,986 as unable to read the lips, and 8,966 "not stated;" but of the partially deaf the whole number, 51,861, were "not stated." The report assumes that all of these partially deaf persons could not read the lips.

Whether this assumption is correct or not for this particular group, it would not be correct to assume from it that all the partially deaf, or the hard of hearing, among the population are not lip-readers. It would be impossible to secure reliably accurate statistics on this point. The census of 1910 reported only the so-called "deaf and dumb," who totalled 45,708; but no report has been made as to their lip-reading abilities. Unquestionably there has been a change in the attitude of the adult deaf toward lip-reading, but there are still hundreds of thousands in ignorance of the possibilities of helpfulness which this art affords. Estimates as to the number of the hard of hearing in the population vary greatly according to what degree of deafness is taken as a basis; but that three in one hundred are sufficiently deaf to gain benefit by at least letting the eyes help the ears is a conservative statement. This would make the total in the United States close to 3,000,000. Many would make it much larger.

The art of lip-reading has its basis in the work done by teachers of deaf mutes in training their pupils to speak. One of the pioneers in this work was Franz M. B. van Helmont who in 1667 published at Sulzbach his "Alphabetum Naturæ," giving thirty-four diagrams of the speech organs, which he believed would be serviceable in teaching the deaf to "learn to speak by observing the appearance of the tongue and mouth of others in speaking." He tells how by their use he had taught a congenitally deaf child to speak and to read speech from his lips. The method of teaching the deaf through speech and lip-reading has been consistently followed in Germany, so that it was long called the German method. In France during these earlier years the deaf were taught by signs and the finger alphabet, so that this was called the French method. During the first half century of the formal instruction of the deaf in this country, from the second decade of the nineteenth century to the seventh, the French method was followed entirely. Credit for the introduction of the oral (German) method into the United States belongs to Miss Harriet B. Rogers who in 1864–65 taught in this way Jeanie, the deaf daughter of Mr. Henry Lippitt, with the encouragement of Mrs. Lippitt who had already begun work with the little girl under the advice of Dr. Samuel G. Howe. In June, 1866, Miss Rogers opened at Chelmsford, Massachusetts, what is generally considered the pioneer pure oral school in this country. The following year the Clarke School was

opened at Northampton, Miss Rogers' School was merged with it, and she became its principal.

The growth of the oral movement has not been rapid but it has been steady and sure. Accurate statistics of the number of pupils taught speech and lip-reading do not begin until 1884, when 2,041 out of a total of 7,482 children in schools for the deaf were taught speech, or a percentage of 27.2. Many of these, however, were taught by the "combined method," that is, signs and the finger alphabet were used as well as speech and lip-reading. In 1892 the statistics become more definite, when 1,581 out of 7,940, or 19.9 per cent., were taught wholly or chiefly by the oral method. In 1913 the percentage of those so taught had increased to 65.1, that is, 8,723 out of 13,391. The number taught speech and lip-reading by all methods in 1914 was 10,481 out of 13,513, or 77.6 per cent. Those statistics tell the story of a gratifying advance.

The instruction in lip-reading for congenitally or totally deaf children goes hand in hand with their instruction in speech and language. The adult who becomes deaf after speech and language have been acquired has a much easier task to accomplish in learning the art of lip-reading. It is not unusual to find those who have picked it up by themselves without any definite instruction; still the art at its best is difficult enough for the great majority to require the help of study and practice. Many slightly deaf persons, however, those who hear the sound of the voice though not the words of a speaker, could greatly help themselves by forming the habit of watching the mouth; in this way what they hear is supplemented by what they see, for some of the sounds that are hard to hear are easy to see, and *vice versa*, and thus each sense helps the other.

Lip-reading is an art. The teaching of it, therefore, requires the imparting of skill to the pupil rather than of knowledge. To develop skill in lip-reading both the eyes and the mind must be trained. The eyes must be trained to see the speech movements as accurately and quickly as possible, and the mind to interpret into thought what the eyes see. Mrs. Alice Mary Porter, a skillful teacher of lip-reading, defined it as "watching the mouth of a person who is speaking, and understanding the thought so conveyed." Unfortunately spoken language, the medium for expressing thought, which throughout the history of the race has been developed for the needs of the sense of hearing, is imperfectly adapted to the requirements of lip-reading. This is evident at a glance from the many sounds that are formed within the mouth or even in the throat and from the fact that the difference between vocal and non-vocal consonants is invisible to the eye. No eye can be so trained as to be infallibly accurate in the perception of the speech movements; it follows therefore that the mind must be trained to act synthetically, to grasp the thought as a whole from the parts which the eye sees. The psychology of lip-reading is in fact of even greater importance than its physiology. This will be clearer as the physiological principles underlying the art are more fully developed.

The lip-reader who has already acquired speech and language is interested not in how the organs form the sounds but in how they reveal the sounds. In some instances the revealing movement is the same as the formative, but in others the revealing movement may be quite different. In the latter case the movements are subject to more or less variation according to the speaker. In the classification given below, the revealing movements, not in the formative, are described.

Vowels.—Vowels are formed fundamentally by the tongue, but to the eye they are revealed chiefly by the lips. There are three groups of vowel movements: (1) Those in which the lips tend to be rounded or *puckered;* (2) those in which the lips are lax or *relaxed;* and (3) those in which the lips at the corners tend to be drawn back or *extended.* Under each of these three groups are to be found in colloquial utterance three widths of opening between the upper and lower lips, a narrow opening, a medium and a wide.

Puckered Vowels.—(1) Long *oo,* as in "coon;" lips puckered with the narrow opening. (2) Short *oo,* as in "good;" lips puckered with the medium opening. (3) Broad *aw,* as in "cawed;" lips slightly puckered with the widest opening of the puckered vowels.

Relaxed Vowels.—(1) Short *i,* as in "kid;" lips relaxed with the narrow opening. (2) Short *u,* as in "cut;" lips relaxed with the medium opening. (3) Broad *a*(ah), in "cart;" lips relaxed with the widest opening of the relaxed vowels.

Extended Vowels.—(1) Long *e,* as in "keen;" lips extended with the narrow opening. (2) Short *e,* as in "get;" lips extended with the medium opening. (3) Short *a,* as in "cat;" lips extended with the widest opening of the extended vowels.

These are the fundamental vowel movements; variant sounds and diphthongs may all be classified under them or their combinations.

Consonants.—The revealing movements of the consonants are divided into three groups: (1) Consonants revealed by the *lips;* (2) consonants revealed by the *tongue;* and (3) consonants revealed by the *context,* being seen by the mind rather than the eye.

Consonants Revealed by the Lips.—(1) *P, b, m,* as in "pie," "by," "my;" the lips open from a shut position. (2) *F, v,* as in "few," "view;" the center of the lower lip touches the upper teeth. (3) *Wh, w,* as in "what," "wet;" the lips open from a puckered position. (4) *R,* before a vowel, as in "reef;" the corners of the lips are drawn or puckered. (5) *S, z,* as in "saw," "zone;" the corners of the mouth tend to be tightened or drawn. (6) *Sh, zh, ch, j,* as in "sham," "azure," "chap," "jam;" the lips are thrust forward or projected.

Consonants Revealed by the Tongue.—(1) *Th,* as in "thin;" the point of the tongue shows between the teeth. (2) *L,* as in "leaf;" the point of the tongue touches the upper gum. (3) *T, d, n,* as in "tie," "die," "nigh;" the flattened tongue touches the upper gum.

Consonants Revealed by the Context.—(1) Y, as in "you;" formed by the tongue, but in colloquial speech the movement is too slight and too rapid to catch. (2) *K,* hard *g, ng,* as in "kin," "go," "rang;" sometimes a contraction of the muscles just above the larynx may reveal these sounds, but usually they are too obscure for the eye to see.

These are the fundamental consonant movements; variations and double consonants may be classified under them or their combinations.

The aspirate, *h,* as in "hat," has no movement, but takes the appearance of the vowel following it.

The difficulties for the eyes to overcome in the study of the movements are chiefly two: first, the obscurity of many of the movements, and second, the rapidity of their formation. The obscurity has been indicated by the descriptions of the movements given above, but this obscurity is further enhanced by the fact that no two mouths are just the same. The average length of time for each sound formation in colloquial utterance is one-twelfth to one-thirteenth of a second, though some are slower and some quicker; but twelve to thirteen movements per second are more than the mind through the eye can consciously perceive. With such difficulties as these, the wonder is that anyone can read the lips at all. Eye-training alone can never eliminate them, though it can lessen them in a measure. The method of learning the movements involves, first, a clear conception of their characteristics, and second, much practice in the observation of them. The aim of the practice is to make the recognition of the sound movements a subconscious

act, that is, by much repetition to make the association of certain movements with certain sounds a habit, something which we do without the consciousness of effort or concentration. Such habits of association can be formed only by repetition in practice; when formed, the mind is left free to concentrate on the thought of the speaker, not on how he is forming his speech but on what he is saying.

The method of practice for the movements should aim always to study or see them in words or sentences, not formed singly by themselves. Sounds pronounced singly tend to be exaggerated or mispronounced; moreover one movement often modifies decidedly the appearance of another connected with it in a word. Each movement should therefore be studied in all possible combinations. The method should also aim to see the movements as the words are pronounced quickly. Accuracy, in so far as possible, is of course to be striven for, but accuracy alone is not sufficient. The quickness of natural speech makes it imperative that the eyes be trained to be quick, and that all forms of exercise be practised as rapidly as the ability of the pupil will allow. Eyes trained in this way will render very material help to the mind in reading the lips. Though no two mouths are just the same, all mouths, like all handwritings, conform to certain general laws, and for not a few of the movements a very reliable accuracy can be attained. The harder movements must frequently be left to the mind to supply according to the context.

Another difficulty arising from the movements, which no amount of eye-training can ever overcome, is to be found in the large body of homophenous words—words that look very similar or alike. Such words are chiefly due to the fact that the sounds in several consonant groups have the same visible movements. The consonant sounds which have homophenous formations are: (1) *p, b, m, mp;* (2) *f, v;* (3) *wh, w;* (4) *s, z;* (5) *sh, zh, ch, z,* (soft *g*); (6) *t, d, n, nt, nd;* (7) *k, g, ng, nk.* Thus the words "few" and "view" appear exactly the same when the words are spoken naturally. These words must be distinguished not by their formation, but by the thought or context in which they are used. The problem is similar to that which confronts those who are not deaf when called on to distinguish between such homophonous, or like-sounding, words as "seem" and "seam," "rough" and "ruff," "rose," "rows," and "roes." But the homophenous words far outnumber the homophonous, and by just so much is the lip-reader's problem more difficult of solution. For the two words, "few" and "view" the difficulty is almost *nil*—it is hard to conceive of a sentence in which, if the rest of the sentence is understood, one of these words could be mistaken for the other. It is easy, for example, to substitute the right word in "There is a beautiful ——— from my window," or in, "I have only a ——— minutes to spare." But when we come to such a group as—pet, pen, pent, penned, bet, bed, bent, bend, met, men, meant, mend—in which there are twelve homophenous words, and when we consider also that, as long *a*, has practically the same appearance as short *e*, the further homophenous group of thirteen words —pate, paid, pane, pain, paint, bait, bayed, bane, mate, made, maid, mane, main—should really be added to it, making a group of twenty-five words which can be told apart by the lip-reader only by their connection in the context, it is evident that the difficulties are much greater than the difficulty a hearing person might have with any conceivable group of homophonous words. However, the problem is not so serious as it sounds; common sense solves it frequently in actual experience, and proper mind-training with exercises based on the different homophenous groups helps greatly in its solution.

In general the problems caused by the very difficult movements, by variations of the movements, and by similarities of movements and words, must be met by training the mind rather than the eyes. Although it is not impossible for the eyes to see each and every movement, it is possible for the mind to grasp a complete impression without even the consciousness that the "mind's eye," so to speak, has done so much of the work. The chief difficulties in the way of the mind in lip-reading may be indicated by describing that type of mind which is uniformly most successful, and that is a mind quick to respond to impressions, or quick in its reaction time, and a mind in which the synthetic qualities are dominant. The difficulties, then, are to overcome the opposite conditions or tendencies, and the aim is to develop the mind to the utmost along the line of these favoring conditions.

Fortunately the human mind naturally takes in thought as a whole and not piecemeal, one word at a time. The hearing person does not think of each word spoken, but of the thought conveyed. When we read the printed page, if we tried to think about each word separately, we would defeat our purpose. One fairly proficient in a foreign language, can understand what is said to him or what he reads without knowing the meaning of every word. The baby, learning to talk, also understands in this way. Correct understanding of an idea is possible, therefore, without a word-for-word accuracy.

Fortunately, also, thought is quicker than speech. Tests with a selected memorized passage show that it requires less than half the time to think of it word by word than to read it aloud at natural speed. Not only is thought quicker than speech; thought skips, thought looks ahead and anticipates.

The method of mind-training should aim to develop the power of grasping thoughts as wholes, and to avoid strictly anything that will enhance the opposite tendency of demanding verbal accuracy before anything is understood at all. Minds of the latter type are literal, analytical, unimaginative. Yet very few are altogether of this kind; almost everyone, however analytical, has some synthetic powers, some ability of putting things together, of constructing the whole from the parts, and of quick intuition. It is by developing these powers that real success in lip-reading can be attained, and it is by working along these lines that the surest way is found in the end to the understanding of every word. When these synthetic and intuitive powers are found already highly developed, the "natural-born" lip-reader is the result. No teacher can do it all; the pupil must cooperate, and especially must the lip-reader seek the widest possible experience in reading the lips of relatives, friends, and acquaintances if he would crown his efforts with complete success.

Two objections to lip-reading are occasionally heard: (1) That it is too great a strain on the eyes, and (2) that, by relieving the ears from hearing, there is a tendency to deterioration in hearing from lack of exercise.

The strain upon the eyes at first is truly no small one; but it happens repeatedly that those who complain of eye-strain during their early lessons, later never think any more about it. If the lip-reader is careful from the outset to cease using the eyes at the first symptom of tire, no injury can result and gradually the eyes will be able to do more and more.

The objection in regard to the deterioration of hearing is the reverse of true. Dr. Albert Barnes, in the *Dietetic and Hygienic Gazette,* of October, 1909, said: "People with ear-strain should spare the hearing as much as possible, and, instead of straining the ear to catch what is said, they should watch the lips more. In other words, the eyes should be called upon to help the ears." Moreover, lip-readers who have enough hearing to hear the sound of the voice should be encouraged to use ears and eyes in fullest cooperation, one helping the other. Under such circumstances, and also in view of the fact that the ear involuntarily gets exercise with every sound

that comes to it, whether the strain to hear is made or not, no possible harm can be done by lip-reading.

What degree of skill can a lip-reader expect to attain? How long does it take? These are natural questions but cannot be answered categorically. What some can attain in three months, others cannot acquire short of a year; and the highest degree of skill, as in any art, is open only to the few. But three lessons a week for three months, will with most pupils, give a very satisfactory and practical skill. Some lip-readers successfully understand the actors at the theater; more can understand a lecture or a sermon. In business, though lip-reading may not be an infallible resource, it may be an invaluable aid; and, with very few exceptions, such a degree of skill is possible to everyone as to make home life and social friendships a joy once more. Lip-reading can never do all that good ears ought to do, but what it can do is almost a miracle. It is not a cure for deafness, nor is it even a cure for all the ills of deafness; but from some of the worst ills it is a true alleviation. It takes first place on the majority of occasions over all mechanical devices. For those completely deaf, or so deaf as to make mechanical devices out of the question, lip-reading is the only resource. For those whose deafness still allows them to hear the sound of the voice, it obviates the necessity of using these more or less cumbersome and inconvenient contrivances. Even at times when these devices can be used to advantage, watching the lips helps to make them more useful and more reliable. Under any circumstances, lip-reading has the power to make deafness of whatever degree much easier to bear. EDWARD B. NITCHIE.

Liquores.—Liquor (meaning a solution) is the pharmacopœial term for any aqueous solution of non-volatile substances (except syrups, infusions and decoctions). The United States Pharmacopœia contains twenty-five of these liquores (solutions) as follows:

Liquores (U. S. P.).	Composition.
LIQUOR ACIDI ARSENOSI (Solution of arsenous acid).	Arsenic trioxide, 10; diluted hydrochloric acid, 50; distilled water, to 1,000.
LIQUOR AMMONII ACETATIS (Solution of ammonium acetate).	Ammonium carbonate, 5; diluted acetic acid, 100.
LIQUOR ANTISEPTICUS (Antiseptic solution).	Boric acid, 20; benzoic acid, 1; thymol, 1; eucalyptol, 0.25, oil of peppermint, 0.50; oil of gaultheria, 0.25; oil of thyme, 0.10; alcohol, 250; purified talc, 20; water, to 1,000.
LIQUOR ARSENI ET HYDRARGYRI IODIDI (Solution of arsenous and mercuric iodides).	Arsenous iodide, 10; red mercuric iodide, 10; distilled water, to 1,000.
LIQUOR CALCIS (Lime water; solution of calcium hydroxide).	Lime, 12; distilled water, *q.s.*
LIQUOR CHLORI COMPOSITUS (Compound solution of chlorine, chlorine water).	Potassium chlorate, 5; hydrochloric acid, 18; distilled water, to 1,000.
LIQUOR CRESOLIS COMPOSITUS (Compound solution of cresol).	Cresol, 500; linseed oil, 350; potassium hydroxide, 80; water, to 1,000.
LIQUOR FERRI CHLORIDI (Solution of ferric chloride).	Iron wire, 125; hydrochloric acid, 680; nitric acid, and distilled water, each to 1,000.
LIQUOR FERRI ET AMMONII ACETATIS (Solution of iron and ammonium acetate).	Tincture of ferric chloride, 40; diluted acetic acid, 60; solution of ammoninm acetate, 500; aromatic elixir, 120; glycerin, 120; water, to 1,000.
LIQUOR FERRI SUBSULPHATIS (Solution of ferric subsulphate).	Ferrous sulphate, 675; sulphuric acid, 65; nitric acid and distilled water each to 1,000.
LIQUOR FERRI TERSULPHATIS (Solution of ferric sulphate).	Ferrous sulphate, 500; sulphuric acid, 96; nitric acid and distilled water, each to 1,000.
LIQUOR FORMALDEHYDI (Solution of formaldehyde).	Formaldebyde not less than 37 per cent., by weight in water.
LIQUOR HYDRARGYRI NITRATIS (Solution of mercuric nitrate).	Red mercuric oxide, 40; nitric acid, 45; distilled water, 15.
LIQUOR IODI COMPOSITUS (Compound solution of iodine).	Iodine, 5; potassium iodide, 10; distilled water, to 100.
LIQUOR MAGNESII CITRATIS (Solntion of magnesium citrate).	Magnesium carbonate, 15; citric acid, 33; syrup of citric acid, 60; potassium bicarbonate, 2.5; water, *q.s.*
LIQUOR PLUMBI SUBACETATIS (Solution of lead subacetate).	Lead acetate, 180; lead oxide, 110; distilled water, to 1,000.
LIQUOR PLUMBI SUBACETATIS DILUTUS. (Dilnted solution of lead subacetate).	Solution of lead subacetate, 40; distilled water, to 1000.
LIQUOR POTASSII ARSENITIS (Solution of potassium arsenite).	Arsenic trioxide, 10; potassium bicarbonate, 20; compound tinctnre of lavender, 30; distilled water, to 1,000.
LIQUOR POTASSII CITRATIS (Solntion of potassium citrate).	Potassium bicarbonate, 8; citric acid, 6; distilled water, to 100.
LIQUOR POTASSII HYDROXIDI (Solution of potassium hydroxide).	Potassium hydroxide, 60; distilled water, 940.
LIQUOR SODÆ CHLORINATÆ (Solution of chlorinated soda).	Monohydrated sodium carbonate, 65; chlorinated lime, 90; water, to 1,000.
LIQUOR SODII ARSENATIS (Solution of sodium arsenate).	Exsiccated sodium arsenate, 1; distilled water, to 100.
LIQUOR SODII HYDROXIDI (Solution of sodium hydroxide).	Sodium hydroxide, 56; distilled water, 944.
LIQUOR SODII PHOSPHATIS COMPOSITUS. (Compound solution of sodium phosphate).	Sodium phosphate, 1,000; sodium nitrate, 40; citric acid, 130; distilled water, to 1000.
LIQUOR ZINCI CHLORIDI (Solution of zinc chloride).	Zinc, 240; hydrochloric acid, 840; nitric acid, 12; precipitated zinc carbonate, 12; distilled water, to 1,000.

R. J. E. SCOTT.

Liquorice Root.—See *Glycyrrhiza.*

Lisping.—See *Speech, Defects of.*

Lissner's Mineral Spring.—Lewis and Clark County, Montana.

POST-OFFICE.—Helena. Hotels.

This spring is located in Helena, about three hundred yards from the International Hotel, at the corner of Main and State streets. The spring gushes from the foot of a granite mountain, three hundred feet high, at the rate of about 20,000 gallons a day. The following analysis has been made:

Solids.	Parts per 100.000.
Calcium hydrocarbonate	23.10
Magnesium hydrocarbonate	11.40
Sodium sulpbate	5.70
Potassium chloride	2.10
Calcium nitrate	.58
Alumina	.04
Iron oxide	.07
Silica	1.35
Total	44.34

The water is free from organic or vegetable matter. It is used commercially and is recommended for indigestion, constipation; liver, kidney, and bladder troubles.

EMMA E. WALKER.

Lissoflagellata.—An old term used to distinguish those protozoans without a collar from the *Choanoflagellata.* This distinction is now believed to be unimportant. See *Protozoa.* A. S. P.

Lister, Joseph.—Born at Upton, Essex, England, April 5, 1827, and educated in medicine at the London University from which he was graduated in 1852. He passed his early professional life in Scotland, being first house surgeon to Syme, then assistant surgeon to the Royal Infirmary, Edinburgh (1856), Regius professor of surgery at Glasgow University (1860–1869), and professor of clinical surgery at Edinburgh University (1869–1887). In the latter year he was called to London as professor of clinical surgery at King's College and retained this chair until 1893 when, broken by the death of his wife, a daughter of James Syme, the celebrated Scottish surgeon, he retired from active work. It was soon after he went to the University of Glasgow, in 1860, that Lister devised his system of antiseptic surgery, to which he was led by a study of Pasteur's work on fermentation and putrefaction. He applied to animal tissues the principles enunciated by Pasteur in the case of plant derivations, showing that suppuration

Fig. 3742.—Joseph, Baron Lister.

and gangrene were of the same nature as fermentation and putrefaction, and reasoned that, as fermentation could be avoided by preventing the access of germs, so might wounds be kept from suppurating by the same means. It was characteristic of the modesty and humility of this great man that he made no claim for himself beyond gently asserting that he had applied the discoveries of Pasteur to surgery; and when it was found that the spray and other antiseptic measures which he had introduced were not necessary he yielded at once, accepting without demur abandonment of his own methods and the adoption of a new system. He saw that the underlying principle was the same and no pride of opinion blinded him to the superiority of the later developments of asepsis.

Even had Lister not made his grand discovery, he would have ranked as a surgeon of no mean order. He was a careful operator, a facile writer, and a good teacher. He was one of the first to undertake osteotomy for the correction of deformities of the legs and to wire the bones in the treatment of fracture. He was awarded the medal of the Royal Society in 1880 and received the prize of the French Academy in 1881. In 1883, he was made a baronet and in 1897 was raised to the peerage, taking the title of Baron Lister. He died on February 11, 1912.

Lister wrote no extended treatises but published a large number of lectures, essays, and occasional papers read before local, national, and international medical societies, and also contributed to several large systems of surgery. On the occasion of his eightieth birthday those papers were collected and published in two volumes by the Clarendon Press. These volumes were carefully edited and contained not everything written by him but only that which he believed would have a lasting interest and would serve as documents of use in the history of modern surgery. T. L. S.

Liston, Robert.—Born at Ecclesmachan, Scotland, October 28, 1794. In 1810 he began the study of anatomy at Edinburgh under Dr. John Barclay. In 1818 he became a lecturer on anatomy and surgery in the Edinburgh School of Medicine. In 1827 he was elected one of the Surgeons of the Royal Infirmary. In 1835 he was chosen Professor of Clinical Surgery in University College, London, and this appointment he held until the time of his death, which occurred in London December 7, 1847.

Liston was the auther of two books: "The Elements of Surgery," 1831–1832; and "Practical Surgery," 1837. As a surgeon he was fertile in expedients, and a bold, skilful and rapid operator. He made several improvements in methods of amputation and in the dressing of wounds. A. H. B.

Lithium.—I. General Medicinal Properties of Compounds of Lithium.—As lithium is closely allied to potassium chemically, so its salts exert practically the same kind of physiological influence as the corresponding salts of potassium. The only substantial differences are, *first*, the purely chemical one that lithium forms with *uric acid* a salt much more soluble than the corresponding potassium compound; and, *secondly*, that clinically, in lithemia and gout, speedier relief seems sometimes to follow from medication with salts of lithium than with those of potassium. But since the results reported have followed the employment of the remedy with the preconceived idea that such results must follow from theory, the clinical superiority claimed for lithium should be received with caution. There is no doubt, however, that the lithium salts are at least as efficient as those of potassium, but then they have the disadvantage of being more expensive.

II. The Compounds of Lithium Used in Medicine.—These are the *carbonate*, *citrate*, *bromide*, *benzoate*, and *salicylate*. The first two only will be considered in this place. For the others, see respectively *Bromides*, *Benzoic Acid*, and *Salicylic Acid*.

Lithium Carbonate: Li_2CO_3. The salt is official in the United States Pharmacopœia as *Lithii Carbonas*, Lithium Carbonate. It is a light, white powder, permanent in the air, odorless, having an alkaline taste and an alkaline reaction. It is soluble in seventy-five parts of water at 25° C. (77° F.), also in 140 parts of boiling water; much more soluble in water saturated with carbon dioxide, insoluble in alcohol. Lithium carbonate behaves in a general way like potassium carbonate, except that, because of its feeble solubility in water, it is not locally so irritant. As an alkali it is remarkably potent, because of its chemically low combining number, and hence great saturating power in the neutralization of acids. Its use so far has been mainly as a substitute for potassium alkaline preparations in internal medication in gout and lithiasis. It is given in doses of from 0.30 to 1 gram (gr. v.–xv.), several times a day, best administered in some effervescing water, since it is freely soluble in such liquids.

Lithium Citrate: $Li_3C_6H_5O_7$. The salt is official in the United States Pharmacopœia as *Lithii Citras*, Lithium Citrate. It is a white powder, deliquescent on exposure to air, odorless, having a slightly cooling, faintly alkaline taste and a neutral reaction. It dissolves in about two parts of water at 25° C. (77° F.), and in 1.5 parts of boiling water; almost insoluble in alcohol or ether. It should be kept in well-stoppered bottles. Lithium citrate bears the same relation, in medicinal behavior, to the carbonate that potassium citrate does to potassium carbonate. It

is pleasanter to the taste and more grateful to the stomach than the carbonate, but undergoes transformation to the carbonate after absorption into the blood. Constitutionally, therefore, it is the equivalent of the carbonate, and it is used internally in gout and urie-acid diathesis. The salt, it must be remembered, is not alkaline while under its own form, and hence would be useless as a local alkali for the direct neutralization of acid. The pharmacopœial dose is seven and one-half grains (0.50 gram).

A pleasant way to administer the citrate is to prescribe the official preparation entitled *Lithii Citras Effervescens*, Effervescent Lithium Citrate. This preparation is a powder composed of the admixture, in dry powder, of 5 per cent. of lithium citrate, 57 per cent. of sodium bicarbonate, 30 per cent. of tartaric acid, and 19.5 per cent. of citric acid. The dose is a teaspoonful of the powder, to be taken in water and drunk during effervescence.

Edward Curtis.
R. J. E. Scott.

Lithium=diuretin.—See *Uropherin*.

Lithobius.—A genus of myriapods, which includes the common flat brown centipedes found under logs and stones. *L. forficatus* and *L. melanops* have been found in the nasal cavities of men. See *Insects, Parasitic*. A. S. P.

Litholapaxy.—(Rapid Lithotrity with Evacuation), from λίθος, a stone, and λάπαξις, evacuation.

This operation, which has superseded the old method of lithotrity, and which successfully disposes of stones that could formerly be dealt with only by lithotomy, has been before the world for thirty-six years.

In January, 1878, Prof. Henry J. Bigelow[1] published his first paper introducing this procedure to the medical profession, and it was at once enthusiastically adopted by the surgeons of all countries.

The writer's association with Professor Bigelow in this branch of surgery lends authority to the description of the operation which follows:

Before the year 1878 lithotrity was performed by short sittings (a few minutes each), with intervals of several days between them. The débris, more or less finely pulverized, was passed with the urine.

If the expulsive power of the bladder was good, the voidance of the fragments was usually successfully accomplished. When, however, the bladder had lost its power, or when, owing to some obstruction, it could not thoroughly empty itself, the discharge of the fragments after crushing was an extremely uncertain matter.

Moreover, in a certain proportion of cases, especially when the stone was a hard one, or when the bladder was much inflamed, the crushing was followed by serious symptoms, with marked increase of the bladder inflammation, which not only put a stop to further crushing, but frequently went on from bad to worse and ended fatally.

This aggravation of symptoms after lithotrity was ascribed largely to the irritation of the bladder wall by the instruments; and operators tried to avoid trouble by making the sittings short, and by extreme gentleness in manipulation.

Sir Henry Thompson, then the English authority upon the subject of lithotrity, had recently stated it as his opinion that a sitting should not be prolonged beyond two or three minutes, and that stones requiring more than three or four sittings for their removal were not advantageously within the province of lithotrity.

Prior to this year (1878) there had been various attempts to remove by suction portions of the débris after crushing, and Clover's apparatus, consisting of a catheter and bulb, was sometimes used to aid a bladder in freeing itself. Such efforts at evacuation were, however, regarded as introducing special dangers into the operation of lithotrity, and writers upon the subject were practically unanimous in thinking that any serious attempt in this direction should be dispensed with, if possible.

In 1875, Professor Bigelow, having devised a more thorough evacuator than those previously in use, tried the plan of operating by a long sitting under ether, with the object of crushing the stone and completely removing the fragments at one operation.

The success of the first cases so treated showed that the previous dread of instrumentation had been to a great degree groundless, and that the presence of sharp angular fragments in the bladder after an operation was a source of more serious danger than that consequent upon the prolonged and skilful use of instruments which resulted in the complete removal of the stone.

These cases showed that, contrary to previous belief, the thorough evacuation of a large stone at one sitting could be accomplished without special danger, and in consequence of this success Professor Bigelow went on to perfect the apparatus which he described in his paper, published in January, 1878, and which he has since that time still further improved, until it has reached the forms which will be described farther on.

The operation of litholapaxy may be divided into two acts: (1) The comminution of the stone; (2) the evacuation of the fragments. We will first consider the instruments concerned in pulverizing the stone.

Lithotrites.—As has been said, lithotritists were formerly possessed with the idea that the bladder was an extremely sensitive organ, prompt to resent any irritation from the use of instruments, and that, therefore, only small stones, not requiring a great amount of manipulation for their comminution, should be crushed.

This belief, together with their failure to recognize the full size of the urethra, led the operators of those days to use instruments smaller and less powerful than the conditions allow, and than those which are now readily and safely employed, when the size and consistence of the stone make their use desirable.

The lithotrite now to be described was devised by Professor Bigelow. The modifications in its form are designed to enable it to meet the needs of the new operation.

It is made in various sizes (corresponding to Nos. 25, 27, and 30 of the French catheter scale), of which the larger are very strong, and, though rarely necessary, enable the operator to deal with larger and harder stones than could be disposed of with the smaller instruments.

The *handle*, which is of hard rubber, is egg-shaped, and gives a better hold with more power than could be attained with the old wheel. By giving a full grasp to the hand it is far more comfortable and less fatiguing in a long operation.

The Lock.—Immediately below the handle is a revolving cylinder cap, which is attached to the screw guard and closes the lock by a mere rotation with the fingers of the right hand while it is grasping the handle.

So far as I know, this is the only lithotrite in which the lock is constantly under the control of the right hand. This arrangement gives the surgeon the great advantage of being able to lock and unlock the instrument indefinitely, and even to complete the operation without disengaging the hold of either hand. It thus saves time and strength, and lends greater accuracy to the manipulations.

The Blades.—In the female blade the rim is low and sharp, while the floor, especially at the heel, is high. A fragment readily falling upon this blade is firmly held by the rim while it is crushed.

The male blade is provided with a series of alternat-

ing notches, which expel the débris at the sides and prevent impaction.

In most lithotrites the dust is seriously impacted in the heel of the instrument. This difficulty is here met by raising the floor at the heel, so that no dust can lodge there. A large spur in the heel of the male blade also drives the débris through a corresponding slot in the female blade.

Fig. 3743.—Handle and Lock of Lithotrite Partly Open, showing the Cylinder Cap in connection with the Handle. The screw guard is seen as two rods alongside of the screw, reaching from the revolving cap to the cap of the lock. These slide through notches in the cap of the lock, and so connect it with the revolving cap that a twist of the latter turns the lock and so wedges up the screws.

The instrument is thus self-clearing and does not clog, so that when once introduced it can be continuously operated as long as fragments can be found to crush. Also, when it is withdrawn the jaws are not held open with impacted fragments of stone to lacerate the urethra. A good-sized instrument, fairly shut, occupies no more room in the urethra than a smaller one which must be withdrawn while partly open to be cleared of its débris.

In a long operation this avoidance of the injury which would be caused to the urethra by the frequent withdrawal of a clogged instrument is a matter of the greatest importance.

The end of the female blade is bent over so as to offer a blunted extremity, which, as may be seen in Fig. 3745, slips along the roof of the urethra and is much less likely to injure it than was the sharp toe of the old lithotrites. This form does not interfere in the least with the catching of fragments in the jaws.

In the lithotrite that has been described the sharp rim upon the female blade is very efficient in holding the fragment which is being crushed. Occasionally, however, in spite of this, the stone constantly slips from between the blades. When this occurs the open lithotrite should be used.

This instrument adds to the usual sharp rim another even sharper at the edge of the opening which the male blade traverses. This arrangement of the fenestrated blade makes the operation much more agreeable to the surgeon. The fragment rarely slips, and as the blades approach each other the force required is constantly diminished instead of increasing, as it does when the solid blade is used.

The inner edge can be quite sharp, as it is prevented from ever coming in contact with the mucous membrane by the width of the broad and flat female blade. It is essential, however, that the male blade should pass absolutely through the female blade and occupy the same level at the outlet; for quite a small portion of the walls of the opening will sometimes so support a fragment not wholly extruded that it will cling to the instrument and be dragged out, and so lacerate the urethra.

Evacuator.—This instrument may be, in general, described as consisting of a tube, and elastic bulb, and a receptacle for the fragments.

Tube.—For convenience of description the tube may be divided into two parts—the movable part, or catheter, and the fixed part, which enters the bulb and is attached to it by a bayonet joint.

Catheter.—A straight tube offers the least possible resistance to the passage of fragments, and is therefore the best. A slight curve at the extremity sometimes facilitates the introduction of the tube in a difficult case.

The receiving orifice should be on the front of the extremity, with a thickened rounded edge, to enable it to slide smoothly along the urethra. If the side walls of this orifice be removed a little, it gives a snout-like extremity, which resembles the head of a shark, the orifice occupying the position of the shark's mouth.

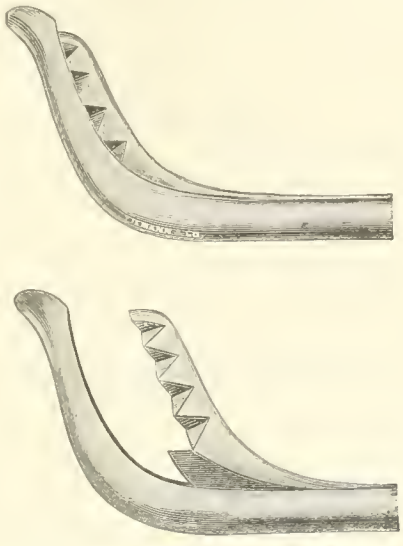

Fig. 3744.—Blades of Lithotrite, Open and Shut.

This form is advantageous; and in introducing such a straight tube the tip should be insinuated through the triangular ligament by rotation. The orifice should not be larger than the caliber of the tube, as it would then admit fragments which would be wedged higher up.

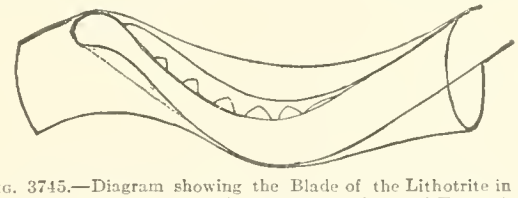

Fig. 3745.—Diagram showing the Blade of the Lithotrite in the Urethra, Illustrating the Advantage of the Blunted Extremity.

At the upper end of the catheter tube is a projecting wing, which facilitates the handling of the instrument. This wing is on the same side of the tube with the orifice, and is therefore a guide to its position.

The fixed portion of the tube connecting the catheter with the exhaust bottle extends obliquely upward to the center of the bulb.

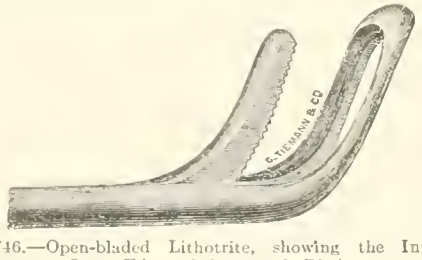

Fig. 3746.—Open-bladed Lithotrite, showing the Inner and Outer Edges of the Female Blade.

This tube is for convenience provided with a stopcock just outside of the bulb, and if a second cock is attached to the upper end of the catheter, the patient and bed clothing can be kept dry when coupling and uncoupling these tubes.

It is, however, the portion of this tube which is within the bulb that is of especial importance. This part, which is simply a prolongation of the catheter up into the bulb, is perforated all around with small holes, the aggregate area of which is larger than the opening at the end of the tube.

When suction is applied the fluid from the bladder, mixed with fragments, rushes up through this tube

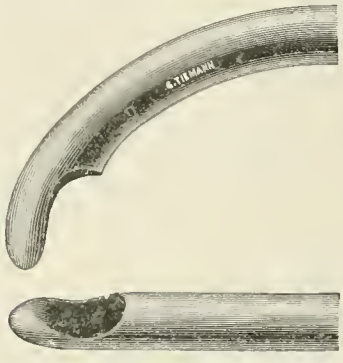

Fig. 3747.—Extremities of a Curved and a Straight Tube showing the Opening.

into the bulb. When pressure is now made, and the water is forced back to the bladder, the greater part of it goes through the perforations in the tube, which afford not only the shortest road, but by virtue of their great area also the largest and freest outlet.

Thus the fragments enter the bulb easily, but are prevented by the strainer action of this tube from returning to the bladder. The simplicity of this contrivance speaks for itself. There are no valves to get out of order, and if any mucus clogs the lateral holes it can be easily removed.

The fragments which are thus caught and retained in the bulb naturally gravitate to the bottom of it where they are received in the glass ball, or reservoir, which can be readily removed and emptied.

At the top of the bulb is an opening provided with a stopcock, to which a hose can be attached. Through this any air which finds its way into the apparatus can be at once expelled, and the amount of water in the bulb and bladder can be easily and quickly altered during evacuation without disconnecting the instrument—a matter of great importance, as an overtense and a too-empty bladder are both to be avoided. One of the most important additions to the evacuator was the brace uniting the metal collar of the catheter with that of the glass receiver. This so steadies the catheter that it does not feel the movement of the bulb when compressed.

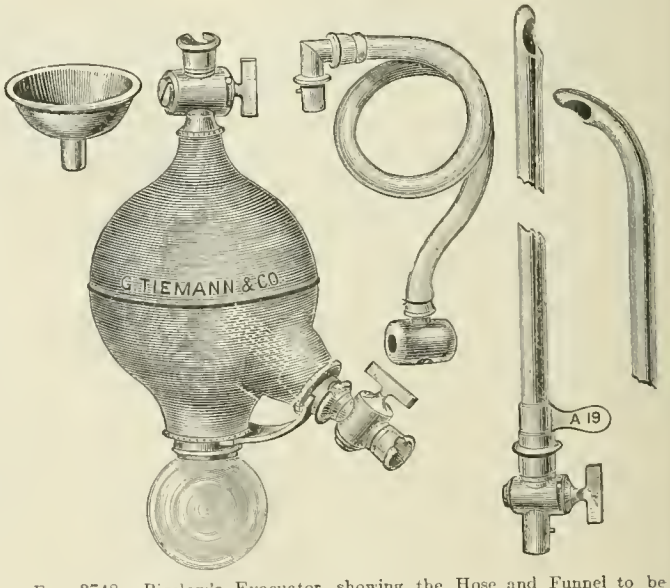

Fig. 3748.—Bigelow's Evacuator, showing the Hose and Funnel to be attached to the Top of the Bulb. It consists of an elastic bulb, with a glass receiver below and a stopcock at the top. Within the bulb, and open at the end, is a tube strainer to prevent the return of débris. To this tube, outside of the bulb, is attached a stopcock, which couples with another stopcock attached to the upper end of the catheter. Below there is a metal brace between the collar of the glass receiver and that of the catheter to steady the latter. The bulb forms a concentric handle to the catheter.

The Operation.—The presence of a stone having been established, a large steel sound may be passed down through the urethra to make sure that there is no stricture or other obstruction. If a stricture is found it may be rapidly dilated with large sounds, or urethrotomy may be done. A narrow meatus may be cut.

The urine should then be drawn with a catheter, and enough boric-acid solution should be introduced gently to distend the bladder and so keep its walls out of harm's way during the crushing of the stone. From six to ten ounces is usually a proper quantity.

An elastic-rubber tube may then be tied lightly around the penis close to the corona glandis, to prevent the escape of water alongside of the instruments. This serves the double purpose of keeping a known quantity of water in the bladder and of preventing the wetting of the patient and bed.

Before each introduction of an instrument the urethra should be filled with liquid vaseline, from a syringe, in order to lessen injurious friction as far as possible.

To introduce the lithotrite properly the point should be carried with considerable gentleness through the constriction made by the rubber tube, and it then slips without difficulty through the movable urethra. After the beak passes below the pubis the handle should be brought to a vertical position, and the instrument will then drop, almost without assistance, by its own weight, until the point rests just in front of the triangular ligament. Traction upon the penis now effaces the depression made by the extremity of the instrument in the bulbous urethra, and if the handle is then brought down gently between the thighs of the patient, and at the same time the point is advanced in the axis of the body, the instrument enters the bladder.

The places where difficulty may be met in a normal urethra are at the triangular ligament and at the prostate.

The point of the instrument may catch on the upper or lower edge of the comparatively rigid opening in the triangular ligament. If the handle is depressed before the back of the instrument has been carried vertically down as far as it will go toward the rectum, the point is likely to catch against the upper edge of this opening; while, on the other hand, if the instrument is pushed too forcibly toward the sacrum, the lax, bulbous urethra is depressed below the aperture and the point catches on the lower margin. Practically, if the instrument catches at the triangular ligament it should be passed down with the beak hugging first the roof and then the floor of the urethra, and in one or other of these ways it will usually find its way through. The finger pressing against the convexity of the curve of the instrument in the perineum will

often lift the point over the lower margin of the opening when it is catching there.

A similar difficulty may be met at the opening into the prostate. This happens but rarely, and is to be overcome by the same tactics. In case of much difficulty the finger introduced into the rectum serves as a good guide, and with it the point of the instrument may be lifted into the prostate where it is catching on the lower edge. An enlarged prostate is, as a rule easily passed by the lithotrite, whose short curved beak carries the point along the roof of the canal, where it rarely meets with an obstacle.

False passages may make the introduction of instruments extremely difficult and dangerous. Even if by long and patient trial they are finally passed, and the stone is comminuted and removed, the danger is not then over, for a serious swelling of the urethra, with retention of urine, is likely to follow, and under these circumstances the passage of a catheter is almost an impossibility.

To avoid this course of things, a

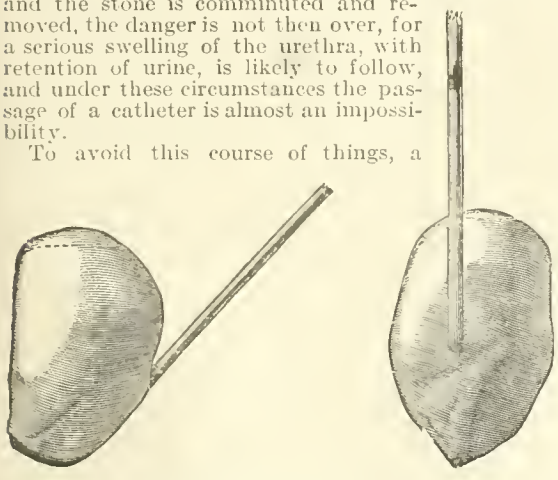

Fig. 3749.—Front and Side Views of a Plaster Cast of Bladder, with a Curved Tube Pressed Down into its Base.

catheter should, in such a case, be tied in at the end of the operation, and left in place until the urethra has, partly at least, recovered from the injury received.

A single false passage, if its position is accurately made out, may usually be avoided by carrying the instruments along the opposite wall of the urethra at that point. If, however, several of these pockets exist, in which the instruments are constantly caught, it will, perhaps, be a wiser plan to resort to lithotomy, which, though a more severe operation, has the great advantage of providing certain drainage for the bladder.

The stone and, subsequently, the fragments are found and seized upon the floor of the bladder. Fig. 3749 shows how, when the lithotrite stands at an angle of forty-five degrees with the axis of the body, the floor of the bladder is indented, so that the extremity of the instrument lies at the bottom of a funnel-shaped depression and fragments naturally gravitate into or close alongside of its jaws. Usually when the blades are opened in this position the stone falls between them. When this does not occur the blades should be opened in the upright position, and then turned over on one side or the other and closed along the floor of the bladder.

A stone may be too large to fall into the depression made by the instrument, and it may then be necessary to depress the handle before it can be seized. This sensation of having the stone above the sound or lithotrite sometimes leads to the belief that it is attached to the upper bladder wall when such is not the case.

The crushing of the stone should be done as thoroughly as possible at the first introduction of the lithotrite. This saves time and irritation to the urethra, and with the self-clearing instruments described above, much may be accomplished by a little patience and skill in searching for fragments.

The form of the female blade, with projecting end and width enough to carry its sharp rim away from close contact with the male blade, makes nipping of the bladder wall unlikely to occur. This accident is so serious that it should be further guarded against by always carrying the blades toward the center of the bladder and slightly rotating, to make sure that they are free, before screwing down upon anything that has been seized.

The curved evacuating tubes are passed like catheters, much in the manner described for the introduction of the lithotrite.

The straight tube should be passed down toward the rectum as far as it will go, and then, being brought down to a horizontal position, it should be gently pushed up in the axis of the body. At the moment of bringing the tube down between the thighs, pressure should be made at the root of the penis to relax the suspensory ligament. Before advancing the instrument horizontally it is well to withdraw it very slightly, in order to disengage its point from the depression which it is likely to make in the bulbous urethra.

When there is a hitch at the triangular ligament, or at the prostate, the tube may usually be carried through by a rotation in the manner of a corkscrew.

When the tube has entered the bladder the bulb is connected with it, and on opening communication between them a gurgle will be heard, indicating the entrance into the bulb of the air contained in the tube. By means of the hose entering at the top of the bulb this air is expelled and its place supplied by water.

Some operators use evacuators which do not provide for the escape of this air, which is churned in and out of the bladder during the pumping, and is a source of some inconvenience.

In commencing evacuation the point of the tube should be held a little above the floor of the bladder. At every squeeze of the bulb the fragments are then thrown into commotion, and by the subsequent expansion are aspirated through the tube as they are flying about the bladder. If the opening were at first buried in the débris, it would be liable to be clogged by the fragments rushing in together and wedging. Later, when but little remains, the point of the tube should be carried to the bottom of the bladder to gather the remnants as they gravitate into the depression thus made.

The direction of the orifice of the tube should be occasionally changed, so that any side pockets may be thoroughly washed out. The pouch behind an enlarged prostate should be especially attended to in this way.

During the earlier part of the evacuation there should be no interval between the compression and expansion of the bulb. The object at this time is to set the fragments whirling and to catch them while suspended. Later, when the fragments are few and the tube is carried to the floor of the bladder, a few moments should elapse after compressing the bulb, to give the fragments time to settle into the depression about the end of the tube before the expansion which is to suck them into it, takes place.

When any particular aspiration brings fragments, the position of the tube should be kept unchanged until they cease to come.

The wedging of a fragment in the tube causes an obstruction which is very noticeable. The compression of the bulb is rendered difficult and its expansion is slow.

An angular fragment may lodge so that while it allows the passage of water, it prevents the entrance of other fragments. This condition may be suspected if there is a constant clicking against the tube and still nothing appears in the reservoir.

The usual point where fragments wedge is at the entrance to the tube. When one becomes thus fixed, it may be dislodged with a stylet; and this is the safest method of disposing of it, although with care the tube

may generally be drawn out with the fragment in it. This procedure, however, is not devoid of danger, for sharp projecting angles may lacerate the urethra, or the bit of stone may even remain sticking in the passage.

The tube may also be obstructed by the bladder wall, which is sometimes sucked into the orifice. The stoppage from this cause is usually not continuous, but the wall flapping against the opening gives a series of jerks to the instrument, which reminds one of the bite of a fish.

When this is felt the end of the tube should be moved to another part of the bladder, and if it then continues, it shows that the bladder is not sufficiently distended, and water should be added through the hose at the top of the bulb.

When for several minutes no fragments appear in the reservoir, the tube should be systematically moved about the bladder until every part has been explored. If no débris appears during this procedure, and there is no longer any clicking of fragments too large to pass, it may be concluded that the bladder is empty and the operation is completed.

Small particles of stone may be caught in folds and pockets of the bladder, and so may escape a thorough pumping. It is therefore wise before the patient passes from under observation to give another washing with the evacuator. This is of especial importance when an enlarged prostate or other obstruction to the flow of urine exists, as under these circumstances a fragment of stone if retained has little chance of being expelled by the natural efforts, and may serve as a nucleus for another calculus. [To-day cystoscopy is the most certain and therefore the best method of settling this question.]

Strict aseptic precautions should be observed throughout the operation. The instruments should be thoroughly cleansed with a five-per-cent. solution of carbolic acid. The vaseline used for lubrication should be perfectly fresh, and may even contain a small quantity of eucalyptus oil as an additional precaution. The fluid used for the evacuator should have borax or boracic acid added to it, to sterilize it and to exert a soothing effect upon the bladder.

Size of Instruments.—A few words upon this subject may not be out of place, as much of the earliest and most persistent criticism of the operation was directed against the use of large instruments.

The advantage of using as large an evacuating tube as the urethra will readily admit is so evident as to need no argument.

Otis' measurements have shown that the average adult urethra has a caliber about thirty-two millimeters in circumference, which corresponds with No. 32 of the French catheter scale. A tube one or two sizes smaller than a given urethra will usually pass with ease, and will give rise to no undue irritation.

The size of the lithotrite selected will depend largely upon the size and hardness of the stone. As the largest Bigelow lithotrite is No. 30 in the French scale, the operator will rarely be limited in his choice of instruments by the caliber of the urethra, except when this is unusually small.

A soft, small stone can be readily comminuted with a small lithotrite, and if the urethra is narrow it is, of course, an object not to pass larger instruments through it than are necessary. But if a large oxalate-of-lime or uric-acid calculus be found, its thorough reduction is greatly facilitated by the use of instruments strong enough easily to overcome the increased resistance.

Under these circumstances a large instrument works faster, and more thoroughly, does not have to be introduced so often, and saves the strength of the surgeon.

This last point is of great importance, as the delicacy of hand so necessary in manipulations through the urethra is with difficulty maintained through a long operation, and yet it is even more necessary toward the close than it was in the beginning.

Arthur T. Cabot.

Lithotomy.—This term (λιθοτομία, from λίθος, a stone, and τέμνειν, to cut) means a cutting operation for the removal of a stone. It is by usage applied merely to the removal of a stone from the bladder. When otherwise used, the different application is designated by a prefix (*e.g.* nephrolithotomy).

Lithotomy is one of the oldest operations in surgery, and was formerly the only surgical procedure to be resorted to in cases of stone.

Early in the last century (1824) the crushing operation (lithotrity) was brought into recognized use by Civiale, and was widely adopted in the treatment of cases in which the stone was so small or so soft as to be easily pulverized.

In 1878, Bigelow introduced the operation of litholapaxy, and showed its applicability to stones of considerable size and hardness. So efficient has this operation proved itself that it leaves but a comparatively small number of cases to be treated by lithotomy.

For a brief discussion of the principles which should guide one to a decision between the crushing and the cutting operations in a given case, see under *Bladder*, page 81, of volume ii of this Handbook.

Suprapubic Lithotomy.—In the first half of the last century the infrapubic routes for reaching the bladder were the only ones in general use. The great fear of the peritoneum and the high mortality resulting from urinary infiltration in the tissues of low vitality in front of the bladder led surgeons to regard the suprapubic route as too dangerous for use except under very exceptional circumstances. With the advent of the modern methods of aseptic and antiseptic surgery the dangers largely disappeared and the great advantages of reaching the bladder by this method have brought it again into prominence. At the present time, it has practically displaced all other methods of lithotomy, and the perineal operations are used only when some indication other than the removal of stone exists.

The suprapubic route enables the operator to do his work under the guidance of the eye and makes it possible thoroughly to examine the bladder and to discover and treat other complicating conditions.

As litholapaxy successfully disposes of stones of large size, it is now necessary to resort to a cutting operation only when a very large calculus is so tightly grasped in a contracted bladder that the lithotrite cannot be manipulated about it, or when some lesion exists within the bladder which in and of itself requires operation.

Thus, for the conditions under which litholapaxy is not the best procedure, the suprapubic operation fulfils the indications better than any of the perineal incisions.

Operation.—The relation of the peritoneum to the anterior wall of the bladder is the important anatomical consideration in this operation. With the bladder in a collapsed condition, the lower fold of the peritoneum lies at or near the upper border of the symphysis pubis. As distention of the bladder takes place, this fold rises until, when the bladder contains fifteen or twenty ounces, a distance of three or four inches separates it from the pubis. This leaves an unobstructed space through which the bladder may be entered without danger of opening the peritoneum. The production of such extreme distention as this is, however, unwise; but, as will be shown, the peritoneum can be easily avoided in other ways. Moreover, if the peritoneal cavity is opened by accident during the preliminary steps of the operation, it can readily be closed by suture and there is little or no danger of infection

entering the abdomen. It is, nevertheless, wise to take precautions to avoid opening the peritoneum and to make the closure tight should this accident occur.

Preparation for any cutting operation for the removal of stone should include an attempt to render the urine as aseptic as possible and, by the use of water and if necessary diuretics, to bring the urine up to a satisfactory quantity. The administration of hexamethylenamin in doses of seven to ten grains three times a day will tend to inhibit the growth of bacteria in the urine, and by thus rendering the urine less infectious will promote rapid healing of the wound. In a certain proportion of cases hexamethylenamin will prove an irritant to an ulcerated bladder. When this is the case, sandal oil may be substituted for it. The lower bowel should be emptied on the day before the operation by the use of cathartics and enemata.

The first step in the operation is the careful irrigation of the bladder with some aseptic or mildly antiseptic fluid, and for this purpose a four-per-cent. solution of boric acid is perhaps to be preferred, but sterile water or sterile salt solution will be satisfactory if other solutions be not at hand. Irrigation should be continued until the wash water returns clear, when a moderate amount of fluid should be left in the bladder for the purpose of distending it and raising the anterior fold of the peritoneum. The amount of fluid to be left in the bladder will depend largely upon the condition of that viscus. In the presence of chronic ulcerative processes, and especially in old men, the danger of rupture of the bladder is not unimportant and care should be used to avoid dangerous distention. In a state of partial anesthesia spasm of the bladder may greatly increase the danger of rupture. The quantity of fluid usually well borne varies from seven to ten ounces and this amount should rarely be exceeded. The operation can be done with ease and safety without elevating the peritoneal fold at all, for the peritoneum can be readily identified during the dissection and pushed back with the finger. With the patient, then in the Trendelenburg position, the incision is made in the middle line above the pubis of a length varying from three to five inches according to the thickness of the abdominal wall. The lower end should come well down over the upper border of the symphysis. The fascia covering the recti muscles should be freely divided in the middle line and the muscles should be separated with some blunt instrument just above the pubis. The interlacing fibers of the pyramidales will be encountered and as they occasionally cross the middle line some of the fibers may have to be divided. The dissection is thus brought down to the deep fascia, which should be cautiously divided, exposing the properitoneal fat and the peritoneum itself. It is to be remembered that between the anterior peritoneal fold above referred to and the upper border of the pubic bone is a fibrous layer called the fascia propria of Velpeau, and it is wise, therefore, in all cases to make a transverse incision along the upper edge of the pubic bone which will divide this fascia and allow the peritoneum to be pushed back with ease to the upper angle of the wound where these tissues may be held by a retractor. The bladder wall is thus exposed over a considerable area.

In cases in which the operation must be done on an empty bladder, as where urethral or perineal fistulæ exist, it is well to pass a sound into the bladder so as to raise the wall on the point of the instrument and bring it readily into the wound. A guide suture may be placed on either side of the point where the bladder wall is to be opened to serve as a retractor and guide to the edges of the bladder wound in the later stages of the operation. As the bladder is opened the forefinger of the left hand is introduced through the aperture and the bladder thus explored and the size, position, and number of stones are ascertained. Stones of good size are most readily removed with the ordinary stone forceps. Small stones, especially when multiple, require a lithotomy scoop aided by irrigation for their removal.

The opening in the bladder wall should be made of a size sufficiently large to allow of the easy extraction of the stone. The peritoneum is easily stripped back off the apex of the bladder when it is necessary to enlarge the incision in that direction. A clean-cut wound of large size may be sutured and will heal readily, wheras a smaller wound, the edges of which have been bruised by the extraction of a stone too large to pass readily, will often give much trouble by sloughing.

It is occasionally found better to break up a very large stone before extraction.

When the bladder is saeculated the possibility of there being a stone hidden in some of the pockets should not be forgotten. Occasionally such a pocket is found with a stone in it which is larger than the orifice. Under these circumstances the diverticulum should be excised with the stone. This involves stripping the bladder from the surrounding structures, freeing the sac, amputating it, and closing the opening with suture. When much peridiverticulitis exists this may be a difficult and tedious proceeding.

No operation for stone should be considered finished until the bladder has been carefully examined to see if any other pathological process exists. It has happened to the author to find a little myomatous tumor of the bladder wall which, being slightly ulcerated, had been acting as the forming place for a succession of recurring stones. This tendency to the recurrence of stone entirely disappeared after the removal of the tumor.

When the operation is finished, the question of the closure of the bladder wound is a matter of considerable importance. The ideal procedure is to close the bladder wound tightly and the abdominal wall over it and rely on the constant drainage of an in-lying catheter to prevent an accumulation of urine sufficient to force its way through the stitches. This technique is applicable to but a comparatively small number of cases—viz., in which the bladder is in good condition —and is more likely to be successful in comparatively young patients. A safer procedure is to close the bladder wall tightly and leave the abdominal wound partially open, thus forestalling the possible occurrence of infiltration between the bladder and the abdominal wall. Where doubt exists as to the widsom of completely, closing the bladder, drainage should always be instituted, as the complications resulting from failure to drain are far more serious than the inconvenience which may be caused by establishing a suprapubic drainage. A drainage tube should be introduced down to the base of the bladder and the bladder wall then closed tightly around it. If, in this closure of the bladder wound, the sutures are placed at a little distance from the edge of the wound so as to roll in the edges, it will be found that these inverted edges will act as a value when the drainage is removed and that more rapid closure of the sinus is thus insured. A single tube combined with an in-lying catheter provides the most satisfactory drainage.

The incision in the abdominal wall should be closed in layers as in other surgical operations.

Some authors have laid much stress upon the firm attachment of the opening in the bladder to the layers of the abdominal wall, and they believe that with this precaution infection of the fatty tissue in the space of Retzius is less likely to occur. This firm attachment of the bladder wall to the abdominal parietes tends to limit the distention and subsequent mobility of the bladder, and we are inclined to think that the placing of a small piece of rubber tissue between the bladder wound and the properitoneal fat layer will be a sufficient safeguard against infection.

After-Treatment.—The tube which provides for drainage of the bladder should be connected with tubing long enough to conduct the urine over the side of the bed into some receptable. If snug closure of the

bladder wall about the tube has been accomplished, there will be but little leakage and the dressing remains comparatively dry. The latter should be large and absorbent to hold what urine does escape and should be changed as often as necessary to keep the patient dry.

Irrigation of the bladder is usually a necessary part of the after-treatment. In cases in which there is but little cystitis, a daily flushing of the tubes is usually sufficient to keep them free from clots of mucus. Where there is any tendency to hemorrhage, or when much cystitis exists, more frequent washings are necessary to remove the clots which tend to clog the tubes.

The advantages of through-and-through drainage, either through two tubes or through a catheter and tube, are obvious.

When the urine has become clear and the prevesical wound has begun to granulate, the time has come for removal of the tube.

In favorable cases the tube may be removed in twenty-four to forty-eight hours.

If the bladder wound has been sutured in the manner earlier described, so as to roll the edges inward, the removal of the tubes will be quickly followed by closure of the sinus. When a large opening in the bladder has been made and only partially sutured, or when sloughing has taken place around the edges of the bladder wound, the closure of the opening may be a very tedious matter. Complete closure may be expected, unless there be obstruction to the outflow of urine through the natural passages. In the presence of urethral obstruction from prostatic enlargement or other cause, great persistence of the abdominal sinus is to be expected, and, unless measures are taken to remove the cause of obstruction, it may be impossible completely and permanently to close the opening.

Complications.—The most serious complication in this operation is infection and infiltration of urine into the cellular tissues of the prevesical space. With careful technique, this accident should occur rarely and then only in debilitated patients. Its prevention will depend upon the avoidance of tearing, crushing, or otherwise mutilating these tissues of low vitality, and the more quickly, carefully, and smoothly the operation can be done the greater will be the probability of escaping this serious complication. It is also wise when dealing with a foul urine from a chronic cystitis to wall off the prevesical space with gauze during the operation and to guard against a later infection by packing around the tubes with gauze at the end of the operation. If infection and infiltration of urine occur, free drainage of any collections of pus is of the first importance.

Another occasional and at times serious complication is excessive sloughing in the region of the wound. This is most commonly seen in patients of much lowered vitality, and at times the slow extension of this process may assume alarming proportions. Its treatment will consist in supporting the patient's general strength, insuring adequate drainage of the bladder, and avoiding any infection of fresh areas by attempts to remove the sloughing tissues before they are properly separated. The dressing should be conducted with great care and delicacy, and too great zeal should not be shown in removing the partially necrotic tissues. Hemorrhage will occasionally occur in cases in which there has been marked ulceration of the bladder wall. When moderate in amount and especially when coming from the prostate or prostatic urethra, it may be satisfactorily dealt with by the administration of ergot and frequent irrigation of the bladder. When it assumes more alarming proportions, it may be necessary to pack or tampon the bladder after the manner of controlling hemorrhage in suprapubic prostatectomy. This will, however, be very rarely necessary in suprapubic operations undertaken solely for the removal of stone.

Prognosis.—The prognosis of suprapubic lithotomy will depend entirely upon the condition of the patient. In uncomplicated cases, with patients in good condition, the mortality should be entirely trivial, but in old debilitated subjects, with disabled kidneys, the mortality is likely to be considerable.

The tendency to recurrence of stone is not essentially different whether lithotomy or litholapaxy be done.

Lithotomy may, therefore, be wisely reserved for those cases to which litholapaxy is not applicable or in which the importance of inspection of the bladder outweighs the additional danger.

Infrapubic Lithotomy.—The bladder may be opened below the pubis by the use of either the so-called lateral or the median perineal route. Neither of these operations is to-day held on a par with the suprapubic method and only a very brief description of them will be given.

Lateral Lithotomy.—In this operation, after moderate distention of the bladder, the patient is placed in the so-called lithotomy position and a grooved staff introduced into the urethra. This staff should be made to touch the stone if possible in order that the operator may be sure of its presence. The staff is then entrusted to the care of an assistant, who holds it vertically, so that its point is just within the bladder, and keeps it strictly in the middle line. The scrotum is held up out of the way and the knife is entered in the middle line at a point an inch to an inch and a half in front of the anus, and then an incision is made downward and outward two and one-half to three inches over the ischiatic fossa. The incision is carried down rapidly through the loose fat and underlying tissues until the membranous urethra is reached. The staff is felt, the knife is introduced into the groove, and both staff and knife are then pushed forward into the bladder. The knife having entered the bladder the handle is depressed, carried to the operator's right, and the blade in the bladder makes the incision of the desired length in the left lateral lobe of the prostate. The knife is withdrawn, the left forefinger introduced along the staff into the bladder, the staff is withdrawn and stone forceps substituted. Stones of large size may have to be broken up before they can be extracted, and care must be used not to leave fragments in the bladder at the end of the operation.

This operation is superior to the median perineal operation next to be described in that it gives more room for the extraction of stones.

Median Perineal Lithotomy.—An incision is made on the raphe, the urethra is opened as in all perineal operations in the membranous portion, and the incision in the prostate is made downward in the middle line.

The space afforded by this incision is so limited that only small stones can be removed through it.

The operation is applicable especially to cases in which the stones are impacted in the urethral orifice so that they are partly in the bladder and partly in the prostatic urethra. It may also be used for the removal of small foreign bodies from the bladder.

In case a stone is found too large for safe removal through the median incision, perineal litholapaxy may be practised. The short route to the bladder makes this an easy and efficient operation.

Hugh Cabot.

Lithotrity.—See *Litholapaxy.*

Litmus.—Lacmus. *Lacca cærulea* or *L. musica.* Litmus is an artificial mixture containing a coloring matter that is made from various lichens, chiefly in the genera *Leeanora, Rocella,* and *Variolaria,* of wide distribution. Collections occur as far north as Sweden, but the important sources of supply are the Azore, Canary, and Cape Verde Islands. The coloring

matter does not exist in the living plant but is the product of fermentative changes, resulting from exposure of the crushed tissues, in a wet condition, to the atmosphere. The product first formed is red, and this is gradually transformed through purple into the blue pigment. The powdered plants are converted into a thickish liquid by stirring with water, potassium carbonate and, usually, with more or less decomposed urine. After acquiring the proper color, which requires about a month, it is mixed with chalk or other non-acid earthy matters to a convenient consistency, and formed into masses of convenient form and size for marketing. In the best litmus, the pigment comprises nearly one-half, the remainder being insoluble matter, with a little moisture. The pigment itself consists of a number of distinct principles, the chief one being the acid body *azolitmin* in combination with potassium. Thus combined, it is blue, but becomes reddish when freed from the potassium. It is the property of thus changing its color, with even the slightest variations from alkaline to acid conditions, and the reverse, which gives to litmus its great value and universal use as a reagent. The litmus test solution is *Tinctura Laccæ Musicæ*, made by extracting the pigment from Litmus. From it are prepared the *Charta Exploratoria Cærulea* (Blue litmus paper) and *C. E. Rubra* (red litmus paper), which must be kept suspended on clean twine in an atmosphere free from acid and alkaline vapors. Its use in testing the acidity or alkalinity of substances is too well known to require description.

H. H. Rusby.

Litten, Moritz.—The discoverer of what is known as "Litten's phenomenon" or "Litten's sign." He was born in Elbing, Germany, August 10, 1845. He obtained his medical education at the universities of Heidelberg, Marburg, and Berlin; received his doctor's degree in 1868; served as a military surgeon throughout the Franco-Prussian war; spent two years in visiting the hospitals and clinics of Vienna, Prague, Paris, London, and Edinburgh; was one of Cohnheim's assistants; was first physician in von Frerich's clinic in the Charité Hospital of Berlin, from 1876 to 1882; and was made a titular professor in the university in 1884. In 1891 he was the first to make practical use of the centrifuge invented by his pupil Stenbeck, and shortly afterward he brought the apparatus to the notice of the Congress of Physicians interested in Internal Medicine. In the same year he discovered the "phenomenon" which bears his name—a phenomenon which is characterized by the fact that the respiratory movements of the diaphragm, not recognizable under normal conditions, become distinctly visible to the naked eye when pyopneumothorax or hydropneumothorax is present. He is also to be credited with the discovery of still other new pathological facts of greater or less importance. He died in 1907.

The titles of some of Litten's more important contributions to medical literature are the following: "Der Nachweis von der Fühlbarkeit der Nieren und deren normale respiratorische Beweglichkeit," in the *Berliner klin. Wochenschrift*, 1890; "Die Contusionspneumonie, in the *Zeitschrift für klin. Med.* No. v; and "Die Endocarditis traumatica," in the *Verhandlungen des Vereins für innere Med.*, No. xvii. (1897).

A. H. B.

Little, William John.—Born in London, England, August 7, 1810. In 1832 he was made a member of the Royal College of Surgeons, England; and in 1833 he visited Berlin, Germany, for the purpose of following the instruction of Johannes Mueller, one of the great chiefs of modern physiology. Three years later (1836) he was operated upon for club-foot by Stromeyer, in Hanover, and obtained a perfect cure. He had previously consulted Diffenbach, the leading surgeon of Berlin, but had received from him no encouragement to expect any benefit from surgical interference. It is an interesting fact that the method (subcutaneous tenotomy) employed by Stromeyer in his operation upon Little's foot, had already been condemned by English surgeons. After he had recovered from the operation Little returned to Berlin and succeeded in making Dieffenbach an enthusiastic advocate of subcutaneous tenotomy for the cure of club-foot. After operating successfully on some thirty cases of this deformity Little published in Berlin (in 1837) a paper entitled "Symbolæ ad talipedem varum cognoscendum. Pars I., Genesis." He returned to England and founded, in 1839, the Orthopedic Institution (now called the Royal Orthopedic Hospital). He died July 7, 1894.

To Little is due the credit of having introduced subcutaneous tentomy into England; his own personal example having greatly aided him in bringing about this result. In addition to the paper mentioned above, the following contributions to medical literature deserve to receive special mention: "Treatise on Club-Foot and Analogous Distortions," 1839; "On the Nature and Treatment of Deformities of the Human Frame, etc.," 1853; "On Spinal Weakness and Spinal Curvatures, their Early Recognition and Treatment," 1868; and "On M-Knee Distortion, its Medical and Surgical Aspects, 1882. Little's name has been given to two nervous affections of children—lateral spinal sclerosis (Little's disease) and acute anterior poliomyelitis (Little's paralysis).

A. H. B.

Littré, Maximilien Paul Emile.—Born in Paris, France, February 1, 1801. His studies were divided between medicine and philology. In 1828 he founded, in association with Andral, Bouillaud, and others, the *Journal hebdomadaire de médecine*. In 1837 he joined with Dezeimeris in starting a new journal, *L' Expérience*. Among his purely philological writings we may here mention the "Dictionnaire de la langue française" (four quarto volumes, 1863–1872), an enduring monument to his extraordinary industry and vast learning. Those of his writings which relate more or less directly to the science of medicine are the following: "Œuvres d 'Hippocrate," ten volumes, 1839–1861; "Histoire naturelle de Pline," two volumes, 1848–1850; and a new edition of Nysten's "Dictionnaire de médecine, de chirurgie, de pharmacie, etc." (in association with Charles Robin), 1865. He died June 2, 1881.

Fig. 3750.—Maximilien Paul Emile Littré.

A. H. B.

Littré, Alexis.—Born at Cordes, France, on July 21, 1658. For fifteen years he was Professor of Anatomy in Paris. He was also a Licentiate in Medicine, Doctor in Medicine of the Faculty of Paris, and a member of the Academy of Sciences. He devoted his life to anatomical research and it is said dissected over 200 bodies, which was a remarkable number at that time owing to the difficulty of obtaining

subjects. He died in Paris on February 4, 1726.

While Littré wrote no single great work, he contributed generously to medical literature through his memoirs and observations, among which are: "Observation sur une espèce de hernie," 1700; "Observations sur les ovaires et les trompes d'une femme, et sur une fœtus trouvé dans l'un de ses ovaires," 1701; "Observation d'un fœtus monstrueux qui n'avait qu'un œil," 1717. The following anatomical conditions have been named after him: Littré's glands, or the mucous glands in the bulbous urethra, Littré's hernia or the hernia of Meckel's diverticulum; also Littré's operation, inguinal colostomy, formation of an artificial anus in the left inguinal region. E. L. J.

Liver, Abscess of the.—*Definition.*—An affection characterized by the production of one or more areas of necrosis and puriform softening in the liver, due to the action of microorganisms, and associated with more or less marked degeneration of the intervening parenchyma.

Distribution.—Suppurative hepatitis (hepatitis apostematosa), as a primary disease, occurs in the temperate zones with the greatest rarity, but is more frequent in tropical and subtropical climes. As we meet it in the temperate regions, apart from cases due to trauma and wound infection, it is practically always metastatic or due to extension of inflammation from neighboring organs.

Etiology and Pathogenesis.—It may be taken as practically certain that all forms of suppurative hepatitis are due to the activity of microorganisms, either bacterial or protozoan. The forms which have been found, and consequently regarded as etiological factors, include the streptococcus, the staphylococcus albus and aureus, the bacillus coli, the diplococcus pneumoniæ, the bacillus pyocyaneus, the ray fungus, and the amœba coli.

Bacterial agents may reach the liver in several ways, namely, by the hepatic artery, the portal vein, and the bile ducts; or, again, by direct extension from contiguous parts. Rarely, infection occurs by retrograde metastasis from the vena cava or hepatic vein.

Some idea of the frequency of the various forms may be gathered from the following figures: In 1,474 autopsies of which I have notes, occurring at the Royal Victoria and the Montreal General Hospitals, twenty-two cases of liver-abscess were found. Of these, three cases were due to dysentery, thirteen were from portal infection, three were biliary, one was arterial, one occurred by extension, and one case was apparently primary.

Apart from metastatic cases some occur which are attributable to trauma. Here, in a previously healthy organ, a severe blow or crush results in a necrosis of an area of liver substance, and this subsequently undergoes liquefaction. This event is best explained on the hypothesis that the liver normally contains bacteria. I have satisfied myself by culture and other experiments that the healthy organs contain bacteria,[1] and these results have been amply corroborated by the work of Dr. W. W. Ford[2] at McGill University. In suitable preparations also bacteria can be traced from the surface of the intestine through the mesenteric lymphatics and glands to the liver, so that it is evident that there is what may be called a "vital absorption" of microorganisms, apparently through the agency of phagocytes, and partly by the tissue fluids, from the alimentary tract to the liver.[3] Normally, the liver has sufficient power to resist the action of these germs, which indeed may be of low virulence from the start or may become attenuated in their passage to the organ, so that disease usually does not result. Should, however, from any cause, the resisting power of the liver be diminished, as, for instance, by trauma or toxic agents, infection and degeneration may result. Except upon this theory it is almost impossible to explain certain forms of so-called "idiopathic" abscess of the liver which occur apparently spontaneously, quite apart from dysentery or other ulcerative lesions of the intestinal tract. Birch-Hirschfeld[4] indeed recognized the probability of "idiopathic" liver abscess being cryptogenic, a term which may at last have some more positive meaning in the light of the above researches.

In discussing the subject of liver abscess it is perhaps most convenient to treat of the disease as falling into two main groups: (1) *Primary suppurative hepatitis*, where the pathological lesion is primarily induced in the liver; and (2) *secondary suppurative hepatitis*, in which the liver is affected by infective agents derived from some diseased tissue external to it.

The first class may again be divided into, (*a*) *Intrinsic*, where the infective agents are originally present in the liver. It is to this form, inasmuch as it occurs apparently spontaneously without any association with dysentery or any other obvious cause, that the unsatisfactory term "idiopathic" has been applied. Most cases of traumatic origin may also be placed in this class. (*b*) *Extrinsic*, where the agents are introduced from without. An example of the latter is seen in "wound infection" of the liver.

By far the most common event is for the inflammatory process to be secondary to disease of some other organ.

Inasmuch as the tropical form of the disease is of the greatest practical importance and presents many features peculiar to itself, it has been thought advisable to treat of it under a separate heading and to discuss first those forms of abscess which are liable to be met with in temperate regions.

Abscess of the Liver from Arterial Infection.—In this form, which is really but one manifestation of general septicemia, the infective agents reach the liver through the hepatic artery. The etiology of this form, therefore, is that of septicemia in general. In the vast majority of cases, if not in all, the microorganisms are not sufficiently numerous to cause blocking of the vessels immediately, but become entangled in the endothelium of the finer capillaries where they proliferate, leading to thrombocapillaritis and complete obstruction. True embolism is by no means common; when this occurs it is generally due to ulcerative endocarditis.

The primary foci whence the infective agents gain entrance to the general circulation are very various. The disease may complicate all forms of wound infection—osteitis, osteomyelitis, gangrene of the lung, putrid bronchitis, bronchiectasis, suppurative lesions about the bladder, prostate, and urethra, from the uterus after delivery, and ulcerative endocarditis and aortitis. It has also been known to follow such simple affections as carbuncle and whitlow, and is occasionally met with as a complication of the acute infective fevers. The organisms usually at work are the streptococcus pyogenes and the staphylococcus albus and aureus. Some writers note that injuries to the head occasionally result in abscess of the liver, but according to K. Bärensprung, who has made an investigation into this point, liver abscess is not more specially related to injuries of the head than to those of the peripheral parts generally. Most of these cases are examples of septicemia, but some are possibly due to retrograde embolism.

Suppurative Hepatitis of Portal Origin.—This is by far the most frequent form. In this case we have practically a septicemia confined to the liver, for it is upon this organ that the brunt of the disease is concentrated. Infective agents may come from any part of the portal tract. They do not necessarily cause disease of the larger venous trunks, but may reach the finer capillaries, where they proliferate and lead to inflammation and obstruction of the vessels.

Often the lesion is an acute thrombophlebitis of the portal vein, or a purulent infiltration of the vessel wall and the adjacent parts (suppurative portal pylephlebitis). An example of this is seen in the case of infection of the umbilical vessels in new-born children. It is fairly common in appendicitis and perityphlitis, which form the most frequent and important single cause. Here there is likely to be thrombophlebitis of the superior mesenteric vein extending directly from the appendicular region into the portal vein. In 517 cases of appendicitis collected by Dr. George E. Armstrong,[5] of Montreal, from the clinics of the Royal Victoria, Montreal General, and Western hospitals, in sixty-seven that died thrombophlebitis of the mesenteric vessels and abscess of the liver occurred five times. Again, combining the statistics of Einhorn, Langheld, and R. H. Fitz, we find that in 479 postmortems upon appendicitis cases, pylephlebitis and abscess of the liver were found in twenty-three cases, or 4.8 per cent. Septic emboli occasionally arise from the small intestine, stomach, spleen, and pancreas, and also occur in dysentery, pelvic abscess, and rectal disease. Exceptionally, in cases of cholecystitis and pericholecystitis, extension of the process to the portal vein may take place, and thus an embolic infection of the liver result.

In the septic embolic and metastatic forms one sees a number of abscesses of varying size. These are usually irregular, pointing to their development from the confluence of isolated foci. Occasionally the union is not complete, so that the abscess presents a more or less lobular arrangement. In the periphery of the larger abscesses, and separated by relatively healthy tissue, minuter areas of suppuration can often be seen. The suppurative process tends to spread along the portal sheaths, but the hepatic veins do not always escape, for thrombi may be found in them extending even into the larger trunks. The cavities are filled with viscid, yellowish-green pus, of foul odor, often mixed with blood, in which sequestra of liver substance may often be found. Round about the abscesses is a narrow zone of yellowish-white color, or, in gangrenous inflammation, of a dirty green appearance.

Microscopically, a study of the most recent lesions shows that the smaller branches of the portal vein and the capillaries are blocked with microorganisms; the liver cells in the neighborhood are swollen, hyaline-looking, and compressed; the nuclei stain badly, and there is a condition resembling coagulation necrosis. At the periphery of the necrosed area is a zone formed of inflammatory leucocytes which gradually insinuate themselves between the columns of liver cells. Necrosis and softening go hand-in-hand until a local abscess is the result. The liver substance between the abscesses usually shows parenchymatous degeneration. When the abscesses are near the surface, the Glisson's capsule is usually infiltrated, its serous covering granular and inflamed, with loss of the endothelial cells and often a deposit of fibrinopurulent exudate (acute perihepatitis).

Suppurative Hepatitis of Biliary Origin.—Here infection takes place from the bile passages. The most common cause is cholelithiasis with consecutive cholecystitis and cholangitis. In this form the affection may arise in three ways: (1) Direct extension of an ulcerative process due to gallstones, to the liver; (2) suppurative cholangitis and pericholangitis; (3) through the blood-vessels of the mucous membrane and the bile-passages extending to the portal vein.

The bacteria usually found in such cases are the streptococcus, the staphylococcus, the bacillus coli, and the proteus vulgaris.

Another cause is obstruction of the duct by carcinoma or by the presence of echinococcus cysts. Sometimes the bile-passages are secondarily affected from the intestines, as in dysentery or typhoid. Lannois[6] has recorded a case of liver abscess developing in typhoid; such an event seems to be excessively rare. Mayo Robson,[7] again, has pointed out the association of suppurative cholangitis with influenza. Rarely, intestinal worms (ascarides) may invade the common bile duct and, dying there, give rise to marked disturbance. Leick[8] has tabulated nineteen instances of this.

The description already given of abscess arising from the portal vessels holds fairly well for this variety; the main difference is that the abscess contents are often stained with bile and contain gritty matter or concretions.

Suppurative Hepatitis per Extensionem.—A fairly common form of hepatic suppuration is that due to the direct extension of an inflammatory process from some organ in the neighborhood. In this case the suppuration is usually superficial, affecting the capsule and the tissue immediately beneath it. Among the lesions which may extend to the liver may be mentioned diaphragmatic and subdiaphragmatic abscess, suppurative cholecystitis and choledochitis, perforating ulcers of the duodenum and stomach, perinephritic abscess, and abscess of the head of the pancreas. Rarely, foreign bodies, such as fish-bones, needles, or other sharp-pointed articles, may pass through the wall of the stomach or bowels and lodge in the liver, where they set up suppurative inflammation.

Symptoms and Physical Signs.—(*a*) In *suppurative hepatitis of arterial origin* the symptoms are those of general septicemia with the addition of certain ones referable to the liver itself. Almost at any period after the infliction of a wound or the formation of a suppurative focus in the body the affection may appear. Rigors set in with the characteristic "church-steeple" temperature, with profuse sweating. The liver is uniformly enlarged, and there is pain in the right hypochondrium which may be spontaneous but more often is merely a dull sense of tension. The heart is weak and rapid, the respirations are shallow; the skin is often icteric or subicteric, and emaciation takes place rapidly. Diarrhea almost invariably occurs, and the patient sinks into the so-called "typhoid state," with perspiration, drowsiness, delirium, subsultus, and finally coma and death.

(*b*) In *suppurative pylephlebitis* the symptoms are rarely so striking as in the first form. There are usually irregular chills, fever, and sweating, followed by "typhoidal" symptoms. In some cases rigors and sweating do not occur, and in still others the disease develops insidiously without fever, its existence being evidenced only by pain over the liver, and enlargement of the organ, with subsequent subsidence into the "typhoid" state. Sometimes, as in a case of appendicitis with liver abscess that occurred under my own observation, there are singularly few symptoms pointing either to the primary affection or to involvement of the liver.

(*c*) *Suppurative Cholangitis.*—When gallstones are the cause there is severe pain occurring in paroxysms, each attack being associated with chills, fever, and jaundice; pain may, however, be entirely absent. Fever and profuse perspiration, followed by emaciation, are marked features. The so-called "fièvre hépatique intermittente" of the French writers is in the majority of cases due to cholelithiasis and abscess of the liver. There is usually a gradually increasing enlargement of the whole liver, which is tender on pressure; occasionally the gall-bladder is enlarged and can be felt, but it is more often contracted. These symptoms are usually followed by general systemic infection. Similar symptoms may be found in non-suppurative cholangitis, but when suppuration is present fever is constant and deterioration is progressive.

Tropical Abscess.—This form is characterized by

the development of one or more foci of colliquative necrosis in the liver, either with or without dysentery. As the name suggests, the disease is most common in tropical and subtropical regions. Unlike the forms incident to temperate climes, where the tendency is for multiple areas of suppuration to form, here large single or, at all events, relatively few abscesses are produced. The abscesses are often so extensive that they are enclosed by merely a thin shell of liver substance.

The etiological factors are as yet but imperfectly understood. It is probable that the liver parenchyma undergoes some form of gradual death previously whereby its resisting power is impaired, and thus infection is brought about more readily. In this it differs from the pyemic forms in which the parenchyma is originally intact.

The exact relationship of tropical abscess to dysentery is still *sub judice*. There can be no question that the large solitary abscess occurs occasionally apart from any obvious intestinal lesion, but most authorities are agreed that the largest number of cases are associated with dysentery. As yet statistics are lacking to enable us to supply the relative frequency of the various etiological factors. Kartulis[9] states that in 500 cases of liver abscess which came under his notice, fifty-five to sixty per cent. gave a history of dysentery. Conversely, Lafleur[10] states that twenty to twenty-five per cent. of cases of dysentery in the tropics are complicated by liver abscess, and these figures are corroborated by those of Manson,[11] who in 3,680 autopsies on dysenteric patients found liver abscess in twenty-one per cent. Hirsch,[12] in 2,377 autopsies in tropical dysentery, found liver abscess in 19.2 per cent. There must, however, be something peculiar in the form of the dysentery, for, as is well known, in the catarrhal dysenteries and the ulcerative forms found in the temperate zones, liver abscess is excessively rare.

Some few cases appear to be due to some other affection apart from dysentery. A certain proportion of these seem to be brought about by dietetic errors; free living, excessive use of animal food, and particularly excess in alcohol, are said to be potent causes. Sachs[13] has advanced the view that in the temperate zones alcohol, as it affects the liver, is apt to lead to chronic fibrosis, but in the tropics to a suppurative lesion.

Race exercises an important influence, for whites are much more liable than the native races to abscess of the liver. The proportion is estimated by some to be 35 to 1. The disease affects adults rather than children and males rather than females. Rouis[14] and De Castro[15] lay stress upon the extreme rarity of the disease in females, and this is corroborated by the Berlin statistics collected by K. Bärensprung,[16] according to which only about 1.48 per cent. of the cases occurred in women. The disease is, furthermore, more common in the cold, changeable season which follows after the summer's heat.

With regard to the ultimate nature of the process, our information still lacks precision. It would seem probable—and this view is certainly in harmony with the most recent studies as to the nature of infection—that the non-dysenteric forms are due to some preliminary deterioration of the resisting power of the liver parenchyma. Excess in diet, extreme heat, lack of exercise, sudden changes in temperature, may all play a part here. Congestion of the liver is no doubt readily induced in this way, and this leads to impairment of the liver function, stagnation of bile, and a tendency to portal congestion. Catarrh of the intestines and even trifling ulceration might easily follow, affording a ready mode of entrance for pyogenic microorganisms. Again, the liver in its turn would suffer from the portal toxemia thus produced, and a true vicious circle is the result. That under such circumstances an abscess of the liver might result is certainly not to be wondered at. The bacteria found are the pyogenic cocci.

As the studies of Kartulis, Lösch,[17] Kruse and Pasquale,[18] Councilman and Lafleur[19] have shown, a fairly large proportion of the dysenteric cases are due to a protozoan, the ameba coli, or ameba dysenteriæ. What this proportion is is still uncertain. Flexner[20] is of the opinion that the great majority of dysenteric cases are of amebic origin. The failure to find the amebæ in the abscess in some cases is probably due to the fact that only a superficial examination has been made, for by scraping the walls of the abscess it is usually possible to demonstrate the living protozoan. It is further probable that many of the so-called "idiopathic" abscesses are really dysenteric in origin, for numerous instances are on record in which only after the most minute examination of the intestine was it possible to find traces, in the form of minute scars, of a dysenteric process which had healed, traces which might readily have been overlooked. In many cases bacteria have been found, notably staphylococci and streptococci, either alone or associated with amebæ.

Some of the earlier authorities were of the opinion that liver abscess was due to the pyogenic cocci and not to the amebæ; still others took a modified view, viz., that the amebæ acted merely as carriers of the germs, and by their growth and movements, which ruptured the capillaries, paved the way for subsequent infection. The most careful observers, such as Councilman and Lafleur, believe, on the contrary that the amebæ are the direct exciting cause of the lesions when present, and this view has the preponderance of evidence in its favor.

The discovery of Shiga of a bacillus resembling that of typhoid in some forms of tropical dysentery, which is now very widely accepted as specific, opens up the question as to this germ being an etiological factor in the production of liver abscess. Flexner in a large experience did not meet with a single case due to the bacillus of Shiga. A few writers, however, refer to the discovery of a typhoid or typhoid-like bacillus which possibly was this form. Pansini and Babès seem to have obtained the organism, or a similar one, in several cases of abscess of the liver.

Morbid Anatomy.—In seventy-five per cent. of cases the abscess is solitary and in more than half it is situated in the right lobe, commonly on the upper or outer surface. The abscess is at first usually somewhat deeply situated, but may become superficial. In amebic cases there is a predilection for the dome of the liver or the undersurface, near the hepatic flexure of the colon. The contents vary much; in some few cases the fluid is serous, but in most there is a mixture of pus and necrotic material. The pus is generally thick, white, yellowish, or greenish in color, often mixed with blood, and is usually very fetid. In amebic cases the pus is somewhat characteristic, being in some cases glairy and translucent, in others grayish or brownish red, and has been compared to anchovy sauce. The quantity varies from a few ounces to many pints. In the early stages the area of necrosis is often scarcely liquefied, being more or less hyperemic, coagulated, spongy, and infiltrated with a glairy tenacious material; but later, when liquefaction takes place, the abscess becomes diffuse and finally more or less irregular. Its walls are formed of necrotic and shaggy débris of the liver parenchyma. In long-standing cases the abscess becomes walled off by pyogenic membrane or a fibrous capsule. The liver substance surrounding the abscess is generally congested, softened, cloudy, and friable, or shows other signs of degeneration, although in some cases the parenchyma has been found practically normal.

One or two special types may be just mentioned: (1) The "fibrous" abscess of Kelsch and Kiener.[21] In this the abscesses, numbering from three to twelve, are of about the size of a pigeon's egg. They are filled with grayish, grumous, semi-solid material and are

enclosed in a stratified fibrous wall. (2) The "abcès aréolaire" of Chauffart,[22] in which the abscesses, extending toward the surface, are in close juxtaposition, and there is more or less free communication between the various cavities, so that a sort of spongy framework filled with rather viscid contents is the result. Adhesive inflammation about the capsule of the liver, the pleura, and the pericardium is not uncommon.

Microscopically, the contents of the abscess, when of the amebic type, are composed of finely granular detritus, red and white blood cells, hematoidin, and degenerating liver cells. The amebæ are most numerous in the small abscesses. There is widespread necrosis of the liver parenchyma. A somewhat characteristic and interesting point is that leucocytic infiltration is practically absent in the abscess contents and at the periphery of the area, except in cases in which secondary infection has taken place, such as occurs in abscess of the undersurface of the liver near the bowel. In the early stages the disintegration always takes place in the interlobular regions. The amebæ are found chiefly at the periphery of the abscess, in the capillaries, and about the portal sheaths.

Results of Abscess.—Cases of this disease almost invariably end fatally, at least in the multiple forms, but when death does not take place shortly, and if the condition be not relieved by operative interference, the abscess may rupture and give rise to further most serious consequences. The most frequent event is rupture into the right lung or pleura and next into the peritoneum. The latter event is not so grave as might be thought at first, since limiting adhesions, which prevent or delay the occurrence of peritonitis, are not infrequently formed. More rarely, the abscess ruptures into the pericardium; then sudden death may be the result. Again, the abscess may discharge externally or into the transverse colon, the stomach, or the duodenum; very rarely into the bile ducts, the hepatic veins, vena cava, or the pelvis of the right kidney. Pressure upon the bile-passages leads to icterus, and in rare cases obstruction of the portal vein has caused ascites.

In some few cases after a longer or shorter period the process becomes latent or comes to an end. The necrotic material is to a certain extent absorbed, the swelling becomes less marked, connective tissue is developed, and a regular capsule is formed about the abscess. Complete healing can occur, but this seems to be more frequent in the tropical abscess than in the other forms. Small foci of suppuration may be absorbed, with the formation of a scar; larger foci, through the removal of the more liquid contents of the pus, become cheesy and often calcareous. In the latter case the resemblance to a syphilitic lesion or to an old echinococcus cyst is striking.

Associated Lesions.—Lung: Abscess of the right lung may occur and is always due to the extension of an abscess of the liver situated in the dome of the right lobe. The abscess is never metastatic. The diaphragm is usually adherent to the undersurface of the liver and to the base of the lung. Occasionally empyema is present; the diaphragm may be perforated, but not invariably so. The abscess in the lung is usually situated in the basal portion of the organ; the lung tissue in the neighborhood is consolidated; the wall of the abscess is very irregular in shape, or again may be fibrous. Allowing for differences due to the tissue in which it is found, the lesion is strictly comparable, anatomically and histologically, to the process in the liver. Frequently perforation into a bronchus takes place and the pus thus finds a vent. The material in the abscess generally resembles that found in the liver.

Peritoneum: Local or general acute peritonitis is sometimes found; it is serofibrinous in character. In amebic cases amebæ may be found free on the surface of the mucous membrane.

Symptoms and Physical Signs of Tropical Abscess.—In many cases the affection remains entirely latent, being discovered only accidentally at autopsy. In still other cases the abscess may remain latent for an indefinite period and then suddenly give rise to acute and fatal consequences, owing to rupture of the wall and involvement of some vital organ. Generally, however, symptoms more or less characteristic are present. These consist of a sense of fulness and weight in the right hypochondrium, inability to lie on the right side, fever, disturbance of digestion, and cough; the patients sometimes feel as if a stick of wood were laid transversely across the upper abdominal region (*sensation de barre*). Pain is extremely variable in amount, but may be an early symptom. When present it is of a dull, boring character or, when the liver capsule is inflamed, lancinating; it is often increased on pressure and when the patient breathes deeply or turns on the right side. A curious feature is that it may be referred to the right shoulder, where indeed it may be more severe than in the hepatic region. Cough is often present and is supposed to be due to reflex irritation. A rise of temperature of from one to three degrees is generally found; in a large number of cases fever is the first symptom. It is usually accompanied by pain in the hepatic region, but occasionally may persist for days or weeks before pain in and enlargement of the liver develop. The fever is not infrequently quotidian in type, or there may be two diurnal exacerbations; these are followed by perspiration.

The irregularity of the attacks of fever is a point of some value in differentiating from malaria. Rigors are not constant. Icterus is one of the rarest symptoms; it is said to arise from pressure of the abscess upon one of the main bile passages. According to Thierfelder,[23] it occurs in about sixteen per cent. of all cases. When hepatopulmonary abscess exists the condition may be quite obscure. Although the liver is first involved, the physical signs as a rule direct attention first to the lung. The resemblance to pleural effusion is striking. Only when the abscess discharges into a bronchus can we get positive information. Here the expectoration of large amounts of characteristic sputum with a diminution in the size of the liver, signs of consolidation, tubular breathing with consonating râles, increased vocal resonance, and whispering pectoriloquy, are conclusive. Pain in the cardiac region, with signs of suffocation and evidence of pericardial effusion, points to rupture of the abscess into the pericardium. Rupture of the abscess into the stomach is often preceded by pain and irritation in the stomach, and is clearly evidenced by vomiting of necrotic matter; or, again, the material may be discharged by the bowel, an occurrence which also may take place whenever rupture has occurred into any part of the alimentary tract.

Prognosis in Liver Abscess.—The outlook in all forms of multiple abscess—as, for example, portal pyemia and suppurative portal hepatitis (pylephlebitis)—is practically hopeless. Treves has, however, recorded a case of abscess of the liver complicating appendicitis in which the patient recovered after an exploratory operation. Suppurative pericholangitis, inasmuch as it presents a greater tendency to form isolated large collections of pus, and therefore is amenable to operative interference, is perhaps more hopeful. At best, however, in all forms of hepatic suppuration the outlook is most grave. More is to be expected in those cases of solitary abscess which can be attacked by modern surgical methods. Much depends upon the position of the abscess, its cause, and the possibility of reaching and evacuating it. On account of the gravity of the primary disease, those cases which are associated with dysenteric symptoms are more liable to turn out badly than those in which there is the so-called "idiopathic" abscess. The relatively favor-

able result in the case of tropical abscess is perhaps to be explained by the fact that the pus is liable to be less virulent and in some cases indeed sterile. It has been estimated that the mortality amounts to from fifty to sixty per cent.

Diagnosis.—The diagnosis of liver abscess is always attended with considerable difficulty, and in fact the condition may frequently only be suspected. This is especially true of multiple small abscesses or diffuse suppuration. The symptoms which should direct attention to the liver are the onset of a sense of weight and oppression, or of actual pain, in the region of the liver, more or less enlargement of the organ, rigors, irregular temperature, cough, dyspeptic disorders, and diarrhea. Pain may be spontaneous or elicited only on palpation. Generally the whole liver is tender, but frequently more painful areas, corresponding to the abscesses, can be made out. Lancinating pain during respiration or a friction rub points to perihepatitis. The tendency for the pain to be referred to the right shoulder has already been referred to, but it is not pathognomonic. Enlargement of the liver is not striking in the very diffuse forms, but in the solitary abscess it is somewhat characteristic; the tendency is for the organ to be enlarged upward. Dulness at the base of the right lung in these cases can usually be made out, and there is some limitation of the free movement of the lung. The dulness reaches its highest point at about the midaxillary line. When the abscesses are in the left lobe, or toward the anterior edge of the enlarged right lobe, they may sometimes be felt as flat nodules which may be so hard as to simulate cancer. Occasionally a fluctuation can be detected. The spleen is not enlarged except in cases of perityphlitis and septicemia.

With the exception of acute yellow atrophy, abscess is about the only grave affection of the liver associated with fever, and here the course of the disease and the alteration in the size of the liver will differentiate. It must not, however, be forgotten that extensive suppuration may exist in the liver without fever.

A condition which will give rise to considerable trouble is croupous pneumonia when associated with enlargement of the liver and icterus. Again, the fever is often remittent or intermittent with chills, and so the affection may be confounded with malaria. A point emphasized by Kelsch and Kiener is the close association of "typhoid" symptoms, viz.: rapid, feeble, and irregular action of the heart, cold sweats, subsultus, drowsiness, emaciation and diarrhea, ending in coma and death, with the presence of small multiple foci of suppuration in the liver.

The previous history of the case often affords valuable information. The presence of a recent wound or injury, a suppurating focus, or recent parturition will suggest a point of departure for a septicemic process; a sudden onset of fever of a septic type, with chills and violent constitutional disturbance, will indicate a systemic generalization of the process, and these symptoms may be so violent as to mask those referable to the liver. In these cases, pain, either dull or lancinating, a sensation of weight or tension in the right hypochondrium, pain or tenderness on pressure with enlargement of the liver, point strongly to liver abscess. Jaundice and involvement of the liver alone, however, are not of so much importance since they may be present in septicemia even in the absence of hepatic involvement.

When the symptoms occur during the course of some ulcerative or infective process within the bounds of the portal tract, this will suggest a portal pyle-

Table for Differential Diagnosis.

Abscess of liver.	Malaria.	Carcinoma.	Right-sided empyema.	Abscess of abdominal wall.	Suppurating echinococcus cyst	Cholelithiasis, cholangitis.
1. History of trauma, suppuration, dysentery, gallstones, parturition, acute infective fevers.	History usually negative; possibly previous attacks.	Possibly a hereditary taint.	History of recent pleurisy; often insidious in onset.	Often a history of previous typhoid or tuberculosis.	A history of previous painless swelling of the liver, without marked deterioration of health.	History of biliary colic, intermittent jaundice.
2. Pain referred to the right hypochondrium or shoulder.	Pain absent or almost trivial.	Pain variable; usually slight.	Pain may be absent.	Local tenderness.	Pain trifling....	Pain, paroxysmal, referred to hypochondrium, passing down the leg or through to the back.
3. High fever almost constant, of remittent or intermittent type, with sweats and chills; may be irregular; resists quinine.	Intermittent fever of quotidian, tertian, or quartan type; does not usually resist quinine; fever regularly returns, according to type.	Fever rare; usually continuous; may be intermittent, with rigors.	Fever often irregular; may be absent.	Irregular fever with chills.	.....	Moderate fever during the paroxysm, otherwise normal or subnormal
4. Often an icteric or subicteric hue; rarely jaundice.	No jaundice.....	Jaundice in one-half the cases.	No jaundice....	No jaundice....	Rarely jaundice.	Jaundice invariably present, recurrent or persistent.
5. Liver may be enlarged and smooth.	May be moderately enlarged.	Liver enlarged and often nodular.	Liver may be pushed down.	Liver not enlarged.	Liver enlarged .	Liver rarely enlarged.
6. May be bulging in right hypochondrium.	Negative.....	May be bulging.	Negative.....	Local swelling..	May be bulging	Negative.
7. Aspiration often detects pus.	Negative	No pus; sometimes cancer cells.	Negative.....	Aspiration will detect pus.	Fluid may contain glucose; pus may contain characteristic hooklets.	Negative.
8. Spleen not enlarged except in pylephlebitis or pyemia.	Spleen enlarged; blood containing plasmodium malariæ.	Negative.....	Negative.....	Negative.....	Negative.....	Negative.

phlebitis or periportal abscess formation. In this form, the brunt of the affection falling upon the liver, the symptoms will at first be mainly referable to that organ. And while symptoms of systemic septicemia, namely, metastatic deposits in the lungs, spleen, kidneys, heart, joints, and skin, may develop, they occur invariably later on. In most instances rigors and sweating are less marked than in the septic embolic form, or may indeed be absent.

The main conditions which may be confounded with abscess of the liver are, malaria, cholangitis, right-sided empyema, abscess of the abdominal wall, carcinoma of the liver and bile passages, and suppurating echinococcus cysts.

An examination of the blood for the hematozoon of malaria will clear up the first question and so also will the therapeutic test; an intermittent fever that resists quinine is not malarial.

The intermittent hepatic fever of cholangitis due to gallstones presents great similarity to abscess, yet in such cases both fever and chills may occur for years without suppuration. The points of distinction are the paroxysmal attacks of fever, the rigors and sweats, an increase of jaundice during the attacks —all are characteristic of cholangitis, when they occur with intervals of apyrexia, cessation or amelioration of the symptoms, and the preservation of fair nutrition.

A right-sided pleural exudate may be excluded by differences in the curve of the upper level of the dulness at the base of the lung without change of this level by posturing, and by the fact that dislocation of the heart does not occur. These considerations will of course not apply when, as is sometimes the case, the liver abscess is complicated by acute pleurisy.

In abscess of the abdominal wall the swelling lies more superficially and is not associated with enlargement of the liver. When it is aspirated the needle does not move up and down with the respiratory movement. If, however, the liver be firmly anchored to the abdominal wall by inflammatory adhesions, even in the case of abscess, the movements may be completely prevented.

Suppurating echinococcus cysts can be differentiated from abscess of the liver only by a comparison of the histories of the two diseases and by an examination of the pus evacuated by aspiration. When the echinococcus is the cause of the suppuration there will be a history of a long-standing painless swelling of the liver, with preservation of fair health, followed by evidences of suppuration; and when the pus is aspirated it will be found to contain the characteristic hooklets.

In cancer of the liver, fever is rare, cachexia is marked, and the disease is essentially chronic. Usually the previous history will throw light on the case.

In all cases of doubt exploratory puncture may be tried without fear of evil consequences. It is well to place the patient under ether, as several punctures may have to be made. The needle may be inserted in the lowest interspace in the anterior axillary line, in the seventh interspace in the midaxillary line, or behind over the area of dulness. The stools and, if perforation has taken place into the lung, the sputum, should be examined for amebæ in all cases of solitary abscess.

Treatment of Liver Abscess in General.—In the multiple abscesses found in the liver as a complication of septic infection elsewhere but little can be expected from treatment. As the condition is not often amenable to surgical interference, we have to fall back on the use of the medicinal measures adopted in septicemia generally. Sponging with cool water at a temperature of 65° F. will often control the fever to some extent. Pain must be relieved by mustard, turpentine, or hot fomentations to the hepatic region, and if necessary by opium. Free stimulation and the use of full doses of quinine are advisable. If there are evidences of a large abscess being formed, operative interference may be discussed and the case treated on the same lines as the tropical abscess.

With regard to the *tropical form*, prevention is better than cure. All Europeans sojourning in the tropics should take special precautions. Sleeping and living rooms should be large and airy, suitable clothing should be worn, and care taken to avoid all sources of chill. Clothing when damp should be quickly changed; moderate exercise is advisable. Diet should be moderate and unstimulating and alcohol should be tabooed; all irregularities of the bowels should be controlled. When signs develop which are suggestive of hepatitis (apart from malaria), whether dysentery be present or not, the patient should be strictly confined to bed on a milk diet. Ipecacuanha should be given in full doses, and intestinal antiseptics, such as benzo-naphthol, should be employed. Occasionally a blue pill is of great benefit. The treatment of dysentery and its sequel abscess of the liver by the exhibition of ipecacuanha has been practised for a century or more, but it is only recently that this method has been placed on a scientific basis. The great difficulty, of course, is that the drug can rarely be administered in large enough doses without producing vomiting. Experience has proved, moreover, that ipecacuanha deprived of its emetic principle, *ipecacuanha sine emetina*, is of no avail. The researches of Vedder have shown that emetine hydrobromide or hydrochloride is fatal for amebæ in dilutions as great as 1 to 100,000, and Roger found that the emetine could be administered subcutaneously without producing untoward effects. The dose is half a grain night and morning. This should be continued for four days, when the amebæ are usually destroyed. The method is most efficient in amebic dysentery and should be used even when hepatic abscess is present. Small purulent foci may be absorbed, and in any case operation is made safer.

When the acute symptoms have passed off, ammonium chloride should be exhibited in fifteen- to twenty-grain doses three or four times a day and continued for some time, or the ipecac may be employed in any suitable form for a couple of weeks. Should an abscess form, it must be treated surgically on the merits of the case. Morphine hypodermically may be given to control pain and relieve cough.

Several methods have been advocated for dealing with large solitary abscesses. These in the main consist of aspiration, siphonage, or open incision. Which method is advisable depends largely upon the position of the abscess and the presence of surrounding adhesions. Aspiration with a stout needle is practically devoid of danger, and should be done under ether so that thorough exploration can be carried out. It is not always possible in this way completely to evacuate the pus, and in any case the cavity is liable to fill again. Nevertheless, some cases of cure after two or three repetitions have been reported. Puncture with a trocar and cannula followed by siphonage is advocated strongly by many Indian surgeons. The method of Manson is first to explore the liver with a hollow needle; when pus is found a small incision is made through the skin and a large trocar and cannula are inserted, care being taken to follow the direction of the preliminary aspiration which revealed the pus. The trocar is pushed in just far enough to reach the abscess, is then removed, and, without allowing any pus to escape, a rubber drain, about nine inches long, is stretched upon a metal rod and carried through the cannula to the bottom of the abscess. The metal rod is withdrawn and the rubber tube stitched to the skin. A long rubber tube is attached to the drain and the contents are allowed to siphon off into a bucket containing antiseptic solution placed at a suitable distance below the patient. An antiseptic dressing, of course, is applied to the wound. Washing out

the cavity is not attempted unless the drainage is imperfect and the temperature begins to rise.

Cantlie[24] advocates this method very strongly and reports twenty-four cases cured out of a series of twenty-eight operated upon. When the method of open incision is adopted, a direct opening into the abscess can be made only when the liver is adherent to the anterior abdominal wall. If the wall over the liver is reddened and edematous, it may be taken for certain that adhesion has taken place. A trocar may be first inserted and a free opening subsequently made. If it be not certain that adhesion has taken place, the operation may be done in two stages. An incision is made through the abdominal walls, the liver is then sutured to the wall, the wound plugged and left till adhesions have formed; subsequently, the trocar may be used till pus is discovered and the track then enlarged with the knife. The sac should be explored with the finger so as to empty any subsidiary pockets.

In more urgent cases and when skilled assistance is at hand an open incision may be made down to the liver; the assistant then holds the liver as nearly as possible in contact with the abdominal wall. Pads are placed so as to prevent infection of the peritoneal cavity, a trocar is thrust in, and when pus is found the opening is enlarged with the knife. After the contents have been evacuated the liver is then stitched to the parietes and the drain inserted. To explore the posterior part of the liver, it may be necessary to insert the trocar through both layers of the pleura and the diaphragm. If an abscess is here found, however, drainage should be established by resecting the rib, stitching the two layers of the pleura together with catgut, and then inserting the trocar and cannula. It has been advocated recently to inject into the abscess cavity, after evacuation of the pus, one grain of emetin chloride dissolved in an ounce of water.

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REFERENCES.

1. Nicholls: Canadian Jour. of Med. and Surg., vi., p. 416, 1899.
2. Ford, W. W.: Bacteriology of Healthy Organs. Trans. Assoc. Amer. Phys., vol. xv., p. 389, 1900.
3. Nicholls: Journ. Med. Research, xi., No. 2, May, 1904.
4. Birch-Hirschfeld: Path. Anat., Bd. xi., 2 Hälfte, Leipzig, p. 716, 1895.
5. Armstrong, G. E.: Brit. Med. Journ., vol. ii., p. 945, 1897.
6. Lannois: Rév. de Méd., November, 1895.
7. Mayo Robson: Article Cholangitis, Allbutt's System of Medicine, vol. iv., 1897.
8. Leick: Deutsche medizinische Wochenschrift, 1898.
9. Kartulis: Zur Aetiol. der Leberabscesse u. über trop. Leberabscesse u. s. w. Cthl. f. Bakteriologie, Bd. 2, 1887 and Virchow's Archiv, Bd. cxviii., 1889.
10. Lafleur: Article, Amebic Abscess of Liver. Allbutt's System of Medicine, vol. iv., 1897.
11. Manson: Quoted by Robinson. Journ. Amer. Med. Assoc., May 11, 1901.
12. Hirsch: Handb. geo. and hist. Path., London, vol. iii., p. 412, 1886.
13. Sachs: Arch. klin. Chir., xix., p. 235, 1876.
14. Rouis: Sur les suppur. endém. du foie, Paris, 1860.
15. De Castro: Des abcés du foie, Paris, 1870.
16. Bärensprung, K.: Langenbeck's Arch. f. klin. Chir., xiii., Heft 3.
17. Lösch: Massenhafte Entwickelung von Amœben im Dickdarm. Virch. Arch., 65, 1875.
18. Kruse and Pasquale: Untersuch. über Dysenterie u. Leberabscesse. Zeit. f. Hyg. u. Infectionskrankh., Bd. xvi., Hft. 1.
19. Councilman and Lafleur: Johns Hopkins Hospital Reports, No. 2, 1891.
20. Flexner: Amer. Journ. Med. Sciences, May, 1897.
21. Kelsch and Kiener: Traité des maladies des pays chauds, Paris, p. 249, 1889.
22. Chauffart: Charest's Traité de Méd., t. iii., Paris, 1892.
23. Thierfelder: Diseases of the Liver. von Ziemssen's Cyclop., vol. ix., p. 126, 1880. English translation.
24. Cantile: British Medical Journal, September 14, 1901.

For a complete histological study of liver abscesses, see Rindfleisch: Ueber die metastatische Abscessbildung. Lehrb., p. 409, 1878.

Liver, Acute Yellow Atrophy of the.—DEFINITION.—Acute yellow atrophy of the liver is a general disease, characterized anatomically by an autolytic granular and fatty degeneration of the liver cells, parenchymatous inflammation of the kidneys, catarrh of the gastrointestinal tract, degeneration of the cardiac muscle, and endothelial degeneration and rupture of the minute blood-vessels. These phenomena may be due to a poison in the blood, or as suggested by Flexner are the result of an acute autolysis of the liver cells. The poison may be organic (microorganisms), or inorganic (phosphorus, antimony, arsenic, alcohol); or it may be generated in the system (pregnancy, mental emotion, etc.). Quincke believes that in some cases the condition is an outcome of acute parenchymatous hepatitis. The nature of the poison, if it be generated in this manner, is not known. As a fact which bears out the view of an intoxicant or poison, the great similarity to phosphorus poisoning must be emphasized. There are distinct differences, however, in the pathology of hepatic degenerations seen as a result of poisoning or acute infections, and the tendency to-day is to consider acute yellow atrophy as a distinct clinical entity. During life intense jaundice, nervous symptoms (delirium, coma, and convulsions), alterations in the size of the liver and spleen, changes in the composition of the urine, and general hemorrhages occur.

FREQUENCY.—Acute yellow atrophy of the liver is a rare disease. Thierfelder collected about 140 cases, and Legg 100 for their monographs. Hunter in 1895 could refer to only 250 cases, Best in 1903 found 450. (Rolleston.) Eleven cases only were recorded in Guy's Hospital in twenty-seven years. There were but three cases observed in Johns Hopkins Hospital in twenty-three years (Osler).

ETIOLOGY.—Certain predisposing influences are noted in the etiology of this disease, viz., the age, the sex and habits of the individual, and the season of the year. It occurs most frequently between the ages of fifteen and thirty-five, although cases after sixty have been recorded. Ashby observed a case in a boy, aged four, and Legg refers to several about two years of age, and to one in a new-born child. Merkel has collected 18 cases in children, Schmidt 16 cases under ten years of age, and Rolleston, 42 cases occurring within the first ten years of life. The female sex is most liable to the disease, the proportion being about eight to five. A larger number of the recorded cases have been observed among dissipated persons—prostitutes, drunkards, and those who drink largely of malt liquors. Syphilis was thought by many to predispose to this affection and it was said that at the commencement of the secondary stage, acute yellow atrophy might develop, following the jaundice sometimes seen at this period, and might terminate fatally. Lebert thought the extremes of heat and cold favored the development of the disease, but the analysis of Legg disproves the predisposing influence of the seasons. Series of cases have been described which appeared to show a marked family tendency to the disease, especially among those of the family who lived together under one roof. They possibly were cases of malignant jaundice, due to some microorganism—epidemic or endemic in character. Quincke speaks of such cases in epidemics of severe icterus; they have usually been fatal, while the other individuals have merely shown more or less severe symptoms of a toxic jaundice with subsequent recovery. Pregnancy is the most marked predisposing cause. The disease usually occurs between the third and the sixth months of gestation. Cloudy swelling and parenchymatous degeneration of all the glands, more marked in the case of the liver and kidneys, is a physiological accompaniment of pregnancy and suckling. Frerichs has insisted upon the importance of this, in connection with the frequency of acute yellow atrophy of the liver in pregnancy. It is

known that epidemic jaundice is more fatal in pregnant women than in any other class of people.

The mode of action of the exciting causes of acute yellow atrophy is involved in much obscurity. Nervous influences have been seen as an exciting cause. Malaria, the continued fevers, and scarlatina have been followed by what was apparently true acute yellow atrophy, similar acute hepatic destruction is seen occasionally in syphilis. Cases have developed after osteomyelitis (Meder), after typhoid, diphtheria, sepsis (Dunkler and Babès), erysipelas, febris recurrens; these may have been and probably were nothing more than severe grades of parenchymatous hepatitis. The development of a special poison in the system by nervous influence, or from faulty digestion or assimilation, has been invoked for the causation of this disease. The growth of microorganisms in the blood and organs has been demonstrated, usually, however, only the *B. coli communis*, streptococci, and staphylococci, and no specificity of action can be claimed; it is more likely that the disease is due to organic or bacterial toxins or even to ptomaïnes absorbed from the intestines. Quincke insists that the disease is an intoxication and in no way to be considered an infection; further, that it may be produced by various poisons, giving rise to varying degrees of severity. As one possible cause he gives obstruction of the diverticulum of Vater and consequent overflow of pancreatic secretion into the bile passages and liver. Some of the intermediate products of digestion, the albumoses, have been found to possess highly poisonous qualities, and have been regarded by some as possible agents.

Morbid Anatomy.—On section of the abdomen the liver cannot usually be seen. It is high up against the diaphragm, or placed backward toward the spinal column. It is small, weighing less than one-half or one-third as much as the healthy organ. Of course, acute yellow atrophy may occur in a liver previously cirrhotic or fatty. Its surface is smooth and of a mottled greenish-yellow color. The capsule is usually wrinkled, but free from opacity. The organ is thin and limp. On section marked changes in color are seen. The entire cut surface may be uniformly yellow, or yellow alternating with a dark red or purple color. The lemon yellow, ochre, gamboge, or Turkey-rhubarb yellow color is distinctly outlined, or shades into the deep red. It is due to bile not to fat. In the yellow portion the lobules are indistinct or increased in size. In the red portion the lobules are diminished in size, and with a lens the interlobular connective tissue is observed to be increased. The red portion is more shrunken and firmer than the yellow, which appears swollen and very soft. The red is considered by most pathologists to be a later stage of the yellow, the bile and necrotic products having been absorbed, leaving a fibrous framework and capillaries filled with blood; the red areas are further depressed below the level of the yellow. The ducts are patulous; the mucous membrane is bile stained or covered with mucus. In many cases a catarrh of the finer ducts has been observed. The gall-bladder is empty, or contains light-colored bile or only some mucus.

The histological appearances of the yellow and red portions vary. The hepatic cells of the yellow portion are swollen and cloudy, are granular, and are bile stained. In fact, all these changes are observed in each case. The nucleus is pushed aside or displaced entirely, and in many instances masses of granules represent the cell. In a section vacuoles or vacant places are often observed, the necrotic elements refusing to take the stain. Hemorrhages occur between the cells.

On section of the red part, an increase of the interlobular connective tissue may be observed, with an abundance of young connective-tissue cells, and capillaries filled with blood cells. The liver cells that remain—most of them having been destroyed—are atrophied and shrunken. The central vein is thickened and often surrounded by a young growth of connective tissue. The capillary bile ducts must to a large extent diminish or disappear with the destruction of the rows of liver cells. Pigment is observed among the cells in all instances, hematin crystals are abundant, and crystals of leucin and tyrosin are almost constantly observed. A definite increase in the connective-tissue elements may be observed. It is not limited to the red areas, although perhaps apt to be here more marked, and often has the appearance of considerable age; proliferation of the interlobular bile ducts is an almost constant feature. Distinct regeneration of liver substance has been described by Marchand in the case of a patient who died six months from the onset of symptoms. W. G. Macallum records a similar observation.

The blood is dark and fluid, the spleen is enlarged and pulpy; the kidneys are enlarged, swollen, and congested. On microscopical examination, cloudy swelling, and fatty and granular degeneration of the tubular epithelium are seen. The heart is soft and flabby, and marked fatty and granular degeneration of the muscular fibers is found. In some cases the degeneration extends to the blood-vessels, and in various parts of the body the endothelium is found to have undergone fatty and granular degeneration. No special lesions of the brain have been observed. The cerebral vessels are markedly the seat of fatty degeneration of the intima; consequently hemorrhages into the membranes and the brain tissue occur.

The mucous membrane of the stomach is congested and the seat of ecchymoses. The glands of the stomach and intestines are filled with granular and disintegrating epithelium. The stomach usually contains clotted or semi-coagulated blood. There is blood also in the intestines, in the lower part of which it assumes a tarry appearance.

In addition to the presence of ecchymoses in the gastrointestinal tract, they are also seen in the skin and in the mucous membranes, in the pleura, the peritoneum and omentum, and in the brain and its meninges. The surface of the body and the mucous membranes are bile tinged, and if a blister is applied, the serum is also bile tinged.

The uterus, in cases occurring in pregnancy, either contains the fetus or presents signs of a recent abortion or childbirth.

Symptoms.—The onset may be gradual or sudden. In that form of the disease with the gradual onset, symptoms of gastroduodenal catarrh may continue for two or three weeks, or even longer, before grave symptoms arise. In the suddenly developing form, acute jaundice, accompanied by marked nervous phenomena, immediately ushers in an attack. The more protracted cases (the first class) present two varieties of symptoms, viz., prodromal and toxemic. The symptoms of the prodromal stage are those of acute gastroduodenal catarrh—headache, nausea, vomiting, loss of appetite, a bitter taste in the mouth, and general malaise. Diarrhea may also occur. At the end of forty-eight hours or frequently after the lapse of some days, slight icterus appears and gradually increases in intensity. Bamberger states that in very rapidly fatal cases, it may occasionally be completely absent. Fever does not usually attend these symptoms. On the other hand, the pulse and temperature, as in jaundice, are often subnormal. The feces are colorless, grayish, or particolored; often, indeed, they are quite natural. The urine contains bile pigment and urobilin. Enlargement of the liver may occur. While this change is not constant in acute yellow atrophy, it is a more or less regular happening in poisoning by phosphorus.

The toxemic stage succeeds these prodromal symptoms more or less suddenly, and after varying intervals of time. The prodromal stage may be very short or

quite protracted—even as long as three weeks. In some cases the toxemic stage is announced by a convulsion or sudden profound coma. Legg insists on careful observation of the pupil in cases of jaundice, and declares that dilatation of it is the most significant indication of approaching cerebral symptoms. In others the typhoid state gradually supervenes, and is characterized by stupor, low muttering delirium, subsultus tendinum, incontinence of urine and feces, restlessness, hiccough, motor and sensory paresis, with dilated, often insensible, pupils. A dry and brown, or fissured and glazed, tongue is present, sordes collects in the mouth, and the vomiting of the prodromal stage continues, though the character of the ejecta changes, frequently becoming black or even bloody from the hemorrhage in the gastrointestinal tract. Dark tarry stools also indicate its presence. Constipation may be present.

The typhoid state terminates in deep coma, death being preceded by irregular or Cheyne-Stokes breathing, an irregular pulse, involuntary discharges, and sometimes by recurring convulsions. In some instances the typhoid type is not assumed, but active maniacal delirium attends this stage, with or without convulsions; coma or exhaustion closes the scene. Again, there is no delirium, but frequent and prolonged general convulsions occur, with local spasms in the interval and coma vigil. It is believed that the cerebral symptoms are due largely to hemorrhagic extravasation in the brain and its membranes. The blood dyscrasia, however, is probably an important factor. The brain symptoms have been attributed to uremia, but the theory of such origin is not upheld by clinical facts. Austin Flint, Jr., thought they were due to cholesteremia, while others attributed them to the presence of bile acids in the blood. Frerichs ascribed them to the presence of leucin and tyrosin in the blood, but experiments do not confirm his notion.

It is in this period that hemorrhages occur from mucous surfaces, as the nares, mouth, pharynx, stomach, and intestines. They also occur in the skin and into the serous membranes. They are due to changes in the walls of the capillaries and small blood-vessels, or, as some assert, to the altered blood. The hemorrhages are passive, and in the skin they are observed as petechiæ or vibices; in the external mucous membranes they appear as sordes or small clots. They may be seen in the conjunctiva. Litten describes hemorrhages in the retina. The constant oozing from the nares may seriously threaten life, while in females an abortion is almost always attended by a most profuse hemorrhage. When hemorrhages into the stomach and intestines have taken place, the discharges present a dark appearance, as indicated above.

The urine undergoes marked change. It is passed involuntarily, and wetting of the person is prevented with difficulty. Albumin and hyaline, epithelial, and granular casts are present from associated tubal nephritis. Glycosuria has not been recorded. The urea is much diminished in quantity; phosphates and chlorides are also diminished. The urea is replaced by nitrogen in the form of ammonia. The presence of leucin and tyrosin is not pathognomonic, and they may be absent (Murchison). This was also the case in nine of twenty-three cases collected by Hunter (quoted by Osler). There is a marked increase in the output of nitrogen owing to destruction of the cells of the liver and other tissues. The urine is usually acid, dark in color, and contains bile pigment. Contrary to their course in the prodromal stage, the pulse and temperature are increased in the toxemic period. This is especially true of the pulse. It is increased in frequency, often excessively rapid, and not uncommonly irregular. The temperature range varies. In the majority of cases there is no rise; in others the ascent does not occur until the last day or two of life, and may attain the highest point after death. The following case of Musser, Sr., is an excellent picture not only of the disease itself but also of the peculiar temperature range. A patient, fifty-one years of age, was admitted into the hospital, for acute maniacal delirium, on March 12, 1885. She did not improve, and on April 9 had a "bilious attack," followed in three days by jaundice and urticaria. After the jaundice the maniacal delirium gave way to a low, muttering form. The icterus appeared on the trunk and arms first, and then extended to the entire surface. She lived nineteen days, and during the course of the disease had diarrhea with pale, loose stools, and hemorrhages from all the mucous surfaces, petechiæ and vibices. The liver dulness decreased in area, while the spleen increased from day to day. The urine became albuminous, contained hyaline and granular casts, blood and bile pigment, leucin, and tyrosin. The urea became diminished in amount. The temperature range is indicated below. During the three days preceding the jaundice, when the patient was "bilious," a rise of temperature occurred. It then fell to normal and remained low until four days before death, when a continuous ascent began, reaching the acme, 105.8° F., thirty-five minutes after death.

Day of illness.	Degrees Fahrenheit.		Day of illness.	Degrees Fahrenheit.	
	A. M.	P. M.		A. M.	P. M.
First	99.0	101.0	Eleventh	96.8	97.0
Second	99.4	100.2	Twelfth	97.2	97.0
Third	100.4	100.0	Thirteenth	96.6	96.8
Fourth	99.4	98.4	Fourteenth	97.0	97.2
Fifth	98.8	98.0	Fifteenth	96.8	96.8
Sixth	98.0	99.2	Sixteenth	97.6	98.4
Seventh	99.0	98.4	Seventeenth	99.0	99.4
Eighth	97.6	97.6	Eighteenth	99.4	100.2
Ninth	97.0	97.4	Nineteenth	101.6	101.8
Tenth	97.4	97.6	Twentieth	104.6	104.8*

* At 5.20 P. M. death.

The pulse did not increase beyond 90. During the first, second, and third days of the illness it ranged from 82 to 90; from the fourth to the eighth day, inclusive, 76 to 82; and from the ninth to the sixteenth day the average daily range was 66. After the latter day it increased daily to the last day, when it was 86 (highest).

With the occurrence of cerebral symptoms and hemorrhages and as the disease progresses, changes take place in the liver and spleen. On physical examination the liver dulness is observed to decrease from day to day, and even may disappear anteriorly. One must be careful to remember that the flatulent distention of the intestines may cause apparent lessening in the area of hepatic dulness. It must also not be forgotten that the liver may be enlarged. The spleen, in a certain proportion of cases, is enlarged. Legg states that in one-third of the cases an enlargement is found at the autopsy. Musser, Sr., states that with the diminution in the size of the liver pain in the hepatic region is experienced, and that it may be extreme, entailing a great deal of suffering. Although attended by vomiting, the pain does not appear to have any relation to it. Marked tenderness in the epigastrium is associated with it in many instances.

The course of acute yellow atrophy of the liver varies. It is sometimes extremely rapid. Fifty per cent. of cases are fatal between the fifth and the fourteenth days; before the fifth day death is rare and is usually to be seen only in pregnant women (Thierfelder). Death has been reported to occur twenty-four hours after the first seizure. The toxic stage is much shorter than the prodromal; the latter usually continues for from one to eight weeks. The disease runs a more rapid course in pregnant women.

Prognosis.—The prognosis is unfavorable, but

not necessarily fatal. Cases of recovery have been recorded (Wickham Legg, Wirsung, Rolleston). In Wilks' celebrated case the patient recovered, and died two months afterward of a relapse. The case of Marchand (*vide supra*) shows that true regeneration of liver substance—and therefore recovery—is a possibility. The cases of Berbacci, Steinhaus, and Stroebe (quoted by Rolleston) point to the same condition.

Diagnosis.—The presence of the cardinal features of a case of acute yellow atrophy of the liver renders the diagnosis easy. The prodromal symptoms, the jaundice, the character of the urine, the nervous phenomena, the changes in the liver and spleen, and the hemorrhagic symptoms are to be kept in mind. Icterus gravis and severe cases of acute infectious jaundice are to be distinguished principally by the presence of an enlarged liver.

Care must be taken to exclude those forms of acute atrophy which are due to phosphorus poisoning, to syphilis, or to acute infections in their late stages, by attention to the antecedent circumstances and the history of the case.

Treatment.—The treatment can be stated in a few words. Some cures have been reported, and hence it is well to seek some methods of treatment. The indications that we can thus far discern are to relieve or cure the catarrhal symptoms as quickly as possible, and to allay the malignant symptoms of the second stage. The former is the treatment of gastroduodenal catarrh or catarrhal jaundice. General principles guide us in the treatment of the latter.

Norman B. Gwyn.

Liver. Anatomy, Topography, and Histology of the.—Historical Note.—From the standpoint of pathological and physiological anatomy the liver (hepar) is the oldest of the viscera. This is due to two causes: (1) its use in divination; (2) because it was for a long time considered the organ of sanguification.

Its use in divination can be traced back to ancient Babylonian history—about 3000 B.C. The Babylonian priests studied carefully the anatomy of the liver and made clay models of the liver of the sheep, the animal ordinarily used for sacrifice, for the purpose of instructing aspirants to the priesthood. A model of this kind is in the British Museum and probably dates from the period of Hammurabi, about 2000 B.C.

That the Etruscans, Greeks, and Romans also used the liver in divination is shown by the finding in 1877 near Piacenza of a bronze model of a sheep's liver which dates from about the third century B.C. The markings on this and the above-mentioned model are practically alike and indicate that an elaborate system of hepatoscopy existed among the Babylonians and Etruscans. A third model of the liver, in alabaster, is in the museum at Voltera. The period to which this belongs has not been determined.

Stensen in 1664 said: "The heart has been considered the seat of natural warmth, as the throne of the soul and even as the soul itself." This was true at a certain stage of culture in Greece, Italy, and India; but at an earlier period this distinction was given to the liver.

Jastrow states that the liver held its supreme position as late as the days of Mohammed and "that on an occasion of great sorrow the prophet wept all night 'as though his liver would crack,' where we would say, 'as though his heart would break.'"

Galen made the liver the central organ of nutrition and sanguification. All the veins arose from the liver; the blood was elaborated in its glandular tissue from the chyle brought to it, by means of the portal system, from the stomach and intestines.

The blood did not circulate, but there was an ebb and flow within the veins, passing from the liver toward the periphery during the day and returning to the liver at night.

Step by step the work of Columbo, Harvey, Pequet, and Bartholin robbed the liver of its high position as an organ of sanguification, and its obsequies were written by Bartholin, who composed a long epitaph the substance of which is, that the liver having for a long time been famous, through an usurped title, is at last reduced to a poor organ whose sole function is that of producing bile.

Gross Anatomy.—The liver is the largest gland in the body and plays an important part in its nutrition; its function being the production of the bile and the metabolism of sugar. It occupies the greater part of the regio hypochondriaca dextra and the regio epigastrica, and extends into the regio hypochondriaca sinistra, in some cases, as far as the linea mammilaris.

It is of a mottled reddish-brown color, soft in consistency and easily lacerated. The mottled appearance is due to the lobules (lobuli hepatis) of which it is composed. Each lobule is from one to two millimeters in diameter.

In the fresh, normal state, owing to its soft consistency, the liver flattens, and all conception of its true shape is lost when it is placed on a solid, plane surface.

Weight.—The weight of the liver varies according to the age of the individual. It is relatively heavier in the fetus than in the adult, being in the former about one-eighteenth of the body weight, while in the latter it is from one-fortieth to one-thirty-sixth of the body weight.

The weight of the liver differs also in the two sexes. The average of the published weights together with some personal observations gives 1,500 grams for the male and 1,300 grams for the female, with a range for the two sexes of from 1,200 grams to 1,600 grams (2.6 to 3.5 lb.). The senile liver has an average weight of only 850 grams.

Size.—It is somewhat difficult to harmonize the various measurements of the liver given by different authors, for no mention is made of the age, sex, or condition of the liver.

Most of the difficulties have been overcome by the introduction of methods which fix and harden the liver *in situ*. Many of the older figures must have been obtained from fresh specimens, for it will be found that the transverse measurement has been lessened while the vertical and anteroposterior have been increased by modern methods of fixation and hardening, as the following table will show.

Measurements of the Liver in Centimeters.

Author.	Transverse.	Vertical.	Antero-posterior.
Luschka	36	13–17	9
Cunningham	17.5	15–17.5	15
Piersol	22–24	16	12–18.5
Howden-Grey	20–22.5	15–17.5	10–12.5
Miller	22–24	15–17	10–12

Shape.—The liver is of an irregular wedge shape with its broadest part directed to the right and its thin edge toward the left. (Figs. 3751 and 3752.) An adequate idea of the true shape of the liver can be gained only by a study of specimens that have been hardened *in situ*, and even in these cases its shape is subject to modifications due to variations in the size and shape of the adjacent viscera.

Facies.—On a liver hardened *in situ* three principal surfaces can be recognized; a facies superior, a facies posterior, and a facies inferior. The facies superior is uniformly and strongly convex, corresponding to the arch of the diaphragm beneath which it is situated. The facies posterior is also convex; it is broad behind

the lobus dexter but becomes narrow on the lobus sinister. The porta hepatis forms the boundary between the facies posterior and the facies inferior.

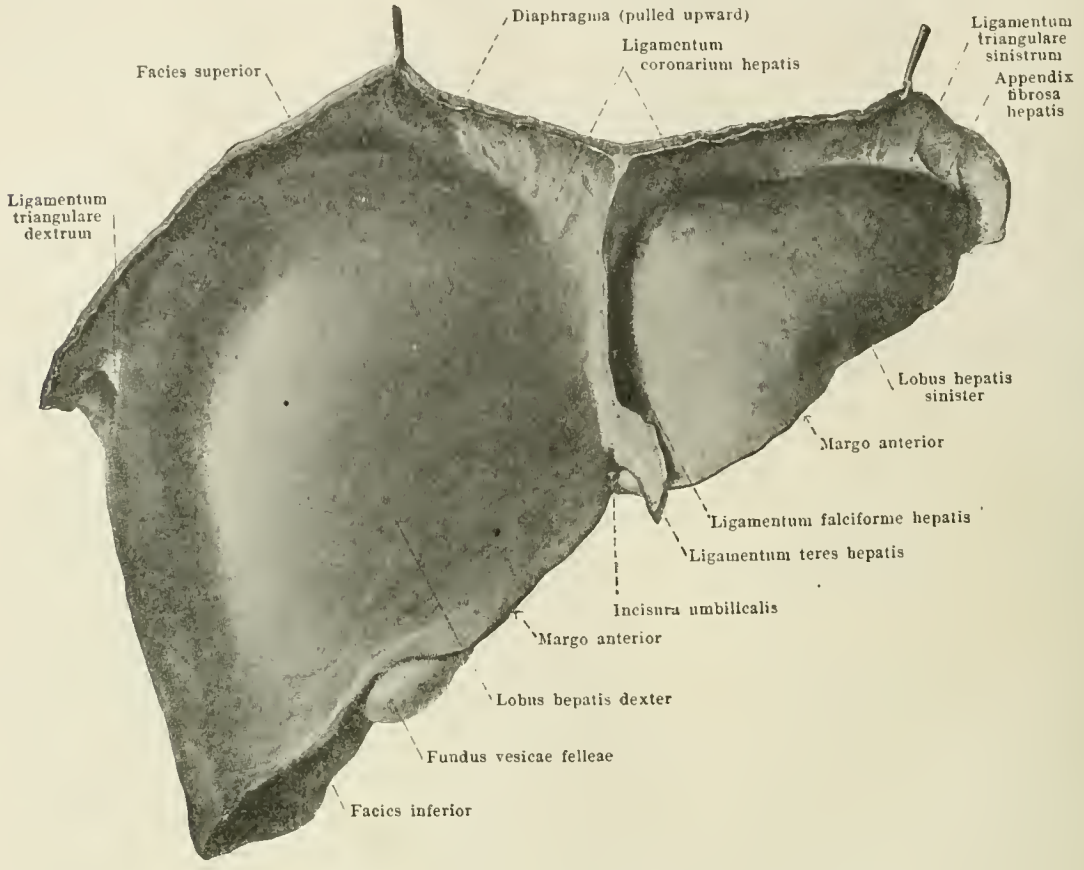

Fig. 3751.—The Liver with Its Ligaments; Viewed from in Front. (After Spaltehnlz.)

The facies inferior, sometimes termed the visceral surface, is flatly concave and directed obliquely downward and posteriorly. Its configuration is influenced by the organs situated beneath it. (Plate XLIII, Fig. 1.)

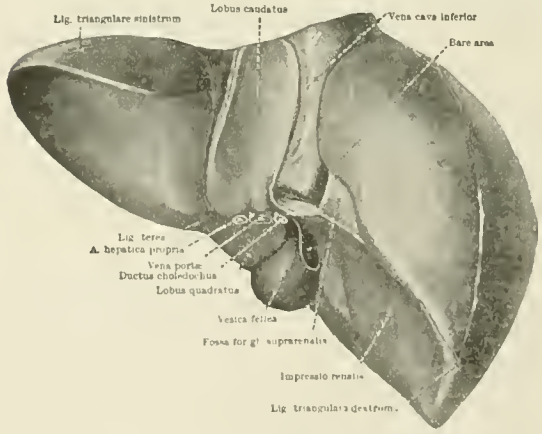

Fig. 3752.—The Liver Viewed from Behind. (After Cunningham.)

Where the facies superior and the facies inferior meet, a thin, sharp border is formed, the margo anterior; this is interrupted at the junction of the lobus dexter with the lobus sinister by a deep notch, the incisura umbilicalis. The margo anterior continues around the edge of the lobus sinister and terminates on the facies posterior at the impressio œsophagea.

Porta Hepatis.—The porta hepatis (transverse fissure) is a deep fissure, from four to six centimeters in length, extending transversely across the liver at the junction of the facies posterior with the facies inferior. (Figs. 3752 and 3753 and Plate XLIII.) The arteria hepatica propria, the vena portæ, and the plexus hepaticus (sympathicus) enter, and the ductus hepaticus and the lymphatics leave, the liver at this point. The porta hepatis forms the boundary between the lobus quadratus and the lobus caudatus. At its left extremity it joins the fossa sagittalis sinister which forms the boundary between the lobus dexter and the lobus sinister.

Within the porta hepatis the vessels and nerves are arranged as follows: the ductus hepaticus formed by the union of the right and left bile ducts is situated in front and near the right extremity of the porta; behind the ductus hepaticus is the arteria hepatica propria and its ramus dexter and ramus sinister, while still more posteriorly, but between the two preceding, is the vena portæ which divides in the porta into its right and left branches. The branches of the plexus hepaticus accompany the blood-vessels and the lymphatics and are dispersed throughout the connective tissue which surrounds and fills in the intervals between all these structures and the adjoining parenchyma of the liver, the capsula fibrosa (capsule of Glisson).

Fossæ.—Extending across the facies inferior and

the facies posterior of the liver are the fossæ sagittales dextræ and the fossa sagittalis sinister. The fossæ sagittales dextræ consist of the fossa vesicæ felleæ, in which the gall-bladder (vesica fellea) is situated, and the fossa venæ cavæ in which the vena cava inferior is embedded. The fossa sagittalis sinister is situated between the lobus sinister and the lobus dexter. The porta hepatis joins this fossa at a right angle. The portion situated anterior to the porta hepatis is called the fossa umbilicalis and lodges the umbilical vein in the fetus and its remains, the ligamentum teres, in the adult; it separates the lobus sinister from the lobus quadratus and is frequently bridged over by a thin band of liver tissue, the pons hepatis. The portion of the fossa sagittalis sinister lying posterior to the porta hepatis, between the lobus sinister and the lobus caudatus, is called the fossa ductus venosi from its giving lodgment to the ductus venosus in the fetus and its remains, the ligamentum venosum, in the adult. (Figs. 3751 and 3753.)

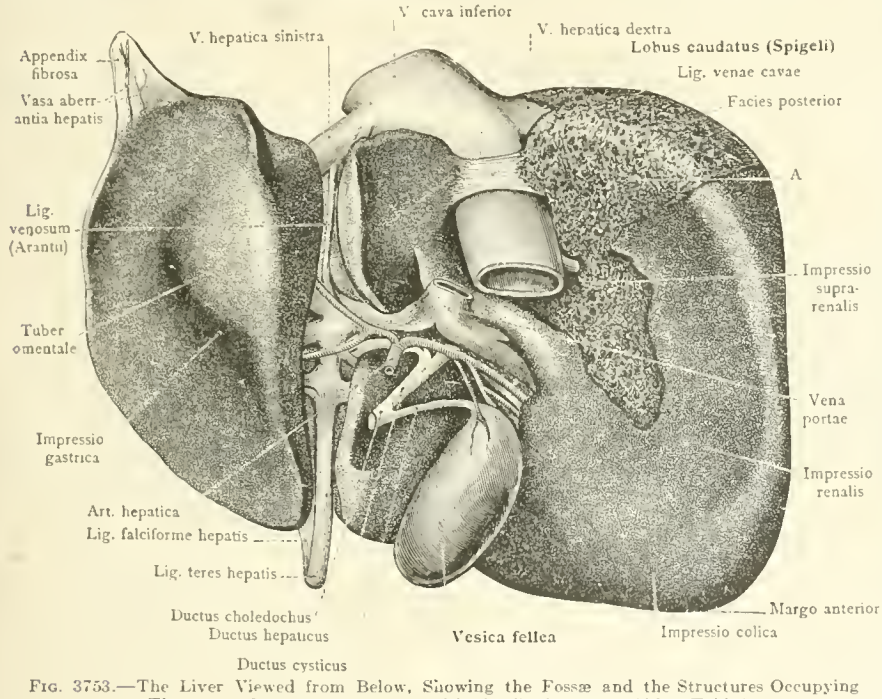

Fig. 3753.—The Liver Viewed from Below, Showing the Fossæ and the Structures Occupying Them. A. Bare area in contact with the diaphragma. (After Toldt.)

Lobes.—The liver is subdivided into four lobes; the lobus dexter, the lobus sinister, the lobus quadratus, and the lobus caudatus. (Figs. 3751 and 3753.) The lobus dexter is the largest of the four lobes. It is situated in the regio hypocondriaca dexter. It is separated from the lobus sinister on the facies superior by the ligamentum falciforme and on the facies inferior and on the facies posterior by the fossa sagittalis sinister. The facies inferior and facies posterior of the lobus dexter are subdivided by the three fossæ described in the preceding paragraph into the lobus caudatus (Spigelian lobe) and the lobus quadratus.

The lobus sinister is much smaller than the lobus dexter. It is situated in the regio epigastrica and partly in the regio hypocondriaca sinister. It forms the thin portion of the thin wedge of the liver.

In the fetus the lobus sinister is much larger proportionally than in the adult. A remnant of the fetal structure is frequently found attached to the margo anterior, as it bends around the sharp edge of the lobus sinister, and is continuous with the ligamentum triangulare sinistrum. This is the appendix fibrosa hepatis and contains the vasa aberrantia hepatis and blood-vessels (Fig. 3753).

The lobus caudatus is situated on the facies posterior of the liver between the vena cava inferior on the right, the fossa ductus venosi on the left and the porta hepatis below. That portion of the lobus caudatus adjoining the porta hepatis is usually notched. The part at the right of the notch is called the processus caudatus and consists of a narrow band of tissue which connects the lobus caudatus with the lobus dexter. It forms the superior boundary of the foramen epiploicum (foramen of Winslow). The part at the left of the notch is called the processus papillaris and is the larger of the two divisions.

The lobus quadratus is bounded behind by the porta hepatis, on the right by the fossa vesicæ felleæ, on the left by the fossa venæ umbilicalis, and in front by the margo anterior. As its name implies, it is of a quadrilateral shape.

Ligaments.— Connecting the liver with the diaphragma and the paries abdominalis anterior are a series of five ligaments; four of these are formed by folds of the peritoneum, while the fifth is formed by the obliterated vena umbilicalis. In addition to these, folds of the omentum minus connect the liver with the ventriculus (stomach) and with the duodenum. (Figs. 3751 and 3753 and Plate XLIII, Fig. 2.)

The ligamentum falciforme hepatis consists of a fold of the peritoneum extending from the paries abdominis anterior and the inferior surface of the diaphragma to the facies superior of the liver. Below its attachment to the liver it presents a free edge along which, enclosed between its two layers, the ligamentum teres passes.

The ligamentum coronarium hepatis consists of a superior and an inferior layer; between these two layers is situated the so-called "bare spot" or "uncovered portion of the liver" (this is the portion of the liver that is in direct contact with the diaphragm and devoid of a peritoneal investure). The superior portion is formed by the prolongation, to the right, of the right layer of the ligamentum falciforme hepatis, while the inferior layer is formed by the continuation to the left of the inferior layer of the ligamentum triangulare dextrum. Both of these ligaments connect the liver with the diaphragm. A reflection of a portion of the inferior layer of the ligamentum coronarium from the liver to the superior portion of the right kidney is termed the ligamentum hepatorenale.

The ligamentum triangulare dextrum is formed by the thick, fused extremities of the superior and inferior layers of the ligamentum coronarium.

The ligamentum triangulare sinistrum is formed from the left layer of the ligamentum falciforme and extends from the facies superior of the lobus sinister to the diaphragm.

The ligamentum teres hepatis (round ligament) extends between the umbilicus and the incisura um-

bilicalis enclosed within the free margin of the ligamentum falciforme. From the incisura umbilicalis it extends along the fossa venæ umbilicalis to the left branch of the vena portæ where it terminates. It is the remains of a fetal structure, the vena umbilicalis sinistra.

The omentum minus extends from the liver to the curvatura ventriculi minor and the duodenum. It is attached above to the margins of the porta hepatis and the fossa ductus venosi; below it is attached to the curvatura ventriculi minor and to the upper border of the pars superior duodeni. The portion of the omentum minus extending from the liver to the ventriculus is called the ligamentum hepatogastricum; that portion extending to the duodenum is called the ligamentum hepatoduodenale.

Impressiones.—The liver presents on its various facies depressed areas of greater or lesser extent (impressiones) due to the pressure exerted by adjacent structures (Figs. 3753 and 3754 and Plate XLIII, Fig. 1.)

The impressio cardiaca is a slight depression on the facies superior situated in front of and slightly to the left of the vena cava inferior.

The impressio œsophagea is situated on the facies posterior of the lobus sinister at the termination of the

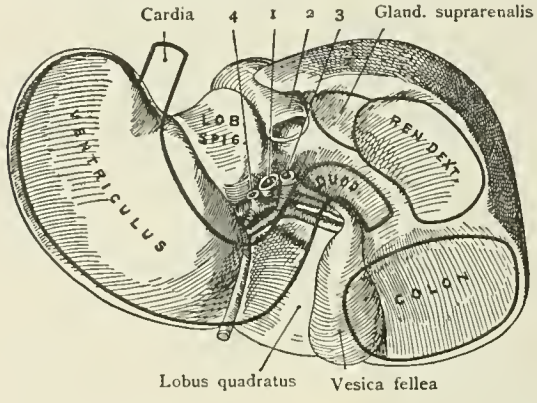

Fig. 3751.—Projection of the Viscera on the Facies Inferior and Facies Posterior of the Liver. 1, Vena portæ; 2, vena cava inferior; 3, ductus choledochus; 4, arteria hepatica. (Corning, after Poirier and Charpy.)

margo anterior. The impressio gastrica is situated on the facies inferior of the lobus sinister. At its right is the tuber omentale; this is a portion of the facies inferior that is free from pressure and projects into the concavity of the curvatura ventriculi minor.

On the facies inferior of the lobus dexter three distinct impressiones can be recognized: the impressio colica, anterior to and at the right of the vesica fellea; the impressio renalis, immediately posterior to the impressio colica; the impressio duodenalis, mesial to the impressio renalis and near the collum vesicæ felleæ.

The impressio suprarenalis is situated on the "bare spot" of the lobus dexter to the right of the vena cava inferior.

Ducts.—The excretory apparatus of the liver consists of a much branched duct, that conveys the bile from the liver to the duodenum, and of a reservoir (vesica fellea) interposed along the course of the main excretory duct.

The beginning of this system of canals and its relation to the liver will be considered in connection with the histology of the liver. The smallest of the excretory ducts are called ductus biliferi (bile capillaries); these unite to form, within the capsula fibrosa the ductus interlobulares (portal canals); these in turn unite and form, eventually, two or more main branches, the larger of which come from the lobus dexter; these unite almost immediately, within the porta hepatis, to form the ductus hepatis.

The ductus hepatis is from 25 to 30 millimeters in length, and, when collapsed and flattened, about 6 or 7 millimeters in width. It lies within the porta hepatis; as it emerges from the porta hepatis it unites with the ductus cysticus to form the ductus choledochus.

Vesica Fellea.—The vesica fellea and the ductus cysticus are, embryologically, an outgrowth from the ductus choledochus. The vesica fellea is of an elongated pear shape and is situated in the fossa vesicæ felleæ on the facies posterior of the lobus dexter. It is from 80 to 110 millimeters in length and from 20 to 35 milimeters in width; its capacity is from 30 to 35 c.c. The fundus vesicæ felleæ is broad and directed downward and forward, projecting somewhat beyond the margo anterior. The corpus vesicæ felleæ and the collum vesicæ felleæ are directed upward and backward.

The ductus cysticus begins at the collum vesicæ felleæ and joins the ductus hepaticus just outside the porta hepatis; it is about 35 millimeters in length and 2.5 millimeters in width. Its course is obliquely backward and to the left. Beginning at the collum vesicæ felleæ and extending the entire length of the ductus cysticus, the tunica mucosa is thrown into a series of folds. These folds are arranged in the form of a spiral (valvula spiralis) and occasion corresponding grooves on the outer surface of the duct (Fig. 3772).

Ductus Choledochus.—The ductus choledochus is formed at the outer boundary of the porta hepatis by the union of the ductus hepaticus and the ductus cysticus. It is from 40 to 65 millimeters in length and from 5.5 to 7.5 millimeters in width. Its general course is downward, backward, and obliquely to the left to the posterior wall of the pars descendens duodeni, the tunica muscularis of which it penetrates; it then passes obliquely through the tela submucosa and opens near the ductus pancreaticus or in connection with it, at the lower extremity of the plica longitudinalis duodeni.

Blood-vessels.—Arteries.—The arteria cœliaca arises from the anterior wall of the aorta abdominalis between the twelfth thoracic and the first lumbar vertebra. It divides almost immediately into three branches; the arteria gastrica sinistra, the arteria hepatica, and the arteria lienalis. The arteria hepatica is the only branch to be considered. This extends along the right crus mediale diaphragmatis at the upper border of the pancreas behind and below the vestibulum bursæ omentalis to the left posterior surface of the pylorus where it divides into three branches: the arteria gastrica dextra, the arteria hepatica propria, and the arteria gastroduodenalis.

The arteria hepatica propria (Plate XLIII, Fig. 2) passes upward between the layers of the ligamentum hepatoduodenale, anterior to the vena portæ and to the left of the ductus choledochus and ductus hepaticus, to the porta hepatis, where it divides into a ramus dexter and a ramus sinister. The ramus dexter as it passes to the right extremity of the porta hepatis is situated either in front of the ductus hepaticus and ductus cysticus or between these two structures. As it crosses the ductus hepaticus it gives off the arteria cystica which runs downward and forward along the ductus cysticus to the vesica fellea where it divides into rami anteriores et posteriores. The ramus sinister is longer and narrower than the ramus dexter. It passes to the left extremity of the porta hepatis, and, after giving off one or two branches to the lobus caudatus, enters the lobus sinister within which it terminates.

Variations of the arteria hepatica propria are not infrequently found and are usually caused by a more or less early division of the ramus sinister in the ligamentum hepatoduodenale. In two instances an

artery corresponding to the ramus sinister was found in the ligamentum hepatoduodenale which arose from the arteria mesenterica superior and gave origin to the arteria cystica. In each of these cases an artery corresponding to the ramus dexter arose from the arteria gastrica sinister and after passing through the ligamentum hepatogastricum was distributed to the lobus dexter.

Veins.—Two systems of veins are connected with the liver; one afferent (vena portæ), the other efferent (venæ hepaticæ). The main trunk of the vena portæ runs between the folds of the ligamentum hepatoduodenale upward and to the right, in front of the vena cava inferior, from which it is separated by the foramen epiploicum, to the porta hepatis where it is situated behind the arteria hepatica propria and the ductus choledochus. A small vein coming from the ductus choledochus and the vena cystica coming from the vesica fellea open into it just before it enters the porta hepatis.

Immediately after its entrance into the porta hepatis the vena portæ divides into a right and a left branch. The right branch is shorter and wider than the left and divides into numerous branches which are distributed to the lobus dexter, the lobus quadratus, and the processus caudatus. The left branch extends horizontally toward the left side of the porta hepatis and sends branches to the lobus caudatus and to the lobus sinister. According to Vierordt the vena portæ is sixteen millimeters in diameter and seventy millimeters in length.

The venæ hepaticæ return the blood brought to the liver by the vena portæ and arteria hepatica propria. They arise from the veins situated on the periphery of the structural units (the venæ centrales of the hepatic lobules of Kernan and J. Müller), and unite to form from six to twelve smaller branches and two or three larger branches which open into the vena cava inferior as it passes through the fossa venæ cavæ on the facies posterior of the liver. As a rule the larger veins, which are sometimes designated as the right and left hepatic veins, enter the vena cava inferior at a higher level than the smaller veins.

Anastomoses.—There are three principal collateral routes by means of which the blood can be returned through the systemic circulation in cases where obstruction of the portal circulation exists: (1) through the accessory portal veins which accompany the ligamentum teres and the ligamentum falciforme to the para-umbilical veins and thence through the vena epigastrica inferior or through the vena epigastrica superficialis to the vena iliaca externa; (2) through the vena coronaris ventriculi to the venæ œsophageæ and thence to the vena azygos and vena hemiazygos; (3) through the vena hemorrhoidalis superior to the plexus hemorrhoidalis and thence through the vena hemorrhoidalis media to the vena hypogastrica.

Lymphatics.—The lymphatics of the liver were the earliest to be seen and described though their true course and nature were not correctly interpreted. In general we can follow the early descriptions and divide the lymphatics of the liver into a superficial and deep set which communicate with each other. The main trunks form three distinct systems and take three different courses. They may follow the vena portæ to the porta hepatis where they join the lymphoglandulæ hepaticæ; they may join the plexus of lymphatics about the vena cava inferior or they may follow the ligamentum falciforme and go partly to the lymphoglandulæ mediastinales anteriores and partly to the lymphoglandulæ celiacæ.

The deep lymphatics can be divided into two sets, one of which joins the plexus about the vena cava inferior, the other follows the venæ portæ to the porta hepatis and joins the lymphoglandulæ hepaticæ.

The lymphatics of the vesica fellea and of the ductus choledochus consist of two sets, a superficial and a deep, which communicate with each other. The superficial set is of the larger caliber and, according to Suddler, forms an irregular network beneath the tunica serosa, the collecting trunks eventually running "on the inner side of the gall-bladder." The deep set is situated in the tela submucosa. The collecting trunks of both sets join the lymphoglandulæ hepaticæ. The lymphatics of the ductus choledochus join a chain of lymphoglandulæ connected with the lymphoglandulæ hepaticæ. The entire distribution of the lymphatics on and in the liver needs a careful restudy.

Nerves.—Both medullated and non-medullated nerves are found in the liver, the non-medullated predominating. The medullated nerves are derived from the nervus vagus sinister and reach the liver from the paries anterior of the ventriculus, passing between the layers of the omentum minus. The non-medullated nerves are derived from the plexus celiacus and follow the arteria hepatica, forming the plexus hepaticus, to the porta hepatis where they inosculate with the fibers of the vagus and enter the liver with the blood-vessels.

Topographical Anatomy.—As has already been stated, the facies superior corresponds to the arch of the diaphragm and is in contact with it. The greater part of it is, therefore, covered by that part of the diaphragm which arises from the posterior surface of the processus xyphoideus sterni and from the internal surface of the anterior ends of the seventh to the twelfth rib. That portion of the facies superior lying below the costal arch and in the costosternal angle comes into direct contact with the paries anterior of the abdomen. This portion of the liver is covered by the peritoneum, the fascia transversa, the Mm. transversus, obliquus internus et externus, and recti abdominis.

The facies inferior overlying as it does a number of important organs presents a much more complicated relationship than the facies superior. The impressiones have already been noted; we will now consider the structures that occasion them.

The impressio gastrica (Figs. 3753 and 3754 and Plate XLIII, Fig. 1) occupies the greater portion of the lobus sinister and runs nearly parallel to the margo anterior. The paries ventriculi anterior and the curvatura minor occupy the impressio and the extent to which they fill it depends on the amount of distention present in the ventriculus. The tuber omentale hepatis fits into the curvatura ventriculi minor.

Following the impressio gastrica to the right it is seen to pass over on the lobus quadratus into the impressio duodenalis which is formed by the pars superior duodeni. Just above the pars superior duodeni will be found the right branch of the ductus hepaticus, the arteria hepatica propria, the vena portæ and the ductus cysticus. As the pars superior arches over into the pars descendens duodeni it lies close to the right border of the vesica fellea.

At the right of the vesica fellea, on the lobus dexter, is seen the impressio colica which is formed by a portion of the colon transversum and of the flexura coli dextra. The extent to which each enters into the formation of the impressio varies in individual cases. Dorsal from the impressio colica is the impressio renalis formed by the right kidney.

The facies posterior is quite irregular in outline and is in contact with the diaphragm and its continuation down the facies posterior abdominis, the crura diaphragmatis. On the lobus dexter just above the impressio renalis is the impressio suprarenalis, formed by the glandula suprarenalis dextra. The extreme upper portion of the impressio renalis and the whole of the impressio suprarenalis are usually situated in the "bare" or "uncovered area" of the liver. The impressio suprarenalis frequently extends as far as the right border of the vena cava inferior. On the lobus sinister at the right of the termination of the margo

anterior is the impressio œsophagea formed by the esophagus; this is continued into the impressio gastrica.

Vesica Fellea and Ductus Choledochus.—The vesica fellea is situated on the facies inferior of the lobus dexter; below and to the right are the flexura coli dexter and the colon transversum; to the left is the pars pylorica ventriculi, the pylorus, and the pars superior duodeni which crosses the right branch of the ductus hepaticus and the ductus cysticus.

The ductus choledochus lies within the ligamentum hepatoduodenale. Its general course is obliquely forward and to the right. It is situated in front of the vena portæ and to the right of the arteria hepatica which it accompanies behind the pars superior duodeni to the groove between the caput pancreatis and the pars descendens duodeni. In a large majority of instances (seventy-five per cent. according to Corning) the ductus choledochus at this point is entirely surrounded with pancreatic tissue. Eventually it opens, in connection with the ductus pancreaticus, at the inferior extremity of the plica longitudinalis duodeni. The statement made by several authors that the opening is on the papilla duodeni is erroneous; only the ductus pancreaticus accessorius opens on the papilla duodeni.

Relation of the Liver to the Exterior.—(Fig. 3755.) On the right side the liver rises to the fourth intercostal space; in the midline it is depressed to or just above the level of the junction of the processus xiphoideus with the corpus sterni; on the left side it rises to the lower border of the fifth rib; its extremity is situated just beyond the apex of the heart at the level of the sixth rib. From this point its lower border passes to

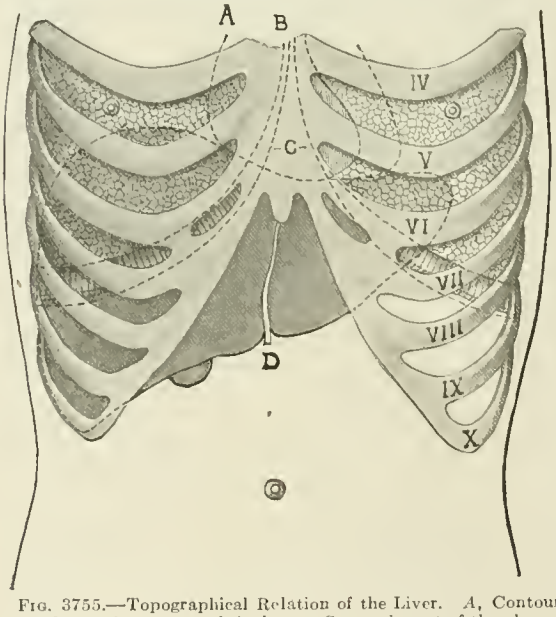

Fig. 3755.—Topographical Relation of the Liver. *A*, Contour of the heart; *B*, contour of the lungs; *C*, attachment of the pleura; *D*, ligamentum falciforme hepatis; *IV–X*, costæ. (Original with the aid of Jössel's figure.)

the level of the eighth costal cartilage on the left side; it then crosses the midline with a slight curve, courses downward to the ninth right costal cartilage; it then follows the arch of the ribs, which it crosses in the right mammillary line, and reaches its lowest point in the scapular line at the level of the eleventh rib along which it slopes in an upward direction to the upper part of the tenth thoracic vertebra.

The superior boundary of the liver rises on the right side of the back as high as the upper margin of the eighth rib or to the angulus inferior of the scapula. Along the right midaxillary line the liver extends from the sixth to the eleventh rib.

In females the inferior boundary of the liver reaches a somewhat lower level, about twenty-five millimeters, than in males. Respiration also effects the position of the liver, causing it to rise and fall with each inspiration and expiration; the range of movement in ordinary respiration being from two to three centimeters. Distention of the ventriculus or the colon transversum may also displace the liver laterally and downward.

Situated superior to the liver, their bases corresponding to the curve of its facies superior, are the lungs (pulmones). During respiration the margo inferior pulmonis is crowded into the sinus phrenicocostalis, although it never completely fills it even in forced inspiration. These facts should be kept in mind when penetrating wounds situated below the sixth rib are being treated.

Variations.—Many of the variations in the form and position of the liver are due to pressure arising

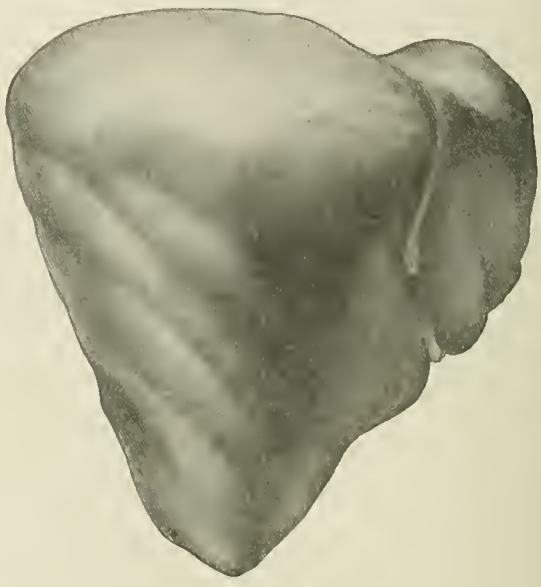

Fig. 3756.—"Corset Liver." Note the indentations caused by the costæ. (Original specimen; drawn with the aid of His' model.)

from malformations of the thorax. These may be either congenital or acquired. In the female they are usually caused by tight lacing; in the male they are occasionally caused by the constant wearing of a tight belt. The writer has seen one case that was undoubtedly due to this cause.

The accompanying illustration (Fig. 3756) shows a liver in which the lobus dexter is elongated as the result of tight lacing; it also shows grooves caused by the unusual pressure of the ribs. Occasionally a tongue-like prolongation extends downward, sometimes as far as the crista iliaca, from the lower portion of the lobus dexter forming the so-called "Riedel's lobe." Congenitally the position of the liver may be reversed in the abdomen (situs inversus). The entire liver may occupy a lower level than normal due to relaxation of the ligaments, ptosis of the liver.

The vesica fellea may be absent; it may be bifid, or it may be double, each vesica fellea having its own ductus cysticus with variable entrances into the main system of ducts. Occasionally there is a duct of variable size opening directly into the vesica fellea—a ductus hepatocysticus.

Ruge has described three (Fig. 3757, *A*, *B*, *C*) principal types of union between the ductus cysticus and the

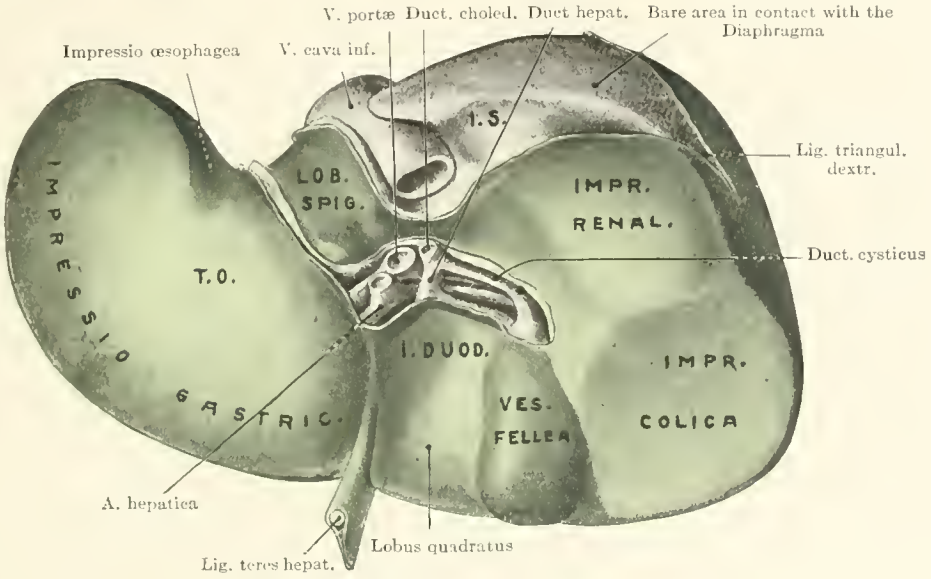

Fig. 1.

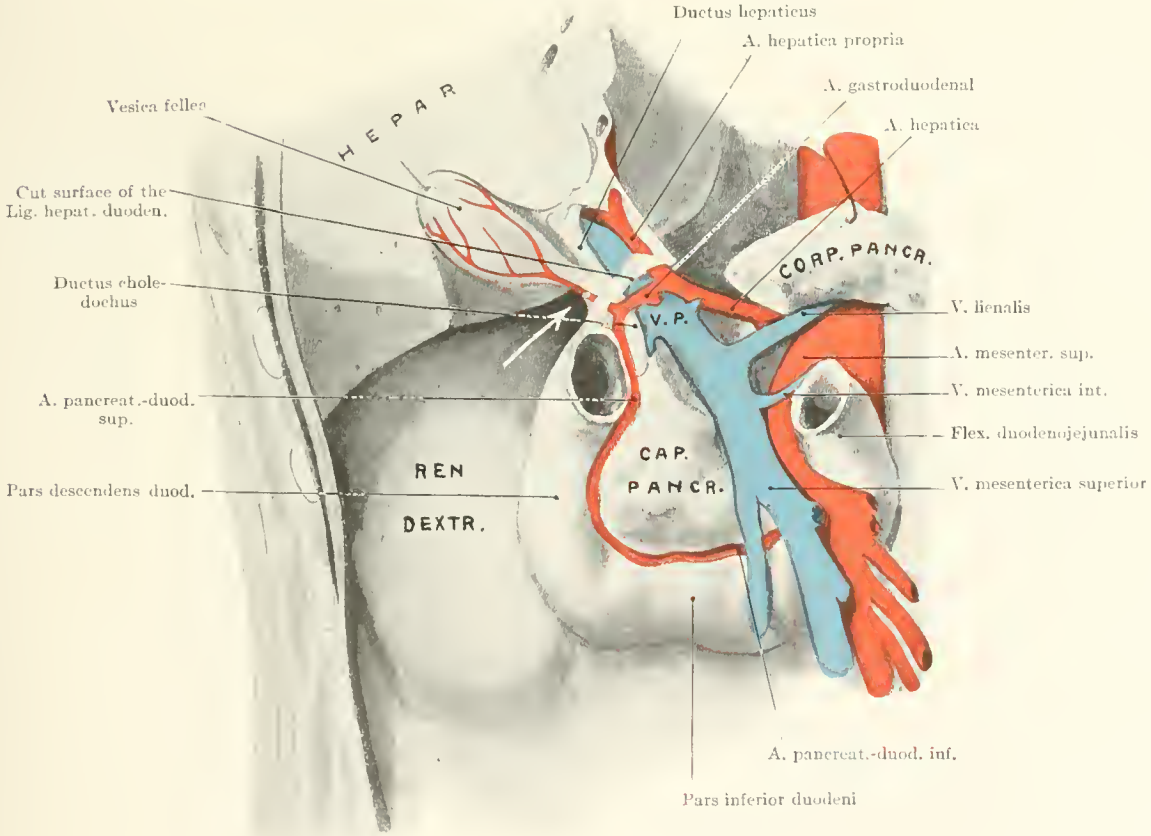

Fig. 2.

Fig. 1.—Facies Inferior Hepatis. Peritoneum green. T. O. Tuber omentale. I. S. Impressio suprarenalis. I. DUOD. Impressio duodenalis. (After Corning.)

Fig. 2.—Topography of the Vena Portæ and the Ligamentum Hepatoduodenale. A portion of the pancreas has been cut out. The arrow points to the foramen epiploicum. V. P. Vena portæ. (After Corning.)

ductus hepaticus: (1) the two ducts join at an acute angle (*A*), thirty per cent. of all cases; (2) the ductus cysticus and the ductus hepaticus run for some distance parallel to each other, enclosed within the same sheath (*B*), twenty-seven per cent. of all cases; (3) the ductus cysticus passes behind the first portion of

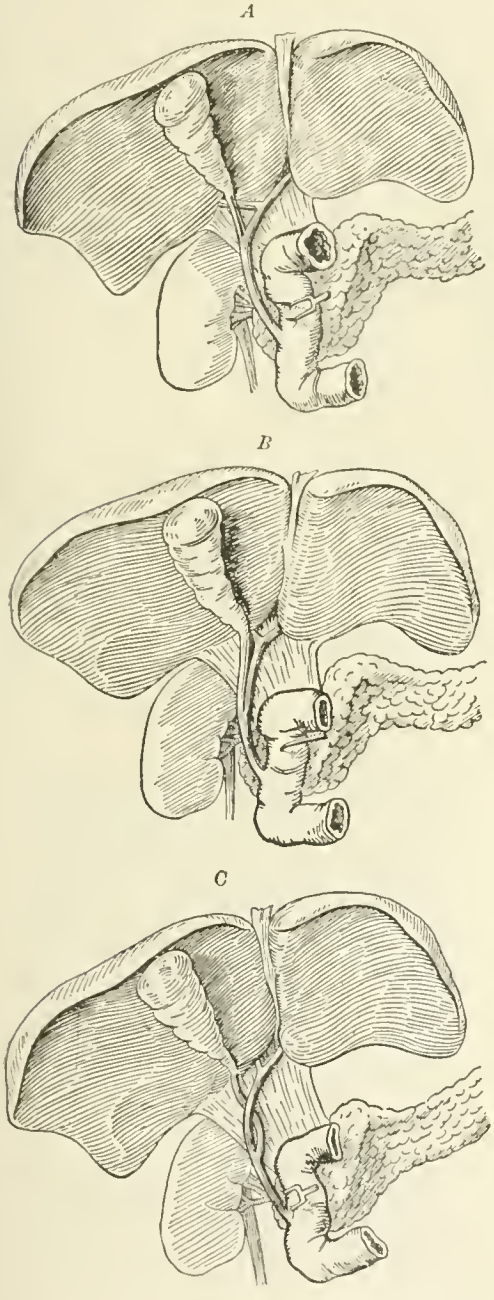

Fig. 3757.—*A*, *B*, *C*, Variations in the Union of the Ductus Cysticus with the Ductus Choledochus. For description see text. (After Ruge.)

the ductus hepaticus and, followed toward the porta hepatis, forms a right-handed spiral about the ductus hepaticus which it may join on the posterior, the left or the anterior periphery (*C*); this type Ruge found in forty per cent. of all cases. Type *A* is generally described as the principal type, but Ruge considers type *C* the principal type.

The union of the ductus choledochus with the ductus pancreaticus, and their opening into the duodenum,

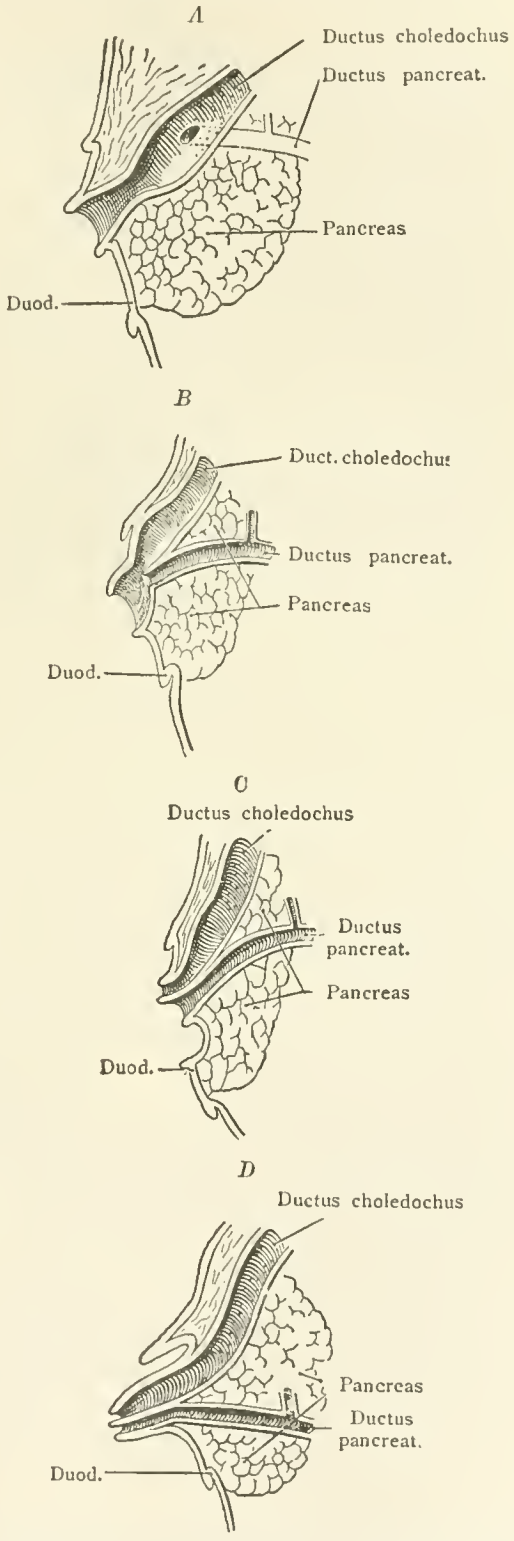

Fig. 3758.—*A*, *B*, *C*, *D*, Variations in the Union of the Ductus Choledochus and the Ductus Pancreaticus. (After Letulle and Nattan-Larrier.)

are subject to considerable variation. Letuelle and Nattan-Larrier have studied these variations and find the following types (Fig. 3758, *A*, *B*, *C*, *D*). The two ducts may unite and open into a dilatation which may be considered as a modified ampulla of Vater (*A*), though they agree with Hyrtl that a true ampulla or diverticulum of Vater is of rare occurrence in man. The remaining three forms (*B*, *C*, *D*) show gradations in the separation of the two ducts. The ductus pancreaticus always opens beneath the ductus choledochus.

Hendrickson has studied by special methods the arrangement of the musculature of the duodenal portion of the ductus choledochus and ductus pancreaticus and finds that, although individual variations occur, there is a general anatomical relation of the structures in that region.

In Fig. 3759 is shown the entrance of the two ducts into the wall of the duodenum through a simple

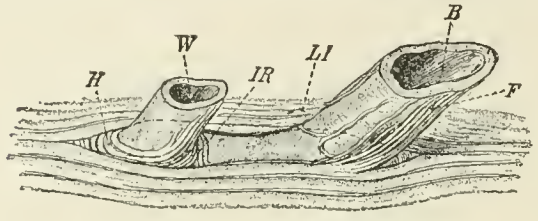

Fig. 3759.—Duodenal Portion of the Ductus Choledochus of Man, showing the entrance of the ductus choledochus and the ductus pancreaticus. × 5. (After Hendrickson.)

separation of the bands of smooth muscle in the stratum longitudinale of the tunica muscularis. A few bands of the muscle extend along the ductus choledochus and gradually disappear.

In Fig. 3760 at *IR* are shown a few bands of smooth muscle which extend around the ductus choledochus between it and the ductus pancreaticus forming an independent ring of muscle. The bands of muscle indicated by *H* extend nearly the entire distance around the ductus pancreaticus; but as they reach that side of the duct nearest to the ductus choledochus they turn and run for some distance longitudinally along the ductus pancreaticus.

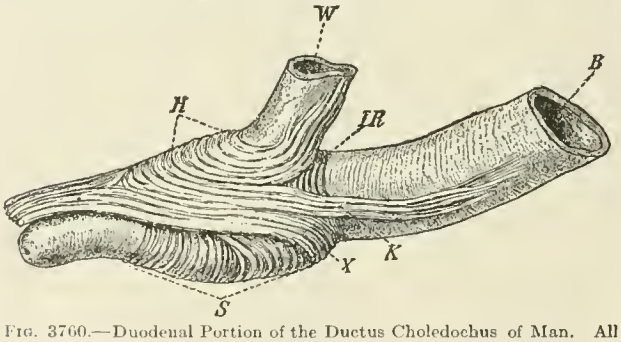

Fig. 3760.—Duodenal Portion of the Ductus Choledochus of Man. All the intestinal coats have been removed. × 5. (After Hendrickson.)

The bands of muscle shown at *S* extend completely around the ductus choledochus and form a sphincter muscle for that duct. The bands just above this sphincter, *X*, do not extend completely around the duct, while the bands, *K*, have their origin on one side of the ductus choledochus and extend around to the opposite side of the duct.

The bands of muscle forming the stratum circulare of the tunica muscularis of the duodenum separate to allow the passage of the ducts in the same manner as in the stratum longitudinale. This muscle coat takes no part in forming the musculature of the ducts.

Histology.—The liver is a compound tubular gland, the individual tubules of which anastomose with each other. The entire organ is surrounded by a capsule, the capsula fibrosa (Glissonii), which sends delicate prolongations into its substance along its periphery and at the porta hepatis is continued into its interior following the vena portæ in all its ramifications.

The structure of the capsula fibrosa varies depending on the presence or absence of a peritoneal investure. Where this is present three layers can be recognized; an outer, composed of a layer of mesothelium; a middle, composed of white fibrous connective-tissue, and an inner, composed of a mixture of white fibrous connective tissue and elastic fibers with the elastic elements predominating. Where the peritoneum is absent (the "bare spot") only the last two layers are present. Frequently it is difficult to distinguish more than the inner or fibroelastic layer. The continuation of the capsula fibrosa into the interior of the liver, where it forms the interlobular septa (portal canals), will be considered later. The capsula fibrosa receives its blood supply from the arteria hepatica propria which forms in it a long-meshed network; from this network the blood is returned by the vena hepatica and not by the vena portæ as is usually stated.

Situated beneath the capsula fibrosa, often visible through it, one can distinguish small areas of an irregular circular outline, about a millimeter in diameter, sharply marked off by a well-defined connective-tissue framework. These are the hepatic lobules and are best seen in the liver of the pig, the polar bear, and camel. In the liver of man, the dog, the rabbit, and the higher mammals usually studied in our laboratories, these definitely marked off areas cannot be recognized.

The hepatic lobules were first described by Wepfer in 1664. The work of Kiernan (1833) forms the basis of the description of the hepatic lobules as usually given in the text-books. As described by Kiernan an hepatic lobule (Fig. 3761) has in its center a branch

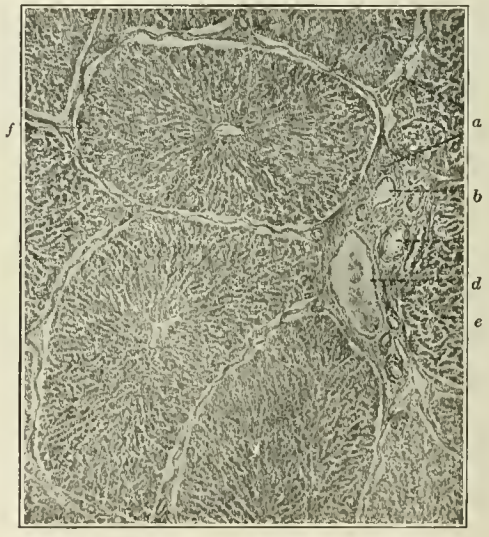

Fig. 3761.—Section of the Liver of a Pig. *a*, Connective tissue (capsula fibrosa) which marks out the hepatic lobules; *b*, ductus bilifer; *c*, arteria hepatica propria; *d*, vena portæ (interlobular vein); *e*, cords of hepatic cells; *f*, vena hepatica (vena centralis). (After Stöhr.)

of the vena hepatica (vena centralis) and on its periphery terminal branches of the vena portæ (venæ interlobulares), of the arteria hepatica propria, ductus interlobulares, nerves, and lymphatics and is sur-

rounded with a well-marked layer of connective tissue, the continuation of the capsula fibrosa (interlobular septa).

Theile has shown that if the liver of a dog or of a rabbit be crushed and washed in running water clusters of lobules are isolated, but they have for their centers branches of the vena portæ and not branches of the vena hepatica.

Sabourin has described the liver as being made up of biliary lobules rather than of hepatic lobules. That is, the lobule thus isolated has for its center a ductus interlobularis and its accompanying vessels while the branches of the vena hepatica are situated on its periphery. Lobules of this character are as clearly marked out in the liver of Phoca (seal) as are the hepatic lobules in the liver of the pig.

Following Sabourin the biliary lobule has been considered the true lobule by Berdal, MacCallum, F. T. Lewis, and Mall. "In all other glands we make the duct the center of the structural unit. From this

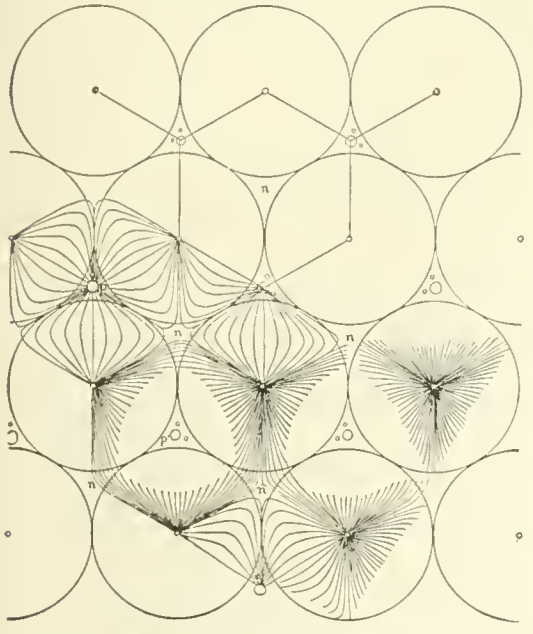

Fig. 3762.—Diagram to Illustrate the Formation of the Hepatic Lobules (Circles) and the Anatomical or Portal Units(Hexagons), with lines indicating the course of the capillaries. *p*, portal unit; *n*, nodal point. (After Mall.)

center often the artery and the framework radiate. In the liver everything radiates from the so-called interlobular space—arterial and portal blood-vessels, bile duct, lymphatics, nerves, and connective tissue; the liver develops from this point; physiologically everything centers there. So, viewed from any standpoint, it is the center of the structural unit" (Mall).

Physiologically and histologically it is more rational to think of a biliary lobule (portal or structural unit) than of an hepatic lobule. Fig. 3762 taken from the work of Mall shows how both types of the lobule can be schematically represented.

In the following account I shall use the term biliary lobule, portal unit, or structural unit for that subdivision of the liver which is built up around a ductus interlobularis and a branch of the vena portæ with their accompanying vessels and nerves, using the term hepatic lobule in its usual signification.

In sections of the human liver (Fig. 3763) absence of the anastomosing bands of connective tissue (capsula fibrosa), so noticeable in the pig's liver, at once attracts attention. Isolated areas of the capsula fibrosa are seen here and there containing the vessels and nerves passing to and from the liver. The ensemble of these structures is termed a portal canal (Figs. 3763 and 3764).

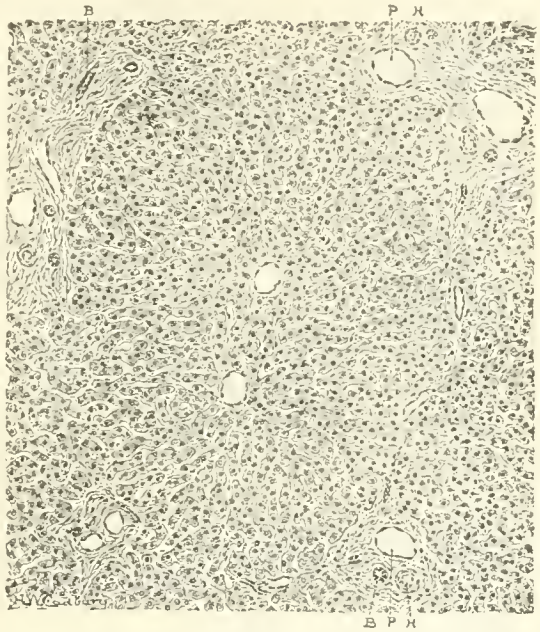

Fig. 3763.—Section of Human Liver. *P*, Vena portæ; *H*, arteria hepatica propria; *B*, ductus bilifer. The two vessels cut transversely in the middle of the section are branches of the vena hepatica. × 80. (After Hendrickson.)

Blood-vessels.—It has now been shown that the blood-vessels play an important part in determining the structural unit of the liver and it remains to describe the course of the circulation through the unit.

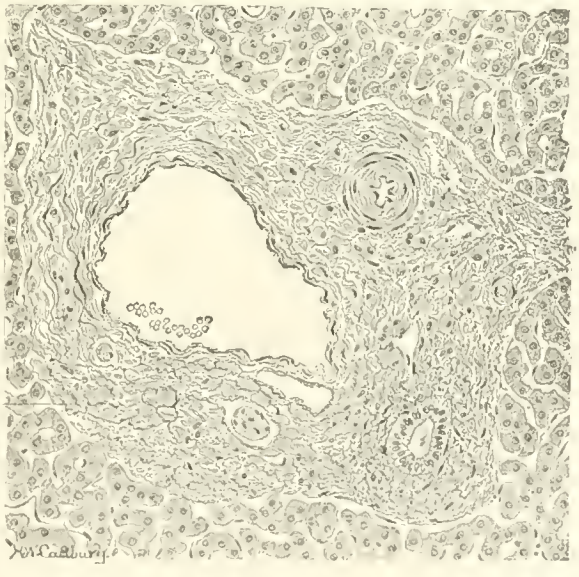

Fig. 3764.—Section through a Portal Canal. (After Hendrickson.)

Vena Portæ.—A branch of the vena portæ, with its three main branches extending into the adjoining fissures, occupies a central position within the structural unit. From these vessels capillaries arise which pass, in either a straight or a somewhat curved course,

into the vena hepatica. The terminal branches of the vena portæ do not extend to the periphery of the structural unit; on the other hand the terminal branches of the vena hepatica extend to the periphery of the

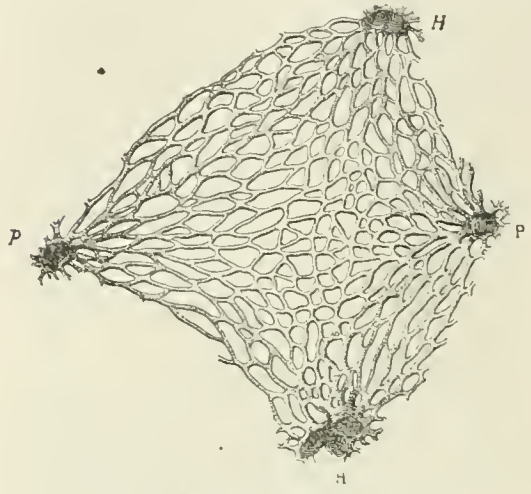

Fig. 3765.—Capillary Network at a Nodal Point. *P*, Vena portæ; *H*, vena hepatica. × 48. (After Mall.)

unit and also to the capsula fibrosa, from which they bring back the blood.

Mall has shown (Fig. 3762) that, owing to the fact that some of the capillaries take a straight course while others have a more or less curved direction, there eventually arises a region where the capillaries from several adjoining units come together and form anastomoses (Fig. 3765). This region is termed by Mall the "nodal point." It marks the place where growth of the units takes place, not by cell multiplication, but by alternate growth toward this point of the vena portæ and the vena hepatica, producing in this manner new blood-vessels and giving origin to new nodal points.

Fig. 3766.—A Branch of the Arteria Hepatica Propria Breaking up into Capillaries. These join a network that empties into a branch of the vena hepatica. *P*, Vena portæ; *H*, arteria hepatica propria. × 40. (After Mall.)

Arteries. — The arteria hepatica propria distributes branches to the capsula fibrosa, to the ductus interlobulares, and to the vesica fellea. The return of the arterial blood has, like the return of the blood brought to the lung by the arteria bronchialis, been a source of much dispute.

It has already been shown that the terminal twigs of the vena hepatica alone reach the surface of the liver and they can be traced to the network into which the arteria hepatica propria breaks up. The blood from the surface of the liver, therefore, is returned by the vena hepatica and not by the vena portæ.

Within the structural unit the artery occupies a central position and its blood is discharged into the capillary network arising from the vena portæ (Fig. 3766) and thence to the vena hepatica. A separate system of venous twigs opening into the vena portæ is found bringing back the blood from the vesica fellea and occasionally a small vein arises from the porta hepatis and joins a branch of the vena portæ within the lobus quadratus. With these two exceptions all the blood brought to the liver by the arteria hepatica propria is discharged into the capillaries arising from the vena portæ.

Vena Hepatica.—By referring to Fig. 3762 it will be seen that the position of the vena hepatica is as far removed from the vena portæ as possible. In general it can be said that the course of the vena hepatica is at right angles to that of the vena portæ.

The venæ hepaticæ arise from the capillary network into which the vena portæ breaks up and also from the network which the arteria hepatica propria forms in the capsula fibrosa.

If the liver be considered as made up of hepatic lobules, branches of the venæ hepaticæ occupy the center of the lobules and are termed venæ centrales or venæ intralobulares; in the structural unit branches of the venæ hepaticæ are situated around the periphery of the structural units, from which they return the blood. Branches of the vena hepatica also return the blood from the capsula fibrosa.

It is generally stated in the text-books that the bases of the hepatic lobules rest upon "sublobular veins." This is an artificial subdivision of the venæ hepaticæ and should be abandoned; the distinction is merely one of size.

The venæ hepaticæ form two groups of vessels, a superior and an inferior, which open into that portion of the vena cava inferior which is situated below the diaphragma and behind the lobus dexter. The superior group is composed of three large-sized vessels which return blood from the lobus dexter, the lobus sinister, and the lobus quadratus. The inferior group is composed of a variable number of smaller vessels, six to twelve in number, which return the blood from the lobus dexter and the lobus caudatus.

Sinusoids.—The blood channels connecting the vena portæ with the venæ hepaticæ differ from those usually designated as capillaries. Minot has named the type of blood channels extending between the two venous systems "sinusoids." They are formed by the growth into the venæ omphalomesentericæ, during embryonic life, of cords of liver cells which carry ahead of them the endothelium lining these vessels. There is thus formed a series of wide channels the endothelium of which is closely applied to the liver cells with little or no connective tissue intervening. True capillaries are found arising from the arteria hepatica propria; they are formed by the subdivision of that vessel.

Kupffer's Cells.—The endothelium lining the sinusoids of the liver present certain characteristics which distinguish it from the endothelium of other blood channels. Scattered along the walls of the sinusoids are certain cells which, when stained by the gold method, present a stellate appearance. These are known as the "stellate cells of v. Kupffer" (Fig. 3767). When they were first described they were supposed to be connective-tissue cells. Later studies proved that they were normal endothelial cells which had become swollen and their nuclei had become paler. They possess phagocytic properties and many of them are often seen containing red and white corpuscles and particles of pigment.

These cells have again become objects of special interest through the studies of Evans, Bowman, and Winternitz who have shown, by the use of special vital stains, that they play a very important rôle in the early development of tuberculosis of the liver.

The endothelium lining the sinusoids of the liver has been described as being discontinuous. Through

the courtesy of my colleague, Prof. C. H. Bunting, I have had the opportunity of examining a number of sections of a liver from a case of leukemia in which the sinusoids were cut in such a plane that the endothelium could be followed continuously from cell to cell for a considerable distance. These sections seemed to negate the statement that the endothelium is discontinuous.

Hepatic Cells.—The hepatic cells have a polyhedral form with six or eight sides and vary in size depending on the quantity of blood contained within the liver. The cells contain one, sometimes two, spherical nuclei. Not infrequently a brown pigmentation is present. Cells are also found in normal livers containing fat droplets of varying size. Glycogen, especially after a hearty meal, is also found in the form of granules or in masses of considerable size. A physiological consideration of the hepatic cells belongs to the physiology, rather than to the histology, of the liver.

Ductus Biliferi.—The gross distribution of the ductus interlobulares and their position in the center of the structural unit has already been described. In their earliest development they are found associated with the arteria hepatica propria and the vena portæ and extend along the same prolongations of the capsula fibrosa. The work of Hendrickson, supplemented by the work of Mall, has given us a very complete account of their growth and relation to the structural unit.

Longitudinal sections of the developing liver and of the adult liver show that from the terminal twigs of the ductus interlobulares the ductus biliferi (bile capillaries) extend into the structural units (Fig. 3768).

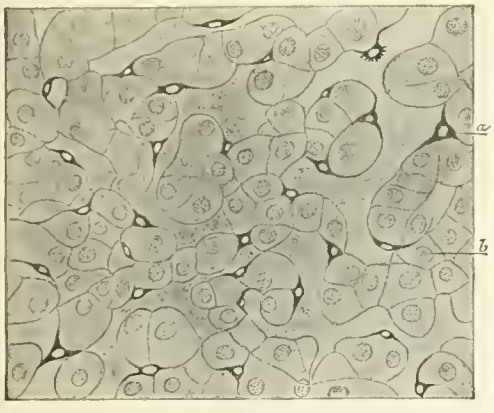

Fig. 3767.—Kupffer Cells in the Liver of a Rabbit. *a*, Kupffer cells; *b*, hepatic cells. (After Böhm and Davidoff.)

Followed into the units it will be found that the terminal twigs are situated along the sides of the hepatic cells while the blood capillaries (sinusoids) are situated along the angles of the cells. By this arrangement there is always a portion of an hepatic cell between the two systems of capillaries; they never lie side by side (Fig. 3769).

The ultimate termination of the ductus biliferi is in a small vacuole situated near the nucleus of the cell. Preparations stained by Golgi's method show each ductus bilifer ending in a small knob which corresponds to this vacuole (Fig. 3770).

Reticulum.—In addition to the white fibrous connective tissue and elastic fibers of the capsula fibrosa there is a third type of connective tissue present in the liver—reticulum. His recognized it as a delicate network of fibrils about the sinusoids. Oppel and Mall devised methods for demonstrating the fibrils more clearly; the former by special methods of staining, the latter by digestion of frozen sections with pancreatin. By Oppel these fibrils were termed

Fig. 3768.—Longitudinal Sections of Ductus Interlobulares and Ductus Biliferi from Fetal Pigs 8, 16, 19, and 21 Centimeters Long and from the Adult Pig. × 53. (After Hendrickson.)

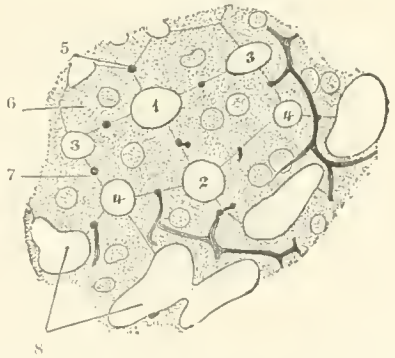

Fig. 3769.—Section of the Liver of a Rabbit with the Ductus Biliferi Injected. Two of the hepatic cells are each in contact with four sinusoids (1, 2, 3, 4) and with four ductus biliferi. 5 A ductus bilifer where three hepatic cells meet; 6, hepatic cell, 7, a ductus bilifer; 8, sinusoids. × 560. (After Lewis-Stöhr.)

"Gitterfasern"; by Mall they were called "reticulum." It is now generally admitted that the two are identical and they are known as reticulum.

Reticulum forms a network of fine, non-refractive anastomosing fibrils (Fig. 3771). These fibrils form a

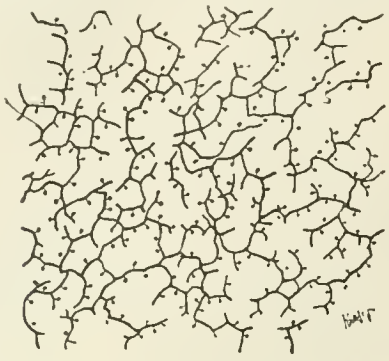

Fig. 3770.—Section of a Human Liver in which the Ductus Biliferi have been Stained by the Chrome-silver Method. The knob-like endings correspond to the secretory vacuoles of the hepatic cells. × 480. (After Böhm and Davidoff.)

considerable part of the capsula fibrosa and can be traced into the structural unit where they surround the sinusoids and enclose clumps of liver cells within their mesh.

Lymphatics.—Sections of a portal canal show lymphatics cut in various planes, but our knowledge of their distribution within the structural unit is still meager and needs careful restudy, especially from the developmental standpoint.

"The lymphatics of the liver do not drain all portions of the liver lobule, but only those portions that are formed by the centers of the portal units. There are no lymphatics at the center of the lobules nor at the nodal points. At the center of the portal units there is a very free communication between the blood capillaries and the lymph radicles in the tip of the capsule of Glisson (capsula fibrosa). So the lymph circulation is marked at this point, *i.e.* the center of the portal structural unit, while in the rest of the unit it is insignificant or wanting altogether" (Mall).

Nerves.—The text-books state that the liver receives its nerve supply from two sources, namely, the Nn. vagi, especially the left, and from the plexus celiacus. Berkley, who made a special study of the nerves of the liver, states that he "found no medullated nerve fibers, nor can definite reasons for their presence within a purely glandular body be advanced."

But little is known in regard to the finer distribution of the nerves within the mammalian liver and what is known is due to the researches of Berkley. He separates the nerves into four divisions which are connected together and morphologically alike: (1) nerves accompanying the vena portæ; (2) nerves accompanying the arteria hepatica propria; (3) nerves accompanying the ductus interlobulares; (4) terminal

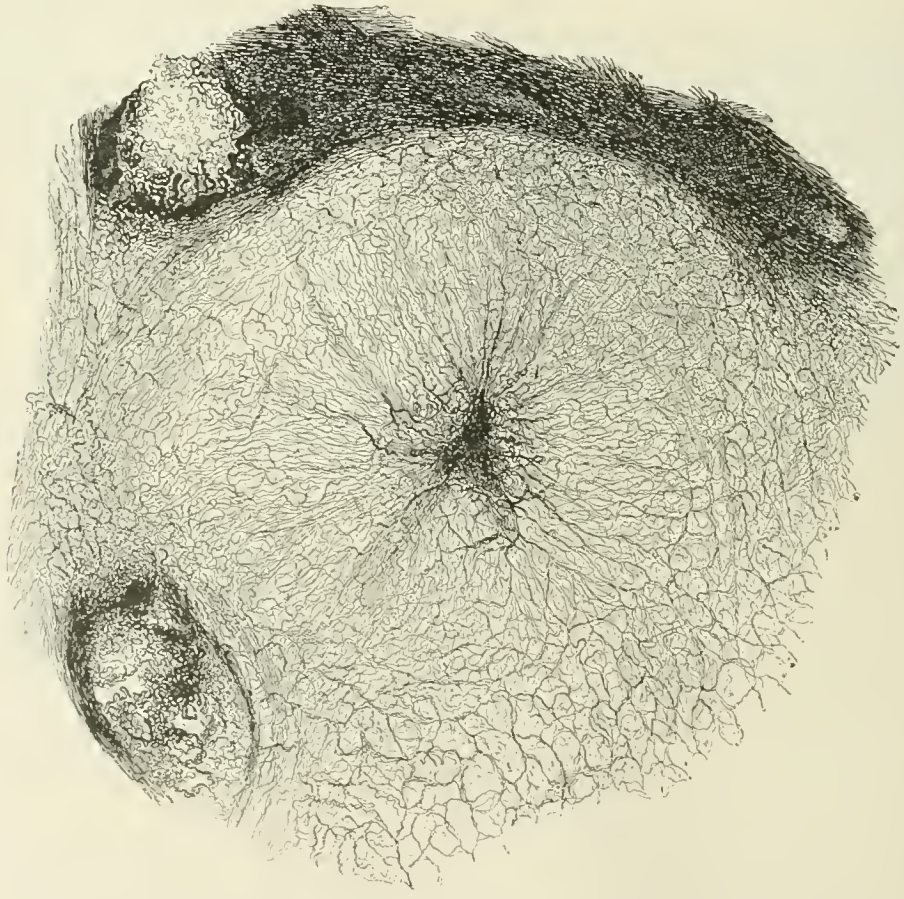

Fig. 3771.—Section of Liver which has been Digested in Pancreatin. The dark wavy bundles of fibrils are white fibrous connective tissue. The anastomosing network made up of finer fibrils is the reticulum. (After Mall.)

plexus of nerves to the hepatic cells. These last nerves are derived principally from the filaments accompanying the vena portæ though the other two divisions contribute to a lesser extent.

The nerves that accompany the vena portæ give off short branches which end in the smooth muscle cells of its media by round, knob-like endings. These branches occasionally send off fibers, which enter the structural units, penetrate between the hepatic cells, and end in a small knob or in a partial arborization.

The nerves distributed to the arteria hepatica propria are less numerous than those accompanying the vena portæ; they terminate in the same manner as nerves distributed to arteries in other situations.

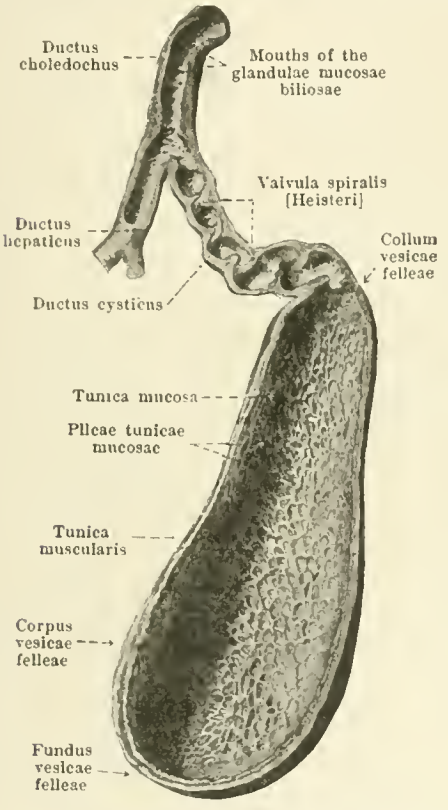

Fig. 3772.—Human Vesica Fellea, Ductus Cysticus and Ductus Choledochus Cut Open. (After Spalteholz.)

The nerves distributed to the ductus interlobulares penetrate their outer walls and terminate in a ball-shaped ending in the cement substance between the cuboidal cells lining the ducts.

The first three divisions send filaments into the structural units where they follow the distribution of the ductus biliferi rather than that of the sinusoids. Berkley thinks that these filaments terminate between the cells rather than in or on the hepatic cells. Other investigators who have used the livers of the lower vertebrates in their studies describe intracellular endings of the nerves.

Vesica Fellea.—The vesica fellea varies in thickness from 0.75 millimeter when distended to 2 millimeters when contracted. It possesses three coats: (1) a tunica mucosa; (2) a tunica muscularis; (3) a tunica fibrosa. In addition to these, where it is covered by the peritoneum, there is present a tunica serosa and an underlying subserosa.

The tunica mucosa consists of an inner layer of tall, columnar epithelium, the free border of which often presents a striated appearance, and an underlying lamina propria which consists of bundles of white fibrous connective tissue and numerous elastic fibers. The entire tunica mucosa is thrown into a series of folds (Fig. 3772), the plicæ tunicæ mucosæ. In places these folds are quite narrow and deep and have been mistaken for glands. Noduli lymphatici are found scattered throughout the tunica mucosa.

The tunica muscularis is composed of smooth muscle. That portion of the tunica muscularis which is situated next to the tunica mucosa is quite loosely arranged with considerable admixture of connective tissue, while that nearest the tunica fibrosa is more compact. The bundles of smooth muscle are not arranged in definite layers but form an interlacement.

The tunica fibrosa is made up of a mixture of white fibrous connective tissue and elastic fibers. The outer portion of this layer is more compact than the inner portion. The tunica serosa, when present, consists of a layer of mesothelial cells which are connected with the tunica fibrosa by means of a subserosa which contains a considerable quantity of adipose tissue.

Blood-vessels.—The origin and course of the arteria cystica has already been given (page 46). The main branch is usually found on the inferior surface of the vesica fellea. Most of the larger vessels are situated at the junction of the tunica muscularis with the lamina propria of the tunica mucosa. Within the tunica mucosa a network of capillaries is formed; from this network the blood is returned by small venous radicles which join the main venous trunk that accompanies the artery and eventually empties into the vena portæ. The arterial supply of the vesica fellea is subject to many variations; these have been made a subject of special study by Brewer to whose paper I will refer those especially interested in the subject.

Lymphatics.—The lymphatics arise as a plexus situated in the tunica mucosa; from this plexus branches extend into the tela submucosa where a second and more voluminous plexus is formed. From this second plexus the main trunks take their origin and follow the ductus cysticus to their termination in the lymphoglandulæ hepaticæ.

Nerves.—Both medullated and non-medullated nerves are distributed to the vesica fellea. "In the wall of the gall-bladder are found numerous small sympathetic ganglia formed by the grouping of the cell bodies of sympathetic neurons (Dogiel). The neuraxes of these innervate the non-striated muscle of the structure. Large, medullated nerve fibers may be traced through these ganglia which appear to end in free sensory endings in and under the epithelium lining the gall-bladder" (Huber).

The ductus cysticus, the ductus hepaticæ, and the ductus choledochus are lined with a columnar epithelium which rests upon a basement membrane. Beneath the basement membrane is a tela submucosa and on the exterior is a tunica muscularis which consists mainly of circularly arranged bands of smooth muscle. In the ductus hepaticæ and the ductus choledochus branched mucous glands are found extending into the tela submucosa, glandulæ mucosæ biliosæ.

W. S. Miller.

Bibliography.

Berdal, H.: Nouveaux éléments d'histologie normale, Paris, 1903.

Berkley, H. J.: Studies in the Histology of the Liver. Johns Hopkins Hospital Reports, vol. iv.

Brewer, G. E.: Some Observations upon the Surgical Anatomy of the Gall-bladder and Ducts. "Contributions to the Science of Medicine" by the Pupils of Wm. H. Welch, Baltimore, 1900.

Corning, H. K.: Lehrbuch der topographischen Anatomie. Wiesbaden, 1914.

Evans, H. M., Bowman and Winternitz: An Experimental Study of the Histogenesis of the Miliary Tubercle in Vitally Stained Rabbits. Journ. Exper. Med., vol. xix.

Hendrickson, W. F.: The Development of the Bile Capillaries as Revealed by Golgi's Method. Johns Hopkins Hosp. Bull., vol. ix.

Hendrickson, W. F.: A Study of the Musculature of the Entire Extra-hepatic Biliary System, Including that of the Duodenal Portion of the Common Bile Duct and the Sphincter. Johns Hopkins Hosp. Bull., vol. ix.

Huber, G. C.: In Böhm and Davidoff's "Text-book of Histology," Philadelphia, 1904.

Jastrow, M.: The Liver in Antiquity and the Beginning of Anatomy. Univ. Penn. Med. Bull., 1908.

Kieroan, F.: The Anatomy and Physiology of the Liver. Phil. Trans., 1833.

v. Kupffer, C.: Ueber die sogenannten Sternzellen der Säugethierleber. Arch. f. mik. Anat., Bd. liv.

Letuelle et Nattan-Layrier: Région vatérienne du duodéoum et ampoule de Vater. Bull. Soc. anat. de Paris, T. lxxiii.

Lewis, F. T.: The Question of Sinusoids. Anatom. Anz., Bd. xxv.

MacCallum, T. B.: In the English translation of Szymonowicz's "Histology." Philadelphia, 1902.

Mall, F. P.: Das reticulärte Gewebe und seine Beziehung zu den Biodegewebsfibrillen. Abh. Math.-phys. Klasse d. K. Sächs. Gesell. d Wiss., Bd. xvii.

Mall, F. P.: On the Origin of the Lymphatics of the Liver. Johns Hopkins Hosp. Bull., vol. xii.

Mall, F. P.: A Study of the Structural Unit of the Liver. Amer. Journ. Anat., vol. v.

Minot, C. S.: On a Hitherto Unrecognized Form of Blood Circulation without Capillaries in the Organs of Vertebrates. Boston Soc. of Nat. Hist., vol. xxix.

Oppel, A.: Ueber Gitterfassern der menschlichen Leber und Milz. Anatom. Anz., Bd. vi.

Oppel, A.: Lehrbuch der vergleichenden mikroskopischen Anatomie, Jena, 1900, Bd. iii.

Ruge, E.: Beiträge zur chirurgischen Anatomie der grossen Gallenwege. Arch. f. klin. Chirurgie., Bd. lxxvii.

Sabourin, Ch.: Les lobules biliaires terminaux et marginaux. Le Progrès Méd., T. 11.

Sabourin, Ch.: Recherches sur l'anatomie normale et pathologique de la glande biliaire de l'homme. Paris, 1888.

Stieda, L.: Anatomisch-Archäologische Studien. Anatom. Hefte, Bd. xv.

Suddler, M. T.: The Architecture of the Gall-bladder. Johns Hopkins Hosp. Bull., vol. xii.

Theile, F. W.: Article "Leber" in R. Wagner's "Handwörterbuch der Physiologie mit Rücksicht auf physiologische Pathologie," Braunschweig, 1842–53.

Vierordt, H.: Anatomische, physiologische und physikalische Daten und Tabellen, Jena, 1893.

Liver, Cirrhosis of the.—By the term cirrhosis we mean a diffuse, extensive increase in the fibrous tissue within the liver. The distribution varies greatly depending upon the type of cirrhosis present and these variations have given rise to a large number of terms such as multilobular, interlobular, intralobular, portal, biliary, etc. The terms atrophic and hypertrophic, which have been frequently used are most confusing since they in no way accurately delimit a definite pathological condition. A great difficulty arises when the attempt is made to correlate the terms with the clinical and pathological findings since the distribution of the fibrous tissue would often warrant the use of several of the terms in the same case. The great majority of the cases of cirrhosis of the liver may be brought quite readily into two main groups which we shall term portal and biliary cirrhosis. The remaining cases may be collected into small groups classified according to their etiology as syphilitic cirrhosis, cardiac cirrhosis, and so on.

Portal Cirrhosis.—Portal cirrhosis (Laennec's, atrophic, alcoholic, multilobular cirrhosis, hobnailed liver) "is a chronic degenerative and inflammatory disease of the liver characterized by recurring degeneration and regeneration of the hepatic parenchyma and by concomitant and consecutive fibrosis in and about the interlobular or portal spaces, all of which leads ultimately to obstruction of the portal circulation" (A. O. J. Kelly).

Etiology.—Portal cirrhosis occurs usually after the fortieth year though a number of cases have been observed in children. It is apparently due to the action of some toxic agent and of all the ones recognized alcohol is by far the most frequent and important. The frequent indulgence in small quantities of distilled liquors is usually more efficacious in the production of cirrhosis than occasional excessive drinking though any sort of an alcoholic history may be obtained. Alcohol probably acts indirectly by favoring the formation in the intestines, of toxins which are absorbed into the portal vein. It also undoubtedly has a direct irritant action upon the hepatic parenchyma. The long-continued or excessive indulgence in highly seasoned foods may be a cause in the absence of any alcoholic history. Cirrhosis may also accompany or follow malaria, hemochromatosis (bronzed diabetes), Banti's disease, and anthracosis, as also poisoning with lead, silver, arsenic, etc. Experimentally cirrhosis has been produced in animals by the injection of bacteria, hemolytic sera, and several chemical agents.

Pathology.—The liver varies much in size in different cases and at different times in the same case. In the majority of autopsies the weight is greater than normal. The average weight is said to be about 1,700 grams. Rapid variations in size may be due to circulatory changes. Not infrequently the liver is large due to the presence of a large amount of fat in the organ, the so-called fatty cirrhosis. It is claimed that the small size found late in the disease is due to the contraction of the new-formed fibrous tissue but this claim cannot be substantiated in all instances. The organ is of increased density unless it contains a large amount of fat. It is of increased consistence and offers increased resistance to section. The capsule is often considerably thickened. Adhesions over the surface of the liver are present usually only if there has been an ascites. The surface of the organ is coarsely granular showing grayish depressions surrounding yellowish-brown or reddish-brown oval or rounded elevations, the so-called hobnails. These elevations may be as large as two centimeters in diameter but usually average from two to four millimeters. The hobnails represent islands of liver tissue which are surrounded by fibrous tissue and squeezed up by its contraction. On section the cut surface is very rough the liver parenchyma being separated off into small islands by bands of fibrous tissue which apparently squeeze them above the surface. The color is usually distinctly yellow but may be reddish or brownish. The islands of liver tissue are in great part new-formed liver cells and not merely areas which have escaped destruction as evidenced by a lack of normal arrangement and the eccentric position of the central vein. There is often more or less obliterating endophlebitis of the hepatic veins and the smaller branches of the portal vein may exhibit compression and thrombosis. The larger branches of the portal vein are dilated while thrombosis is more common in cirrhosis than in any other condition. Communications exist between the portal vein and the systemic circulation. These serve in part to relieve the stasis which follows the obstruction to the portal circulation. They occur between the veins of the peritoneum and those of the abdominal wall; between the veins of the hepatic capsule and those of the diaphragm; between the esophageal and the gastric veins; between veins in the round ligament and those in the anterior abdominal wall which when dilated form the so-called "caput medusæ," though it must be remembered that this condition may be due not directly to portal obstruction but to the pressure of ascitic fluid on the inferior vena cava; between the superior and the middle and inferior hemorrhoidal veins leading to the formation of piles. The gall-bladder and biliary ducts are usually normal.

On microscopic examination there is seen a marked change from the normal arrangement of the liver lobules. The lobules vary tremendously in size and shape and are surrounded by fine or broad bands of connective tissue. The actual size may be smaller or much larger than those found normally. The parenchyma cells show degenerative, atrophic, and hyper-

plastic changes. Many of the cells, especially in the periphery of the lobule are quite apparently newformed being large, clear, and plump, a fact that speaks against the argument that the lobules are compressed by the fibrous tissue. It is due to this active regeneration that the functional activity of the liver is so little affected by the development of the cirrhosis. There is also marked proliferation of bile ducts either from the extension of previously existing ducts or they may result from the proliferation of the liver cells themselves. The central veins are situated eccentrically or even in the connective-tissue bands. There is generally more or less round-cell infiltration about the portal vein, evidence of the inflammatory factor in the disease. The elastic tissue is markedly increased while the increase in the white fibrous tissue is relatively less marked. The changes in the reticulum are those of hypertrophy rather than hyperplasia.

The spleen is usually enlarged as a result not only of chronic congestion but also of the toxins which reach it through the blood stream. The gastrointestinal system will show the lesions of chronic alcoholism in those cases in which alcohol has been a factor. In addition there are frequently dilated and tortuous veins beneath the mucous membrane at the gastroesophageal junction. Hemorrhoids are often seen. The changes in the kidneys, heart, and bloodvessels are due probably more to the alcoholism than to the cirrhosis.

Symptoms.—In the majority of cases the lesions in the liver are well advanced before the appearance of any symptoms. In the early stages of the disease the greater number of cases show only symptoms due to the action on the stomach and intestines of the most frequent cause of the cirrhosis—alcohol. There may be coated tongue, loss of appetite, nausea, morning vomiting, epigastric distress, irregularity of the bowels, hemorrhoids, etc. In a few cases there may appear symptoms which have been attributed to an active hyperemia of the liver; these are vague gastric symptoms, a feeling of weight in the right hypochondrium, temporary slight elevations of temperature, occasional very slight jaundice and actual pain in the region of the liver. Attacks may last for several days and recur at irregular intervals. With the progress of the disease, the increasing portal obstruction leads to congestion of the spleen and the gastrointestinal tract. The spleen enlarges, the stomach and intestines begin to exhibit a deficiency in functionating power, and constipation increases. The constipation and its accompanying tympanites may be temporarily relieved by an attack of diarrhea. Hemorrhoids become more troublesome and the caput medusæ may appear. Pain and tenderness over the region of the liver and spleen are quite frequent. The pain may be referred to the angle of the scapula and to the tip of the right shoulder. In a considerable number of instances the first symptom of the disease is the vomiting of a fairly large amount of blood which is usually dark and partially clotted. The hemorrhage is usually large and may be repeated but is not often fatal. The source of the bleeding may be rupture of the dilated veins in the esophagus or stomach, oozing from distended gastric capillaries in the presence of a gastritis or abrasion of the gastric mucous membrane. Accompanying or following the gastric hemorrhage there is usually blood in the stools. These patients also show a tendency to bleed elsewhere. Epistaxis, bleeding from the gums, the mucous membrane of the larynx, from the lungs or into the skin, or menorrhagia or metrorrhagia may occur. Jaundice is not a common finding but the conjunctivæ frequently show a subicteric tint. This usually varies in intensity from time to time. From fifteen to twenty per cent. of the cases develop a well-marked icterus. Due to the toxemia present are such symptoms as weakness, headache, apathy, coma, or sometimes delirium. Ascites and edema of the legs are later manifestations. The urine is apt to be diminished in amount and the urea may be decreased. It usually contains urobilin. Albumin may be present if the kidneys are congested or pressed upon.

Physical Signs.—In the early stages there is pallor and sallowness. Later, there is emaciation and the face is thin, the eyes sunken, and the bones prominent. The skin is wrinkled and the color subicteric. The abdomen is distended and the superficial capillaries and veins are prominent. The lips are dry, the tongue coated, and the breath foul. The liver is enlarged and palpable in most cases unless palpation is made difficult by the presence of fluid in the abdomen. The liver is often tender, the edge sharp and the surface rough. Late in the disease the liver may be reduced in size. The left lobe is often disproportionately small. The spleen is usually easily palpable. There may be a functional murmur in the heart. Ascites when present yields the usual signs of free fluid in the peritoneal cavity. Although generally considered as a late manifestation of the disease it is probable that there is an increase in the abdominal fluid rather early. If repeated tappings are required many investigators think that the liver condition is complicated with chronic peritonitis. The ascitic fluid varies in amount, quantities as large as twenty liters having been recorded. The fluid is usually pale amber, clear, slightly opalescent and alkaline. It has a specific gravity of 1,008 to 1,015 and contains one-half to one per cent. of albumin. It is generally sterile and contains few cells, mostly lymphocytes and endothelial cells. Varying with the amount of the fluid there may occur displacement of the thoracic and abdominal organs. Embarrassment of the action of the heart and lungs may be a sequel of such displacement. Edema of the legs is rather common after the appearance of ascites. The blood shows the picture of a secondary anemia.

Complications.—Tuberculosis is a frequent complication. Tuberculous peritonitis is frequently overlooked. Other complications are pleurisy, bronchopneumonia, nephritis, alcoholic neuritis, endocarditis, myocarditis, thrombosis of the portal vein, etc.

Diagnosis.—In a well-developed fairly advanced case of portal cirrhosis the diagnosis is comparatively easy. In the early stages it is much more difficult but should be made more often than it is. In an alcoholic subject with dyspepsia, the presence of an enlarged and tender liver should suggest the diagnosis; if, in addition, there is an enlarged spleen, slight jaundice and urobilinuria the diagnosis becomes highly probable. Biliary cirrhosis presents a large smooth liver, an absence of evidence of portal obstruction and by marked and persistent jaundice. The syphilitic liver is usually much more irregular but the diagnosis may be quite impossible. Fatty liver is soft and smooth. In amyloid disease, malaria, and passive congestion, the etiological factor can usually be determined with sufficient accuracy at least to decide on a probable diagnosis. Hematemesis may necessitate differentiation from pulmonary tuberculosis and gastric ulcer, a matter which is apt to be facilitated by *x*-ray examination. Banti's disease is excluded by the more marked anemia and the fact that in this disease the enlargement of the spleen is the primary condition. Most of the cases of Banti's disease are in young people. The ascites must be differentiated from that which may accompany chronic cardiac disease, cachectic states, and chronic nephritis. The examination of a portion of the fluid removed from the abdomen will reveal the fact that it is a transudate. No satisfactory functional tests have yet been devised though several substances, notably levulose and phenoltetrachlorphthalein are being investigated.

Prognosis.—If recognized early the process may be arrested and the patient live for a considerable period of time. If seen late, after the development of ascites the outlook is bad. Occasionally following

repeated tappings an adequate collateral circulation will be established and the condition remain stationary. The liver undergoes hyperplasia to such an extent that if the progress of the lesion can be arrested the organ will be able to functionate properly. Death usually results from intercurrent disease or from exhaustion. In young subjects the course may be very rapid.

Treatment.—The only trustworthy treatment is based on our knowledge of the etiological factors of the disease and must therefore be instituted early before the destruction of much liver tissue or the growth of much fibrous tissue. The diet is of the greatest importance. Alcohol principally and all stimulating and irritating articles of food such as spices must be absolutely prohibited. If cure or improvement is obviously impossible because of the extent to which the process has advanced, it may be unnecessary or unwise to stop the alcohol entirely. The diet should be nourishing and non-irritating. Milk, alone for a while, then with the addition of eggs, gruels, cereals, stewed fruits, and the occasional use of fish and green vegetables will provide a dietary which will, as a rule, prove satisfying to the patient and without harm to his liver. Meats and carbohydrate foods should be avoided as far as possible. The absolute milk diet should be resorted to again and again at intervals. Indulgence in tea, coffee, or meat may be permitted when it seems that the patient will gain thereby but only at infrequent intervals. Syphilis and malaria must be treated if present. Potassium iodide has been recommended in the belief that it will prevent the further formation of connective tissue. It is extremely doubtful if it has any favorable action except in cases of syphilis. A course of treatment at one of the well-known Spas may exercise a beneficial influence upon the gastrointestinal tract since it will lessen the intestinal catarrh, the portal congestion, and the constipation. Saline cathartics persistently used will approximate these good effects. The nausea and vomiting should be treated as in other conditions. Bismuth, the mineral acids, silver nitrate, belladonna, and nux vomica are perhaps the most efficient of a long list of remedies which have been recommended. Hematemesis should be treated by ice, morphine, and absolute rest. All food should be withheld. Adrenalin chloride may be given by mouth in the hope that it will reach the bleeding point. Ascites demands the use of vigorous purgation whether to prevent its development or its reaccumulation. When the fluid is present in large quantities, tapping should be resorted to and it should be repeated as often as may be necessary to keep the patient comfortable. Continuous drainage is sometimes practised and many operations have been devised to bring it about. Perhaps the most successful has been the connection of the abdominal cavity with the femoral vein so that the fluid is thus readily carried off into the general circulation. It is not often that any of the surgical measures are attended with more than evanescent relief. Tapping, if done carefully and under strict aseptic precautions may be repeated an indefinite number of times without causing any ill effects.

Special Types of Portal Cirrhosis.—In the condition known as hemochromatosis or bronzed diabetes there is extensive proliferation of the fibrous tissue not only in the liver but also in the pancreas. There occurs marked pigmentation due to the action of some hemolytic agent and later on a glycosuria develops as a result of the pancreatic changes. The skin pigmentation suggests Addison's disease while the other symptoms are similar to those of portal cirrhosis. The diabetes is of a severe grade and coma is a frequent outcome. The prognosis is bad. The treatment is first that of cirrhosis, later that of diabetes.

In tropical countries following frequent and prolonged attacks of malaria there may develop a cirrhosis of the liver. The organ is smaller than in the typical portal form and the granulations are finer. The spleen is always enlarged, often to a very marked degree.

In Banti's disease, hemolytic splenomegaly, there usually is a cirrhosis of the liver which appears rather late in the course of the disease.

In syphilitic cirrhosis the distribution of the fibrous tissue has been described as pericellular, extending into the lobules and surrounding the individual cells. The liver is often greatly distorted and may present scars which represent the cicatrization of old gummata.

Biliary Cirrhosis.—Biliary cirrhosis is a chronic disease of the liver, probably infectious in nature, also known as Hanot's, hypertrophic or monolobular cirrhosis. It is a comparatively infrequent condition and is characterized by recurring attacks of jaundice, abdominal pain, and fever. It occurs in early adult life but is quite common in children in India. The cause of the disease is unknown. Alcohol plays but little part in its etiology. It is believed that it is an infection in which the organisms produce a toxin in the spleen from which the poison reaches the liver and produces the lesions of a radicular cholangitis. The liver is enlarged weighing from two to four kilograms (about four and one-half to nine pounds). Its consistence is increased. It is finely granular externally though the surface is smooth as compared to that in portal cirrhosis. The organ is usually olive green in color and may be mottled. The cut surface is dark green or yellowish green in color, smooth, and the lobules are distinct. The bile ducts outside the organ and the gall-bladder are normal. On microscopic examination there is a marked overgrowth of fibrous tissue which is limited to no particular region but the essential process is a remarkable proliferation of the bile ducts. The borders of the lobules are notched with small processes of connective tissue which, extending into the lobules, separate more or less completely single liver cells or groups of them from their respective cords and columns. Such isolated liver cells often contain bile pigment in rounded and club-shaped masses or branching plugs moulded to the shape of the biliary canaliculi. These isolated liver cells are directly continuous with the newly grown bile ducts and the whole may be looked upon as a reversion to a less highly specialized type of structure. The liver cells themselves are but slightly altered. Acute necrotic changes may occur at any time. Icterus is general and marked. All the organs are bile stained. The spleen is enlarged. The lymphatic glands in the portal fissure and usually the adjacent glands are enlarged, edematous, and congested. Ascites if present at all appears toward the end.

The first real *symptom* is usually the onset of jaundice though the patient has generally suffered for a long time with malaise, anorexia, and weakness. The jaundice, slight at first, undergoes many remissions and even intermissions but gradually increases until it becomes extreme even greenish. Bile pigment is rarely absent from the stools. The usual accompaniments of jaundice are seen; itching, eczema, bleeding from the mucous membranes, and slow pulse may occur from time to time. The urine contains large amounts of bile pigment. There are periodic attacks of fever and intense abdominal pain which are attended with symptoms of a gastroduodenitis. The leucocytes are increased in number and there may be severe cerebral symptoms. These attacks not infrequently have a fatal outcome. The abdomen is enlarged due to the increased size of both the liver and the spleen.

Diagnosis is often difficult. A long-continued jaundice with the presence of a large liver and spleen is suggestive but it must be remembered that portal cirrhosis may at times present a similar picture. The age, the absence of an alcoholic history, the absence

of large hemorrhages and the long course are all points which help in a diagnosis of Hanot's cirrhosis. The prognosis for a cure is hopeless though the course is protracted, averaging from five to ten years. The general health during the remissions may be quite good but the acute attacks may be very severe and may prove fatal at any time.

The *treatment* is essentially that of portal cirrhosis though the diet need not be quite so restricted. The use of antiseptics such as hexamethylenamine and salicylates has been advised but their use has not produced any very definite improvement. The need for the treatment of recurring ascites does not arise in this form of cirrhosis.

An obstructive biliary cirrhosis accompanies or follows congenital obstruction to or absence of the extrahepatic bile ducts. The liver is enlarged, firm, and jaundiced and contains numerous biliary retention cysts. Microscopic examination reveals an interlobular cirrhosis. These cases, naturally, all end fatally after a very short course.

RALPH G. STILLMAN.

Liver, Fatty.—There are two varieties of fatty liver: (1) fatty infiltration, (2) fatty degeneration. During life it is impossible to be absolutely certain which variety exists and indeed in many cases the two conditions exist side by side. There is considerable evidence that in all cases the fat found in the liver is derived from other portions of the body and the tendency at the present time is to class all such conditions together under the term fatty liver. The liver of phosphorus poisoning has been taken as the typical example of fatty degeneration.

According to Perls, chemical analysis shows that in fatty infiltration there is a much greater quantity of fat than in fatty degeneration. It proves that in fatty degeneration there is a diminution of the solid (non-fatty) matter, that is, of the albumin, while the amount of water in the liver remains normal. In fatty infiltration, on the other hand, the fat is increased mainly at the expense of the water, the watery constituents of the liver falling from seventy-seven to fifty per cent., while the amount of the non-fatty solid matter, albumin, remains about the same. On post-mortem examination, if the other fat-containing tissues of the body, such as the epicardium, mesentery, epiploic appendages and subcutaneous connective tissue, show an abnormal amount of fat, it is very likely that the liver will show an infiltration.

ETIOLOGY.—(1) *Dietetic.*—It is well known that the liver is normally one of the fat repositories of the body; physiologically there is a certain amount of fat in the liver cells. This does not interfere at all with the function of the liver. When this infiltration becomes excessive, it is pathological. Pathological fat infiltration may occur in gluttons and those leading a sedentary life. Infants who are overfed, especially with a food containing an excess of sugar, show a fatty liver. In these cases the fatty deposits are probably due to an incomplete oxidation of the food material.

(2) *Anemic and Cachectic.*—It is rather a paradoxical fact that the various cachexias—in which there is marked emaciation—show a fatty liver. Among these cachexias the tuberculous affections of lungs, bones, joints and lymphatics are especially to be mentioned; also carcinomata of various organs, chronic suppurations, such as bone disease, old bed-sores, chronic dysentery and chronic anemia, including leukemia and chlorosis. Here also it is probably a result of deficient oxidation.

(3) *Passive congestion*, secondary to failure of the circulation, frequently results in a fatty infiltration of the periphery of the lobules producing the so-called "nutmeg liver."

(4) *Toxic.*—Chronic alcoholism is the most frequent form of fatty liver seen which is due to a toxic agent. The alcohol demands oxygen for its own oxidation and at the same time causes a diminished oxidation in the tissues. It is usually associated with a fibrosis of the organ causing the well-known fatty cirrhosis such as is often seen in chronic alcoholics. Other poisons which may cause fatty liver are phosphorus, arsenic, mercury, hydrochloric, nitric, and sulphuric acids, chloroform, iodoform, phlorizin, fungi, and certain meat poisons. Phosphorus poisoning is the best example of this variety. Since the enactment of stringent measures, enforcing the use of a more insoluble and less poisonous form of phosphorus in the manufacture of matches, this form of poisoning is much less common than formerly.

(5) *Infectious.*—In many of the acute infectious fevers a fatty liver is found. Local and general infections, especially if prolonged, are apt to figure prominently in the etiology. Fatty degeneration of the new-born, so-called Buhl's disease, has been described; so also has an acute fatty degeneration occurring in puerperal women.

PATHOLOGY.—The liver is usually enlarged, weighing from 3,000 to 4,000 grams. It may occasionally be smaller than normal. The specific gravity is diminished so that the organ may float in water. It is soft, showing a diminished resistance, pale yellow and on section obviously fatty. In nutmeg liver the lobules show a dark center and a pale periphery. In fatty cirrhosis the fibrosis is quite obvious. Histologically, the cells contain fat droplets of varying size displacing the cell protoplasm and the nuclei. It may involve any part of the lobule but is more often in the central zone. The cells show fat droplets in the cytoplasm which is granular and opaque. The nuclei are at first unaltered and later show retrograde changes.

SYMPTOMS.—There are no characteristic symptoms of this condition. In the majority of cases there are no symptoms referable to the liver, practically all being due to the initiating disease. In some instances there may be a sense of fullness or distress due to the enlarged size of the organ. The liver is large and may be felt two or three fingers below the costal margin though an excess of fat in the abdominal wall and the flaccidity of the liver may make this examination unsatisfactory. In phosphorus poisoning the liver may be very tender.

DIAGNOSIS.—Minor grades are hard to recognize. The more marked grades have to be differentiated from other large livers. In fatty cirrhosis, there are the symptoms of cirrhosis, hematemesis, ascites, large spleen. Amyloid liver is firmer and is usually accompanied by an obvious cause. Leukemic enlargement is identified by means of a blood examination. The large liver of passive congestion is recognized by observing the cause. A displacement of the liver should be discovered by careful physical examination. The liver of phosphorus poisoning should easily be recognized from the history. Jaundice occurs only in this last type of fatty liver.

PROGNOSIS.—This depends upon the prognosis of the fundamental disease. In itself, fatty liver does not tend to shorten life.

TREATMENT.—The treatment is that of the primary causative condition.

JAMES RAE ARNEILL.
Revised by RALPH G. STILLMAN.

Liver, Hyperemia of the.—(Congestion of the Liver.) A more or less persistent increase in the volume of the blood in the liver constitutes hyperemia, and is pathological, in contradistinction to that temporary physiological increase which occurs during the period of digestion.

When the hyperemia is due to an increased afflux of blood, it is termed a *fluxion;* when to a diminished efflux, a *congestion.* An *active* hyperemia signifies a sudden determination of blood to the organ, or a fluxion, made manifest by definite acute symptoms; it usually subsides without structural changes in the viscus. A *passive* hyperemia, diminished efflux, is developed slowly, with few accompanying symptoms until after structural changes, which usually occur, have taken place.

An *active* hyperemia is essentially acute; a passive, chronic. Some passive hyperemias, however, occur in a short space of time, as in the form that accompanies a large pleural effusion.

Mechanical hyperemia, active or passive, is caused by an obstruction to the outlet of blood, and this obstruction may be seated in the vena cava, the heart, or the pulmonary circulation.

It is, however, wellnigh impossible to separate the various forms of hyperemia by hard-and-fast lines, and clinically it suffices to consider hyperemias as either active or passive—which terms are practically synonymous with acute and chronic congestion of the organ. The difficulty of accurate subdivision arises from the fact that the various forms blend. Three sets of vessels are involved in the occurrence of congestion. The congestion due to overrepletion in the hepatic veins differs in form and behavior from that due to portal fulness. The two forms are readily distinguished by a consideration of the primary causal factors. To distinguish the hyperemia which is due to an excess in the portal system of veins, from that which is dependent upon a fulness of the hepatic artery, is clinically impossible and scarcely practicable.

Etiology.—*Active Hyperemia, Acute Congestion.*—The ingestion of stimulating food and drink causes active hyperemia. When alcohol, fermented liquors, spices, and rich foods are taken frequently or in excess, especially by delicate persons who lead a sedentary life, the normal congestion associated with digestion becomes excessive and more or less permanent. Musgrove (*Medical Record,* 1902) considers the overindulgence in highly seasoned articles of diet as seen in the East, and the consequent hyperemia of the liver, to be directly contributory to the frequency of hepatic abscess. Residents in hot climates, with or without such indulgence, are particularly prone to attacks of hepatic congestion; hence high temperature has been considered a causal factor. Sudden checking of the perspiration, a severe and sudden, or a prolonged, chill or repetition of chills, is followed quite frequently by active hyperemia. Persons living in a malarious region are liable to attacks of hepatic, as well as of splenic, congestion. During the seasons when malaria is rife, or when the changes in temperature are sudden and extreme, the disease is most liable to occur. Congestion of the liver is found, oo, in many infectious diseases, as relapsing fever, yellow fever, epidemic cerebrospinal meningitis, and scarlet and typhus fevers. After traumatism, a determination of blood to the injured area of hepatic tissue is always observed. It is said, also, that hyperemia of the liver occurs in scurvy.

The suppression of customary discharges, especially of blood, causes fluxion to the liver. Cessation of the menses at the menopause, or by cold or nervous influence, and arrest of the hemorrhages of uterine disease from various causes, are not uncommonly followed by attacks of hepatic congestion. So, also, congestion of this organ not infrequently follows the stanching of hemorrhoidal bleeding.

It is said that habitual constipation induces passive congestion of the liver. We see in some diseases—as tuberculous peritonitis—a hyperemia of the liver. The condition, however, is usually found to be more a fatty infiltration of the liver substance. As Thierfelder suggests, the congestion associated with diabetes mellitus may be due to paresis of the abdominal sympathetic. The sluggishness of the circulation, which occurs in persons who exercise sparingly, is markedly seen in the stasis that occurs in the liver.

Active or acute congestion of the liver, therefore, is liable to occur in persons of sedentary habits, without muscular vigor, who are high livers and reside in hot climates. It should not be forgotten, however, that its occurrence in temperate climates, though of comparative infrequency, is yet not very rare. A chill, or sudden checking of perspiration, is a frequent exciting cause. Malaria is most commonly observed, of all diseases, to excite an attack. Hepatic congestion occurs most frequently in the autumn, and usually affects individuals of middle life.

Chronic Hyperemia.—The most important and frequent causes of chronic hyperemia of the liver, whether in temperate or in tropical climates, are mechanical. The forms of heart disease which cause backing of the blood into the venous system—such, for example, as cardiac dilatation and mitral and tricuspid valvular disease—are attended by hepatic congestion. In emphysema, interstitial pneumonia, and atelectasis, the venous flow is obstructed. The form of congestion is, under these circumstances, passive. Tumors of the mediastinum, aneurysms, thrombosis, and tumors of the inferior vena cava, effusions in the pleura, pressing upon or bending the vena cava, also cause hepatic congestion.

Frequency.—Musser, Sr., collected some interesting facts concerning hepatic disease in a study of all the cases of liver disease presented to the Pathological Society of Philadelphia, from 1857 to 1881, inclusive. The condition of the liver was recorded 430 times—184 times normal and 246 times diseased. In 10 instances the liver was congested, in cases in which death occurred from accidental causes. The subjoined table indicates the proportionate frequency of occurrence of congestion of the liver, simple and nutmeg, in 246 cases of liver disease. It is of interest to note that in 36 cases of cardiac disease the liver was healthy 5 times, the seat of nutmeg congestion 9, and of simple congestion 4 times. Nine times it was fatty; 8 times cirrhotic; 1 the seat of red atrophy (due to congestion). Of 13 instances of nutmeg congestion, 9 attended cardiac disease; 1 chronic pleurisy; 2 carcinoma (heart weak); and 1 chronic diarrhea. The liver was enlarged 8 times in 13. The spleen was enlarged 6 times; healthy, 2; cirrhotic, 1; not mentioned, 4 times in the 13 cases. The kidneys were congested or cirrhotic in 10 of the 13 cases. Eleven of the cases were males; 6 of them were over forty, 5 between twenty and forty, and 2 under twenty. In no instance were symptoms referable to the liver recorded.

Table of Relative Frequency of Alterations of Hepatic Structure (Total Number of Cases Two Hundred and Forty-six.)

Variety.	No. of cases.
Fatty	80
Carcinoma	41
Cirrhotic	38
Congestion	24
Congestion, nutmeg	13
Abscess	13
Tuberculosis	9
Syphilitic gumma	5
Hydatid disease	4
Rupture of liver	3
Hemorrhage into liver	2
Pigment liver	3
Amyloid liver	2
"Diseased" liver	3
Leukemic, "atrophied," red atrophy, chronic hepatitis, cavernous angioma, myeloid tumor, one each	6

Symptomatology.—It is manifest that the symptoms of hyperemia of the liver differ according to the

cause. Moreover, they are intermingled with the symptoms that belong to the respective causal factors. In mechanical hyperemia, for instance, the symptoms of obstructive heart or lung disease are present, along with those of hepatic congestion. In active hyperemia the hepatic symptoms are less complicated, and serve as a type of the acute form.

After a chill, excesses in diet, or exposure to high temperature, complaints of pain in the liver, and of weight and fulness in the right hypochondrium, are made. The pain may extend to the right shoulder, is constant and associated with tenderness of the liver, and is excited by palpation along the margin of the ribs. Febrile reaction, not marked, attends the attack for two or three days, while general malaise is marked. At the same time a bad taste in the mouth, a tongue heavily coated with a yellowish material, nausea, thirst, anorexia, epigastric fulness, flatulency, and often vomiting, are present. The bowels, at first torpid, are relieved by diarrhea. A gastrointestinal catarrh usually accompanies the hepatic congestion, in which case vomiting and diarrhea are more frequent. The ejecta from the stomach are composed of the food, an acid, glairy mucus, and bile-stained watery fluid. The stools may be clay colored and pasty, or watery, acid, and greenish, or dark colored. Often there is some dyspnea. Headache, usually frontal, accompanies the attack, and is associated with vertigo.

On physical examination the liver is found to be enlarged, often extending two or three inches below the margin of the ribs. Its edge is rounded, elastic, and smooth.

In a day or two the conjunctivæ become yellowish, and even a light degree of general jaundice supervenes. The jaundice is due to associated catarrh of the gall ducts, or to pressure on them by the engorged vessels. Languor and debility continue for some time, while melancholy and hypochondriasis commonly occur. The countenance, at first flushed, or, if the pain is severe, anxious and pinched, grows sallow and worn.

The urine is scanty and high colored. It contains an excess of urates, some bile pigment if there is jaundice, and often small amounts of albumin.

If the hyperemia persists, the overloaded state of the portal vessels results in sluggish absorption of the products of digestion and overrepletion of the vessels of the gastrointestinal mucous membrane. A true catarrh of the tract arises, and is all the more aggravated and persistent on account of the vascular stasis. Its symptoms replace largely those of congestion. In passive and mechanical hyperemia, this catarrh is most marked. In these forms the liver is large, more firm, but less tender on palpation. Its size, in hyperemia due to obstruction, is variable. Depletion by a purgative, or removal or relief of the cause (cardiac dilatation, etc.), would reduce it, and a recurrence of the cause would again be followed by enlargement. This temporary change characterizes mechanical hyperemia. An enlarged, congested liver may be temporarily increased in size by sudden obstruction in some other area of the blood circuit. A pneumonia or a pleural effusion may thus aggravate the hepatic engorgement, and in turn be aggravated by the old liver disease.

In long-standing cases the stasis in the hepatic circulation may be so extreme as to cause overfulness in the portal vessels and secondary enlargement of the organs in that area. An ascites, out of proportion to the general anasarea usually present, will arise, the spleen becomes enlarged, and the hemorrhoidal vessels are dilated. The secondary phenomena are more probable if the changes incident to overgrowth of the cellular tissue of the liver ensue. In this class of cases the liver is diminished in size, and, if palpable, is very firm and hard.

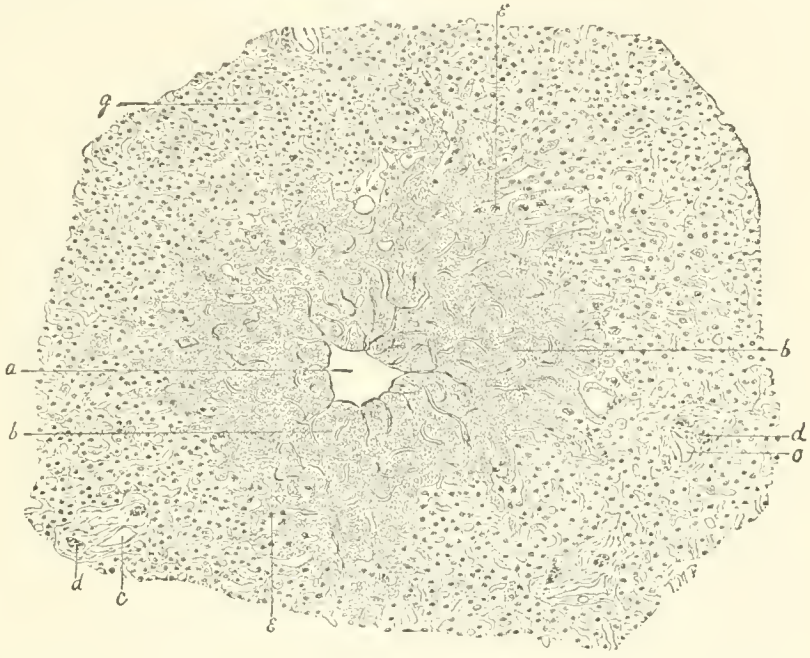

Fig. 3773.—Chronic Congestion of the Liver. (× 300 and reduced.) Complete atrophy of the liver cells at the center of a lobule. *a*, Dilated vena centralis; *b*, dilated capillaries filled with blood; *c*, portal vein surrounded by connective tissue; *d*, gall ducts; *e*, atrophied liver cells; *g*, nearly normal tissue. (From Delafield and Prudden's "Handbook of Pathological Anatomy and Histology.")

Course, Duration, and Prognosis.—The course and duration are largely determined by the cause. An active congestion of the liver will subside usually in from two to three weeks. The subjective symptoms are often removed, while enlargement of the organ may continue for some time. Congestions of the liver which originate on the portal side of the hepatic circulation are more amenable to treatment, and last a shorter time, than the congestions on the hepatic side. The latter are due to chronic heart and lung disease, and in their varying course, now better, now worse, depend upon the primary causal agency. The prognosis, likewise, depends on the cause. When the liver becomes enlarged from congestion, and subsequently undergoes marked atrophy, the prognosis of the hepatic trouble is serious, and it in turn renders more grave, day by day, the primary disease. Care must be exercised not to mistake the initial congestion and enlargement of true cirrhosis for simple hyperemia. An active congestion of a liver, in which the anatomical structures are abnormal from previous disease, is serious and may fatally terminate a slow cirrhosis or a fatty liver.

Diagnosis.—The diagnosis is usually easy, but the condition cannot be clearly recognized unless the causal influences previously mentioned are evident. In addition to the cause, the shape and size of the liver,

the gastrointestinal catarrh, the condition of the urine, and the signs of secondary portal obstruction, must also be considered.

Morbid Anatomy and Pathology.—Before advanced secondary changes have taken place the liver is uniformly enlarged. The enlargement is most marked in the thickness of the organ. The surface is smooth, the capsule transparent, the edges are thick and rounded. On section, dark blood oozes freely from the vessels. The tissue is soft and darker in color than normal. The vessels are dilated; the enlargement of the hepatic veins in the acini is especially distinct in passive congestion, though a similar increase in size of the portal vessels occurs when the engorgement is limited to that side of the circulation. Throughout the substance of the organ numerous hemorrhages are seen. On microscopical examination, the vessels are seen to be dilated and their walls thickened by increased cell proliferation and the migration of leucocytes. Atrophy from compression of the hepatic cells is early seen. A catarrh of the minute ducts is often present.

In the more advanced stages, the atrophy of the cells is more marked, pigmentation and fatty degeneration of the cells in the portal zone are present to a great degree, and the cell proliferation and the infiltration of leucocytes are not only seen in and about the vessel walls, but also between the hepatic cells of the individual acini. New-formed bile ducts are frequently to be seen in the new-formed connective tissue. This is due to an overgrowth of connective tissue, or to greater distinctness of the cells on account of destruction of the hepatic cells. A liver that presents the following gross changes is called the *nutmeg liver*. It is normal in size or lessened, firm on section. The capsule is opaque, and the surface and interior are granular, the latter gorged with blood. The acini are distinct, the central vein much dilated and dark in color. The periphery of the lobule is yellow, the center dark red. The term "nutmeg" is applied to the marbled appearance.

In more advanced stages the overgrowth of connective tissue is extreme and leads to great atrophy and pigmentation of the gland elements. Crystals of hematin are observed free in the tissues. The liver is small, very firm, dark red. Such is the liver of *cyanotic atrophy*. The same macroscopical appearances are seen in *cyanotic induration*, but the increase of the connective tissue is greater, the cells are more degenerated, and the vessels are more engorged. These advanced changes are located in the region of the hepatic vein, while the interstitial overgrowth in cirrhosis begins in the portal veins.

Treatment.—The first indication to be met is the removal or amelioration of the cause. The methods to be pursued readily suggest themselves to the physician if he possesses a knowledge of the cause and mechanism of the congestion. Thus, the diet must be well selected, and bland, non-stimulating articles are to be given. Rich foods, pastries, condiments, sugars, and starches are to be avoided. Milk, eggs, beef-broth and beef-tea, lean meat, succulent vegetables, and acid drinks are required. Systematic exercise is essential, especially in sedentary subjects. Daily walks, horseback riding, etc., are all good. Horseback riding is the best. A change of air, especially a residence by the sea, is often beneficial. Bathing, sponging, and douching are of much service.

The acute manifestations are best treated by local depletion, with morphine given internally to relieve the pain. Wet-cups over the liver, and leeches in the same area or around the anus, may be used. If the pain is not so severe any hot fomentation or mustard plasters will be sufficient.

To assist further in the depletion of the hepatic circulation, purgatives are indicated. The salines are of great value. Phosphate of soda, Rochelle salts, citrate of magnesia, and other salines may be used, preference being given to those first named. If there is much nausea or vomiting it may be relieved by small doses (from one-sixteenth to half a grain) of calomel frequently repeated taken dry on the tongue. Some practitioners use large doses of the drug at once, and see evidences of liver congestion and torpor in every disease. The resinous cathartics are used by many, podophyllin being the favorite.

If the congestion of the liver be due to cold or checking of the perspiration, remedies to equalize the circulation must be administered. Saline diaphoretics or Dover's powder, a warm bath or a foot-bath, aconite to quiet the circulation, and bromides to allay nervous excitement, are indicated. If there is much pain, small doses of Dover's powder are of great service. In malarious districts, large doses of quinine are used. In fact, quinine and calomel form the sheet-anchor combination for many practitioners. High temperature must be combated, and the usual remedies to relieve the cardiac and pulmonary affections that are the primary source of the congestion should be administered.

There are two drugs that have acquired a reputation in the treatment of congestion of the liver, viz., muriate of ammonia and ipecacuanha. Their use originated in the East. Ammonium chloride is given in doses of from gr. x. to gr. xxx. every four or six hours. Ipecacuanha is given in the same way as in the treatment of dysentery. The patient must be at rest, and the dose of ipecac should be preceded by a small dose of laudanum and by the application of a mustard plaster to the epigastrium. In this manner vomiting is often prevented. From thirty to sixty grains of the drug, every four or six hours, are given.

Alkalies are of great service in congestion of the liver. They must be administered well diluted, and on an empty stomach. It is advantageous to use the alkaline solution hot, and to sip it slowly. The natural mineral waters may be used. Those of Vichy, of Ems, and of Carlsbad, or the Hathorn and Congress waters of this country, are indicated.

The so-called grape-cure and the whey-cure were at one time quite in vogue in Germany, and both are, no doubt, of great value, largely because abstinence from other heavier foods is insisted upon.

The patients who can afford it will be much benefited by a residence at the various springs, taking a course of the waters and following the prescribed diet.

After a course of alkalies, or the use of the means suggested above, the patient may be enfeebled and the digestion weak. Tonics are then indicated. The mineral acids, quinine, and nux vomica are the best. With or without gastric disturbance, the chalybeate alkaline waters are of great value. Especially after a course at the "springs," an after-course should be taken at other springs, where a stimulating outdoor life and tonic waters would add to the vigor of the patient. In this period of convalescence the diet must be carefully selected, some mild wines employed, and particular attention directed to the regulation of the bowels by gentle saline laxatives.

Norman B. Gwyn.

Liver, Injuries of the.—See *Abdominal Injuries*.

Liver, Neoplasms of the.—Tumors of the liver are more generally of a pathological than a clinical interest. The benign comprise adenoma, angioma, fibroma, and are almost never diagnosed in life. Next to the adenoma the angioma are the most frequently met with. They are about as common in the liver as in other organs, and may be congenital or developed later in life.

Adenoma.—Adenoma of the liver can be of three types—arising from the liver cells, from the bile capillaries, or adenocystoma. The first two classes

are the more numerous. They are mostly found just under the liver capsule, and much more commonly in the right lobe. They are generally very small—not much larger in size than a walnut—are white in color. Frequently they are found in cases of cirrhosis embedded in the cirrhotic tissue. They are never diagnosed clinically and generally found only on very careful postmortem examination.

Sarcoma.—Primary sarcoma is very rare, but secondary deposits from all organs are more commonly found in the liver than in any other organ except the lungs. All types of sarcomata are found, but the most frequent and most malignant are the melanotic.

Even from a pathological examination it may be difficult to say whether a tumor is primary in the liver or not. There is no clinical picture. There is a liver tumor—generally with ascites. Jaundice and fever are almost always present. The duration of life is short. In children especially the course of the disease is rapid.

Two forms may be distinguished, an infiltrating tumor and a circumscribed mass.

Primary Carcinoma.—Primary carcinoma of the liver is very rare indeed. It is most frequently found in adult males, and is with great difficulty diagnosed from cirrhosis. Often it invades tissues previously weakened by some disease—for example, in a cirrhotic liver. It seems to come from the terminal bile duct cells, or from liver cells. Pathologically the point of differentiation from adenoma is the ability of the cancer to invade the blood-vessels of the liver. While metastases may be found in other organs, and where found are of the greatest diagnostic significance, they are not at all common.

Secondary Carcinoma.—Carcinoma of the liver is by far the most commonly encountered tumor. It is in the liver that carcinomatous secondary deposits are most frequently found. This is explained by the fact that not only does the major portion of the blood pass through the liver en route from the organs affected to the heart, but the liver has very extensive lymphatic connections with the digestive tract. Hale White found deposits in the liver in about fifty per cent. of all persons dying in a General Hospital (Guy's). Naturally the primary focus of disease in these cases will be the organs most intimately connected with the liver by the blood stream. The stomach, colon, esophagus and pancreas is the order of frequency described by Rolleston.

The secondary deposits are generally multiple—grayish-white nodules scattered through the liver, more particularly at the periphery—and frequently they coalesce to a marked degree. They are characterized by a tendency to umbilication. The liver is enlarged—it may weigh as much as nineteen pounds—it is generally studded with these umbilicated bosses, which probably can have been felt through the abdominal wall before death. The blood supply to these masses is from the surrounding liver tissue. As the masses enlarge it is cut off; hence autolysis takes place in the center and this accounts for the umbilication.

When the carcinoma has lasted a long time, or when it is in an organ from which the liver receives blood, glands in the transverse fissure are early affected and pressure of these on the common bile duct leads to jaundice. In some instances this jaundice, which is intense and not intermittent, may be the initial symptom of which the patient complains.

Symptoms.—As will be gathered from the last statement, the secondary deposits may cause almost all the primary symptoms of the patient. The onset is insidious. The patient may have been out of sorts for some time, been depressed, had indigestion with fatigue, shortness of breath and slight edema, characteristic of anemia. The slight progressive loss of weight noticeable in the largeness of his ordinary wearing apparel may be the first definite complaint. The loss of weight and general malaise may be out of all proportion to the carcinoma found in the liver. This will be readily understood when one remembers that many cases reported as primary carcinoma of the liver have really been secondary to a focus in the digestive system—the uterus and particularly the prostate—that has escaped the observation of a fairly careful postmortem investigation, and it is natural that the patient should have suffered from the primary carcinoma.

There may be no local disturbance of sensation, though discomfort, up to fairly severe pain, is common. Pain is usually due to a perihepatitis over nodules. Jaundice occurs in over fifty per cent. of cases. It is persistent and increasing. It is due to pressure on the bile duct, or to primary carcinoma of the gall-bladder, to extension along the bile capillaries in the liver tissue, or to the widespread destruction of a massive carcinoma. If due to the latter cause, some bile will escape and there will not be clay-colored stools. There is usually ascites, and both ascites and jaundice in about twenty-five per cent. of all cases. The ascites is rarely severe.

There is almost always progressive nodular enlargement of the liver, usually involving the right lobe more than the left. The edge is firm, irregular, and may be tender (perihepatitis). Sometimes umbilication of the nodules may be appreciated by palpation. In many cases the enlargement proceeds to such a degree that the base of the right lung is compressed and there are to be found loss of respiratory movement, dulness, and many râles with signs of an exudate into the pleura.

Prognosis.—Prognosis is, of course, hopeless as to life. Hale White gives the average duration of life as four months after the development of symptoms in primary cancer, and seven after the development of symptoms from secondary deposits in the liver.

The treatment is purely symptomatic. Not only the pain, but the itching occurring with the jaundice, may demand morphia. Constipation and vomiting may be treated by either enemas or stomach washing.

Diagnosis.—While the diagnosis may be easily made from palpation alone, it will be an indication that the disease is far advanced, and there are many cases where a diagnosis is most difficult or even impossible. One must determine if the enlargement is genuine—that is, that the liver is simply not out of position, and that the enlargement is in the liver—and if there is any evidence at all of a primary focus.

First of all, fecal collections in the transverse or ascending colon may simulate tumors. Consequently one should insist upon an enema before examination. Then thickenings of the gall-bladder may be felt, but these almost always follow cholecystitis; the liver is seldom enlarged; jaundice, if present, is rarely permanent. Great care, too, must be exercised to prevent one mistaking a tumor of a neighboring viscus. The omentum may be found much enlarged. There may be a thickened pylorus, or even a renal tumor has been mistaken for one in the liver. Careful percussion before and after inflation of the colon with air will almost always show the correct position of the swelling.

Tumors of the liver are attached to the liver—move freely on respiration, but movement while it may be present in other organs is more restricted. Tumors of the stomach cause special local disturbances, change the character of the gastric contents and are separated from the liver in the vast majority of cases by the colon. Tumors of the omentum are generally longer and very irregular and are separated by the colon.

When one has restricted the swelling to the liver one has to consider other causes—chronic passive congestion, cirrhosis, syphilis, abscess, hydatid disease, leukemia.

The chronic passive congestion liver is uniformly enlarged, tender, and the patient is obviously sick.

There will be signs of cardiac embarrassment and of lung complications.

In cirrhosis there is usually the history of alcoholism or high living. The liver is generally uniformly enlarged, but may quite quickly change in size. I once saw one recede from the umbilicus to above the costal margin in three weeks. When nodules are felt they are small and multiple.

In syphilis we shall have the benefits of the Wassermann reaction, which, while by no means conclusive as to the cause of the liver enlargement, demands thorough antisyphilitic treatment. The pain is more marked and the size does not increase so rapidly.

Abscess has a history of preceding infection. There is no cachexia. Jaundice and ascites are not so common, and fever with leucocytosis is frequent. The course of the enlargement is more rapid.

Echinococcus cysts are rarer than carcinomata, and with improved public health regulations as to slaughter houses are becoming still rarer. In these cases the striking feature is the predominance of physical signs of liver enlargement with marked absence of symptoms.

Echinococcus Cysts.—Echinococcus cysts are the cystic or bladder stage of a tapeworm, *Tænia echinococcus*, found in the adult stage in the dog's intestine. The eggs escape from the dog and are taken into the alimentary tract of man in drinking water, or on green vegetables. The ova are destroyed in the digestive process and the embryos so liberated hurried through the walls of the intestine, whence they are swept through the blood stream to the liver. Because all the blood from the enteric canal goes through the liver, a very high proportion of the embryos that do develop are located in this organ, but they have been found in the kidneys and spleen. The liver cyst may develop to enormous proportions; one has been reported by Rolleston that filled three-quarters of the abdomen, and from which forty liters were removed on aspiration. Usually the cyst is in the right lobe of the liver. The wall is thin, elastic, bluish white, and tears readily. The cyst is full of a clear fluid which becomes thicker and thicker after death of the cyst, and may become smaller in amount so that the cyst shrinks very greatly.

Hydatid disease is rare on this continent, but with a large immigration the incidence rises.

Symptoms.—The presence of the cyst may only be found after a careful abdominal examination, such as a conscientious life insurance or examination in pregnancy. The abdomen may be large, there may be a sense of dragging, or, if there is an associated peritonitis, there may be marked pain with tenderness. Symptoms of indigestion resulting from pressure on the stomach and intestines may be prominent, but intestinal obstruction is almost never encountered.

Signs.—Physical signs on the contrary are prominent. The upper right quadrant is firm and bulging. The liver is enlarged, firm, and often compresses the right lung, simulating an effusion. The signs vary with the position of the cyst. Usually the tumor is tense and elastic. The usual signs of common duct and inferior vena cava pressure, jaundice ascites, and caput medusæ may be present.

Diagnosis.—A cystic tumor with absence of constitutional disturbance of any severity. The best diagnostic method is an abdominal exploration.

In some cases the cyst ruptures through the diaphragm into lung tissue and hooplets may be coughed up, or it may be discharged through the ureter or by the bowel. In some instances the cyst has been aspirated and hooplets so found.

Serodiagnosis seems satisfactory. The most delicate test is a fixation of complement. The other test is a precipitin reaction, but both are apt to be of no use if the cyst suppurates.

Treatment.—The treatment is essentially surgical for the individual and prophylactic for the community. Care must be exercised in opening the cyst, because severe hemorrhage has taken place from the cramped vessels.

All hydatid diseased offal at slaughter houses should be destroyed. No dog should be permitted to leave a slaughter house when once he has entered. The disease is rampant in Iceland and Australia, and quite common in some parts of America—particularly where there is a large number of immigrants. Careful public health measures should suffice to remove the disease, not only from areas which are served by large, well-kept abattoirs, but even from thinly populated districts where individual slaughtering is done—all depends on the disposal of the excreta.

Alexander McPhedran.

Liver, Physiology of the.—The position of the liver in the pathway of the blood from the gastrointestinal tract to the heart has its significance. If we turn back to the development we find the liver developing in the pathway of the vitelline veins in their way to the heart, ultimately intercepting all the blood of these veins. As these veins ultimately become the portal vein, it can readily be understood why the blood of the gastrointestinal tract and spleen should first traverse the liver. This also accounts for the large size of this organ, but its size would not have been increased were this organ not of great physiological importance.

The *manufacture and secretion of the bile* is one of the functions of this important organ. Excess carbohydrates in the circulation would soon lead to unpleasant disturbances, so the liver must maintain a balance of carbohydrates by storing the excess in the form of *glycogen*. Then again it has the important function of *forming the urea* as will be pointed out later. It also removes certain heterogeneous products as metallic salts from the blood and retains alkaloids which it, no doubt, decomposes. *Toxins* are removed from the blood and neutralized or destroyed, so that this organ exerts a *protective action against poisons*. During fetal life the liver plays an important part in the *manufacture of red blood cells* while the adult red cells or hemoglobin are destroyed in the production of the bile.

In order to comprehend the functions we must allude to the source of its blood. Entering the portal fissure is seen the *hepatic artery* which is much smaller than should be the main nutrient vessel of so large an organ. Entering the portal fissure is the exceedingly large *portal vein*. This vessel is formed by a confluence of the superior mesenteric and splenic veins, the latter receiving the inferior mesenteric vein. In addition, gastric and cystic veins are tributary to the portal vein. It can readily be seen that the liver naturally has the first opportunity at the products of digestion absorbed by the vessels of the gastrointestinal tract. The blood in these two sets of vessels passes into the liver ultimately mixing and coming out through the *hepatic veins*.

The *chemical changes* that occur in the liver are very complex and highly important. The great activity that must be maintained by its cells in order to carry out the manifold functions above mentioned requires an active and excessive supply of blood. As many substances absorbed by the gastrointestinal tract during digestion would be deleterious and poisonous, if allowed to pass through the body generally, this blood of a necessity must pass through the liver where these products are removed, modified, or rendered less harmful. This gastrointestinal blood is diluted by the addition of the blood from the splenic vein. This is a function of the spleen which has not hitherto been brought into prominence; but it furnishes an easy explanation of the peculiar position of the

spleen with regard to the portal circulation, of the well-known anatomical fact that the blood supply of the spleen is much larger than the metabolic wants of that organ demand, and also of the increased size of the spleen and of the vigor of its rhythmic contractions during the period of digestion. By this anatomical arrangement of the spleen and its vessels as an adjunct to the portal circuit, a supply of blood which has not been materially vitiated by metabolic changes can be directly mixed with the portal blood coming from the intestinal area, before it is sent on to the hepatic cells, for the interposition of the resistance of the splenic capillaries and splenic spaces lowers the arterial pressure down to that of the portal vein. On operative removal of the spleen compensation probably takes place by means of an increased supply of blood through the hepatic artery.

Another reason for the connection of the spleen with the portal vein and liver is the fact that the worn-out red blood cells are destroyed in the spleen, as is evidenced by deposits rich in iron. The splenic vein blood is richer in hemoglobin than the arterial blood and the excess hemoglobin is apparently used in the manufacture of the pigments of the bile by the liver. It is also stated that red blood cells are destroyed in the formation of the bile. In order to understand the functions of the liver, the chemical composition must first be considered.

Chemical Composition.—During life, in normal activity, the liver cells are *alkaline*. After death the reaction is acid, due to the formation of fermentation lactic acid and other organic acids accompanied possibly by the coagulation of the protoplasmic proteins.

Proteins.—The best work on the proteins of the liver has been done by Plósz. He obtained in a watery extract a number of substances one of an *albuminous nature*, that coagulated at 45° C.; another, *globulin*, that coagulated at 75° C.; a third, *nucleo-albumin*, that coagulated at 70° C.; a fourth *protein substance* that was dissolved upon the application of heat forming an albuminate, but washable in weak acid and alkalies. From liver cells Halliburton obtained *two globulins* which coagulated, one at 45° to 50° C. and the other at 68° to 70° C. He obtained a *nucleoprotein* containing 1.45 per cent. of phosphorus that coagulated at 60° C. and traces of albumin. Pohl, after washing finely divided liver tissue with sodium chloride solution to remove the blood, obtained an "organ plasma" that had a low coagulation point. Dastre obtained a *liver globulin* that coagulated at 56° C. These are all very soluble proteins.

Difficultly soluble proteins have been found by St. Zaleski and others. These are *ferruginous nucleoproteins*. Upon boiling liver in water, a solution containing a nucleoprotein rich in nucleic acid is obtained, called *ferratin* by Schmiedeberg. A number of complex cleavage products are also formed, including leucine, tyrosine, glycocol, lysine, glutamic acid, aspartic acid, etc.

The brownish and yellowish pigment of the liver has been differentiated by Dastre and Floresco into a ferruginous pigment, *ferrine*, soluble in water, and a pigment *chlorochrome*, soluble in chloroform, but not in water. Seitz claims that the liver is a *storehouse for proteins*.

Fat.—Under normal conditions the liver cells contain a variable quantity of fat. This is usually in the form of minute globules. The fat is most abundant in those cells at the outer part of the lobule (portal vein zone). The quantity of fat varies with the character of food. If this be rich in fat the quantity in the liver will be increased and the globules are usually larger. If the food be rich in carbohydrates, the fat content is reduced and the glycogen content increased. The *liver fat* is different from that of the subcutaneous region in that it contains less oleic acid and has a higher melting-point as shown by Noël-Paton. Fat may easily be demonstrated by osmic acid, or Sudan III. (See *Histological Technique.*)

Lecithin.—This normal constituent is usually present in considerable quantities representing over 10 per cent. of the total solids or 2.5 per cent. of the fresh tissue. It, however, varies according to the quantity of fat ingested. After foods rich in fat are ingested it is greatly reduced, while after starvation, it represents the great part of the ethereal extracts. It is a phosphorized fatty substance and the relation of phosphorus to nitrogen is 1 : 1.

Cholesterin is present in small quantities. It is present in other organs and tissues, especially in the brain. It belongs to the *lipoids* and is insoluble in water, dilute acids, and alkalies, but dissolves readily in ether, chloroform, benzine, and volatile and fatty oils. It is of importance pathologically as it frequently forms gallstones.

Jecorin is another phosphorized fatty substance that is obtained in the ethereal extract of liver tissue. It contains also sulphur to the extent of over 2.75 per cent., while the relation of phosphorus to nitrogen is 1 :2 to 1 :6, seeming to indicate that it is a mixture of several substances. Although at first considered a constituent of the liver only, it has since been found in muscle, spleen, blood, and brain. It is soluble in ether. It is closely allied to the protagons found in the nerve system.

Extractives.—In addition to glycogen there are large quantities of *xanthine bodies*. Kossel found 1.21 parts *xanthine*, 1.34 parts *hypoxanthine*, and 1.97 parts *guanine* in 1,000 parts of dried liver tissue. In addition *urea*, *paralactic acid*, *cystine*, *leucine*, and *adenine*.

Enzymes.—Many ferments are found in this organ. *Lipase* is an enzyme that has the power of breaking up various esters and has been studied by Dakin, Magnus, Chanoz, and Doyen. It converts neutral fats into fatty acid and glycerin. *Proteolytic enzymes* are of importance in the study of autolysis of the liver, especially after phosphorus poisoning. *Arginase* is an enzyme that splits arginine with the result that urea is formed, as Thompson has recently proven. *Oxidases* and *catalases* are enzymes that directly or indirectly assist or further various chemical reactions in the cells. *Glycolytic* enzymes are those that take part in the decomposition of the sugars and seem to be closely related to the oxidases. All enzymes in aqueous solutions are rapidly destroyed at about 65° to 75° C. Pavy found that the diastatic ferments of the liver are not destroyed by boiling in alcoholic solutions. The more active an enzyme solution is, the more readily it is destroyed by variations in external conditions.

Mineral Substances.—Among the mineral substances are *potassium*, *sodium*, *phosphoric acid*, *alkaline earths*, *chlorine*, and *iron*. In human beings the amount of *iron* varies greatly. In the male it averages a little more than 0.20 p.m. and in the female a little less. Above 0.50 p.m. it is considered pathological. According to Biefeld between twenty and twenty-five years of age the iron is at its lowest. This iron content may be increased by feeding inorganic iron salts, giving iron-containing drugs, or injecting dissolved hemoglobin. The destruction of blood pigment with the separation of compounds rich in iron seems to take place in the liver in the formation of bile pigments. In invertebrates that contain no hemoglobin the liver gland is rich in iron showing that the iron content of the liver is independent of the decomposition of the blood pigment; in vertebrates this is partly so. Iron is especially abundant in the livers of new-born animals but it sinks soon after birth to the proportion in the adult. This high content in the newborn is probably due to the fact that the milk contains no iron. Any disease leading to the destruction of the red blood cells will increase the iron content of the liver. While a part of the iron exists as phosphate, the greater part is in the form of *ferruginous protein bodies*.

This *organically combined iron* responds to the ordinary tests for iron only after treatment with an inorganic acid like hydrochloric acid. Iron albuminates give up their iron to acid alcohol. The iron albuminates are simple, salt-like compounds and are easily decomposed by inorganic acids and resemble the same salts artificially prepared by the action of iron oxide upon alkali albumin. These *ferratins*, or artificial compounds, are supposed to be more readily absorbed than other iron compounds, but this is questionable. They may possibly be converted into iron containing nucleins. The *ferruginous nucleoproteins* do not give up their iron to acid alcohol and are true organic iron compounds in which the iron is directly united with the carbon. The nuclein molecule must first be split before the iron will give the ordinary reactions. These organic iron compounds, or *hematogens*, are the ones concerned with the manufacture of hemoglobin. These iron nucleins are the only source of hemoglobin in the viviparous animals. Newly born mammals fed upon egg yolk, rich in ferruginous nucleins and food free from iron, absorb these iron-containing nucleins in the intestine; these are carried to the red bone-marrow where they are changed to hemoglobin.

The presence of the organically combined iron of the liver cells may be shown by different microchemical methods, such as treatment by the alkaline sulphides, by acids followed by either potassium ferrocyanide, or pure hematoxylin dissolved in distilled water.

That no inorganic iron, or iron simply combined as a salt with albuminate, is present in normal liver except in the fetal condition, is shown by the negative results obtained by either the ferrocyanide method or the hematoxylin method, unless previous treatment by acid is employed which decomposes the organic compounds of iron. The treatment with acid is effected by placing the tissue in one part of hydrochloric or sulphuric acid to nine parts of alcohol, at a temperature of 35° C. for from one to twenty-four hours (Macallum). Then the acid may be removed by washing in alcohol, and the iron demonstrated by the ferrocyanide or hematoxylin method. The latter method is strongly recommended by its discoverer, Macallum, as giving perfectly permanent stains of a striking blue or blue-black color, which is given only by inorganic iron, and is apparent even when only traces are present such as cannot be demonstrated by the ferrocyanide or ammonium sulphide methods. This method may further be used for the demonstration of iron in extracts of the gland.

In the liver of a young man who had died suddenly, von Bibra found 76.2 per cent. of water and 23.8 per cent. of solids. These solids consisted of *proteins* 15.2 per cent., *fats* 2.5 per cent., *extractive* 6.1 per cent. and the remainder of gelatine-forming and insoluble substances. The quantitative composition varies greatly with the variety and amount of food.

Glycogenic, or Amylogenic Function.—The percentage of glycogen is greater in the liver than in any other organ and as the percentage of sugar in the systemic blood is nearly always constant in the portal vein it varies according to the activities of the digestion. This fact would suggest that the liver, mainly, regulates the supply of sugar in the systemic blood. It is more evenly distributed in the various tissues of the fetus than in the adult where it is chiefly located in the liver and muscles. *Glycogen*, first discovered by Bernard (1857), is widely distributed in the body, but exists in the greatest quantity in the liver where it is formed and stored. It is a starch-like carbohydrate $(C_6H_{10}O_5)_x$, and seems to be connected with rapid cell formation and development. The quantity depends upon the food, increasing as high as seventeen per cent. after ingestion of food rich in carbohydrates and disappearing during starvation, first of all from the liver. It is an amorphous, whitish, tasteless powder forming an opalescent solution (?) in water in which it is dextrorotary. It is precipitated from an aqueous solution by alcohol, tannic acid, and by saturating the solution with magnesium sulphate or ammonium sulphate. It is converted into dextrose by mineral acids and some diastatic enzymes.

Glycogen is formed by the activity of the liver cells as a result of dehydration of the dextrose into which the carbohydrates are mainly converted by the action of the digestive fluids. It seems to be deposited, at first, in the connective-tissue cells and, later, in the epithelial cells, just as in starvation it disappears first from the epithelial cells and lastly from the connective-tissue cells. It is deposited in the cytoplasm of the cells and in some animals chiefly in those cells about the central veins. It seems to be evenly distributed in the various lobes. Starvation alone will not remove all of the glycogen, but by combining this with muscular energy, after a few days' starvation, or the use of poisons, like arsenic and phosphorus that affect the liver cells, or by the use of strychnine that causes excessive muscular contraction, the glycogen is completely removed.

The *chief origin of glycogen* is from the sugars, dextrins, and starches ingested. Experiments by Cremer upon rabbits and hens showed that the glycogen was increased by pentoses, as xylose, rhamnose or arabinose. Glycerine, gelatine, and arbutin increase it, while Kulz found the same after giving inosite, dulcite, saccharic acid, saccharine, urea, and a number of other such substances. Nebelthau obtained like results with ammonium salts, narcotics, antipyretics, and hypnotics. Lépine and Porteret found this especially the case with antipyrine. Fats do not increase the glycogen content of the liver though they do that of the muscles. The office of the proteins varies. In some animals casein will increase the glycogen, while in others it will not. The same holds true of gelatine and of albumin. It must not be forgotten that, while the liver forms and stores glycogen that it also consumes it, and that an increase may be due to an overproduction or a diminished consumption.

The theories as to the formation of glycogen are as follows:

Anhydride Theory.—In this the sugars are reduced to anhydrides by the removal of water. This does not explain the production of glycogen from proteins such as gelatine, from carbohydrates, etc.

Sparing Theory.—In this the protein splits in two parts, one containing the nitrogen and the other nitrogen free, the latter being glycogen. In this theory the carbohydrates act only in that they spare the protein and the glycogen produced therefrom. On the other hand C. and E. Voit and others have shown that the carbohydrates are true glycogen formers. At present only dextrose, levulose, galactose, and d-mannose are considered true glycogen formers. Disaccharids and polysaccharids must first be converted into fermentable monosaccharids.

Glycogen is of importance in the formation of *heat* and the development of *energy* in the body. It also forms fat in the liver cells and this later may be deposited in the connective tissues.

The *fate of the glycogen* is still disputed. Bernard considers that glycogen is to the animal what starch is to the plant, *a reserve carbohydrate*. He found that the liver contains more glycogen than any other organ and that after death the *glycogen disappears* and *sugar takes its place through the action of a ferment in the hepatic cells*, that acts after death as it did during life. He noted that the percentage of sugar in the hepatic vein is greater than that in the portal vein at such times when no absorption of food in the intestine is taking place and that the blood going to the muscles contains more sugar than that which leaves.

Pavy believes that the glycogen is used without being changed to sugar. He maintains that the liver mainly arrests the passage of the sugar and that once

in the liver, it never leaves it, but is used in the construction of tissues. He believes that the sugar that appears in the liver after death is a postmortem change and that the liver does not form sugar during life.

Seegen maintains that the liver forms sugar. He found by experiments upon dogs that the hepatic vein always contains more sugar (sometimes double) than the portal vein. He believes that the sugar is not derived from the glycogen, but from the protein and fat. He obtained a substance from the liver besides glycogen which yielded dextrose upon heating with dilute acids.

Simon has also isolated a proteose-like substance that yields a fermentable sugar upon boiling with acids.

The *conversion of the glycogen into sugar* in the liver cells is due to the action of an *endozyme*, or *zymase* produced by the hepatic cells. A similar ferment is found in the blood and it may possibly be derived from the liver cells.

The blood contains about 0.15 per cent. of sugar under normal conditions, but when the liver is cut out of the circulation, this amount drops to one-half or a third the usual quantity. Minkowsky, after removing the liver of a goose from the circulation, found no sugar in the blood after a few hours. When the quantity of sugar in the blood arises to 0.3 per cent. or above, the sugar passes into the urine. There is a limit to the amount of sugar that the liver and other organs can destroy and when an excess is taken into the system, then the kidneys eliminate it (*alimentary glycosuria*). When the liver becomes incapable of converting all of the carbohydrates into glycogen or to utilize the glycogen in the normal way, then the lighter forms of glycosuria result. This condition may follow certain diseases of the central nerve system and chronic poisonings. If the liver did not store up the dextrose in some form, it would reach the systemic circulation, and so the kidneys, and be nearly all excreted in the urine and lost to the body. That this is the true explanation of the prevention of glycosuria after a carbohydrate meal is perhaps most clearly demonstrated by slowly injecting a strong solution of glucose in whipped blood, under like conditions, in one case into the central end of a mesenteric vein and in the other into the central end of a systemic vein, such as the jugular. In the former case, no glycosuria occurs because the liver cells store up the sugar; but, in the latter case, glycosuria follows immediately, obviously because the sugar in excessive amount reaches the general circulation and so the kidneys, before it can be taken up by the liver cells.

Most of the glycogen is used by the muscles, but these tissues do not possess a glycolytic power; neither does the pancreas alone, yet when the expressed juices of these two tissues are mixed, the resulting mixture has a powerful glycolytic action! Apparently the internal secretion of the pancreas gives rise to a ferment that affects the ferment of muscle so that it has a glycolytic power.

Biliary Function.—Schwann, in 1844, was the first to produce a biliary fistula for the study of the bile. The flow so produced is continuous, but varies in intensity. The amount secreted in twenty-four hours varies in different animals. In man the quantity has been found by various observers to vary from 514 c.c. to 1,083 c.c. Stadelmann has shown that the amount secreted is subject to great variation, even under physiological conditions. During starvation the secretion diminishes.

Barbera's observations seem to point to the fact that the proteins cause the greatest secretion of bile, while carbohydrates either diminish it or cause less secretion than proteins. He has also shown a direct relation between bile secretion and urea formation, *i.e.* more bile, more urea, less bile, less urea. According to him the bile is a product of disassimilation.

The *bile* consists not only of the secretion of the liver, but also of the mucous glands of the biliary passages. The bile taken directly from the liver is thin and clear and lower in solids than that from the gall-bladder. The *latter* is also viscous. It is alkaline in reaction and varies in color in the different animals. In the human being its specific gravity is 1.010 to 1.020 and is yellowish or brownish in color; it is bitter in taste with a sweetish after-taste. The odor varies in different animals, but human bile has no odor when fresh. It contains *salts of bile acids* combined with *alkalies, bile pigments, lecithin, cholesterin, urea, chlorides, phosphates of calcium, magnesium, and iron*, and a number of other substances. It consists of about 97.74 parts of water and 2.26 parts solids. Of the solids two-thirds are inorganic and one-third organic.

Bile Salts.—Of these the most important are *sodium glycocholate* and *taurocholate*. The *former* is more abundant in herbivorous animals and the *latter* in carnivorous animals. These salts are formed by the liver cells as they do not occur in any tissue of the body. In the intestine they are changed chemically and so probably are reabsorbed and used elsewhere on the body. When the sodium is separated from these salts the acids are obtained in the form of acicular needles. When these acids are treated with dilute acids or alkalies, they are split into glycocoll and cholalic acid and taurine and cholalic acid respectively.

Pettenkoffer's test is used for these acids and the temperature of the mixture should be below 70° C. To some bile salts add a small quantity of ten per cent. solution of cane sugar and shake to produce a froth, then a small quantity of strong sulphuric acid. A *brilliant red color that soon changes to purple* appears in the froth. This is the result of a formation of a substance called *furfurol* formed by cane sugar and sulphuric acid and this reacts with the cholalic acid to produce the purple color.

Glycocholic, taurocholic, and *fellic acids* are found in human bile.

Lecithin.—This is a complex fatty substance that is generally a whitish, crystalline powder, when pure, and soluble in ether and alcohol. Upon decomposition it yields glycophosphoric and stearic acids and cholin. This is apparently a decomposition product of nerve tissue that is removed from the blood by the liver and held in solution in the bile by bile salts.

Cholesterin.—Although this is a non-nitrogenous compound resembling fats, it does not saponify when treated with alkalies. It is crystalline in nature, insoluble in water, but soluble in ether and boiling alcohol. It also arises from the nerve tissues and is excreted by the liver, being held in solution in the bile by the bile salts. It is converted into stercorin in the intestine and as such passes out with the feces. It may become precipitated and form *gallstones*.

Bile Pigments.—The usual bile pigments are *bilirubin* and *biliverdin* and occasionally *urobilin*. The first two are the ones that give the color to the bile.

Bilirubin, sometimes called *hematoidin*, is derived from the blood pigment. In the liver the hematin loses its iron, combines with water and is thus converted into bilirubin. It is sometimes amorphous, sometimes crystalline and of a reddish-yellow or reddish-brown color. It is insoluble in water, somewhat soluble in ether, benzine, and fatty oils and more soluble in alcohol and alkalies. An alkaline solution of bilirubin by oxidation is converted into green bilirubin.

Biliverdin is an amorphous substance that is insoluble in water, ether, and chloroform. It is soluble in glacial acetic acid and in alcohol imparting a green color to the reagent, and in alkalies. By the action of ammonium sulphide, it is converted into bilirubin.

In the intestine the bile salts are converted into *hydrobilirubin*, or *stercobilin* and excreted with the feces. These bile salts can be detected by *Gmelin's reaction* as follows: Allow some bile to flow under some

nitric acid containing some nitrous acid and at the junction of these two solutions will be seen a series of colored layers, green, blue, violet, red, and reddish yellow from above downward. These indicate the presence of bile pigments and form an exceedingly delicate test.

Other less prominent constituents of bile are *jecorin*, *palmatin*, *stearin*, *olein*, etc., and *proteolytic enzymes*. The *mineral constituents* are *sodium* and *potassium chlorides*, *calcium* and *magnesium phosphates*, and *iron* (chiefly combined with phosphoric acid). The quantity of iron varies and depends upon the foods. Novy and Kunkel consider that the iron is introduced and transitorily retained by the liver and is eliminated by the bile, while Hamburger, Anselm, and others disagree with this.

The quantitative composition of bile is, according to Hammarsten's cases as follows (in parts per 1,000):

Solids	25.200
Water	974.800
Mucin and pigments	5.290
Bile salts	9.310
Taurocholate	3.034
Glycocholate	6.276
Fatty acids from soaps	1.230
Cholesterin	0.630
Lecithin / Fat	0.220
Soluble salts	8.070
Insoluble salts	0.250

The question naturally arises as to the exact origin of the bile pigments, bile acids, and bile salts.

Köbner by extirpation of the liver of pigs attempted to explain this. He was unable under this condition to detect bile acids in the blood of these animals, but upon tying the common bile duct they were found there. Ludwig and Fleischl also found that these acids were formed entirely by the liver. When the common duct is tied, the bile constituents are absorbed by the lymphatics and carried by the thoracic duct to the blood where it can easily be detected. When both common bile duct and thoracic duct are tied, no bile acids can be detected in the blood.

The *bile acids*, that is glycocoll and taurine, are formed from protein bodies. The origin of the non-nitrogenized cholic acid is still obscure.

Bile pigments are formed chiefly in the liver, but may be formed in old blood extravasations and in other organs than the liver; still it is the function of the liver to remove these from the blood. *Intravenous injection of bilirubin* causes a considerable increase in the bile pigments eliminated. Stern, after tying the biliary passages of a pigeon, detected bile pigments in the blood serum five hours after the operation. Upon tying all the bile passages and blood-vessels of the liver, no pigment was detected even after ten to twenty-four hours. Minkowski and Naunyn found that geese poisoned with arseniureted hydrogen show increased bile pigments in the bile. Mammalia do not lend themselves well to these experiments as they do not live long enough after the operation.

There seems to be but little doubt that the bile pigments are derived from hemoglobin, for if the latter appears free in the plasma through red blood-cell destruction there is an increase in the elimination of bile pigments. Again if hemoglobin solution be injected there is an increased elimination of bile pigments. Hematin upon reduction yields urobilin which is identical with hydrobilirubin. As bilirubin contains no iron it seems as if the iron of hemoglobin is replaced by a molecule of water, thereby forming bilirubin. The iron thus liberated is not eliminated by the liver, but retained as a ferruginous pigment in a protein substance.

Both bile acids and bile pigments are formed by special activity of the liver cells. With an increased production of bile pigments there is a decrease in formation of bile acids.

When discharge of bile is retarded, it is absorbed by the blood with the result that its pigments are deposited in the body and eliminated in the urine, producing *icterus*. This occurs under various conditions.

Bile concretions or *gallstones* are of three kinds. One variety consists of cholesterin, another of lime pigments chiefly, and the third of calcium carbonate and phosphate (rare in man). The cholesterin variety is the usual form found in man. These concretions vary greatly as to size, shape, and number. When numerous they become faceted and have a waxy appearance. The cholesterin varies from 642 to 981 parts per 1,000.

Formation of Urea.—Urea was first synthetically prepared by Wöbler in 1828. Urea crystals are needle shaped, or colorless four-sided rhombic prisms. It is neutral in reaction and melts at 132° C. It is soluble in an equal weight of water, or in five parts of alcohol at the ordinary temperature. It is insoluble in anhydrous ether or chloroform. When heated strongly it decomposes and gives off ammonia and leaves an opaque, white residue that contains *biuret*. If this be dissolved in water and treated with copper sulphate and an alkali, a beautiful reddish-violet color results (*biuret reaction*). When heated with barium hydrate or caustic alkalies, it is changed to ammonia, carbon dioxide, and water. If an alkaline solution of urea be treated with sodium hypobromite it is decomposed into carbon dioxide, nitrogen, and water. It is produced in the body by the decomposition or oxidation of such substances as *purin bodies*, *creatin*, *arginin*, *other amino-acids*, and *polypeptides*. It is found most abundantly in the urine of carnivorous animals and man. In sharks it is found in considerable quantities in the blood, liver, muscles, and bile. The amount of urea depends chiefly upon the amount of absorbable protein in the food ingested. Its elimination is greatest after an exclusively meat diet and decreased during starvation as well as after meals rich in non-nitrogenous substances. The bulk of the eliminated hydrogen is in the form of urea.

Arginin, derived from protein metabolism, is said to give rise to about ten per cent. of the total urea. Kossel and Dakin discovered the presence of the enzyme *arginase* in the liver and other organs. If arginine be introduced into the body of an animal, most if not all of its nitrogen is eliminated as urea. *Amino-acids* are in part converted into urea. Salaskin has shown that three of these acids, glycocoll, leucine, and aspartic acid are in part converted into urea. Those amino-acids formed in intestinal digestion are, without dispute, converted into urea. The same may be said of *polypeptides*.

It appears that the urea is formed partly from ammonia and partly from carbamic acid. Schmiedeberg, Walter, and Hallervorden and others have shown that ammonium carbonate, and ammonium salts that are converted into carbonate in the animal body, are eliminated as urea. Von Schroeder has shown by experiment that this change takes place, at least in part, in the liver. It has been proven that the liver forms urea from ammonia. The ammonia of amino-acids is, no doubt, split off in the body and the ammonia combining with the carbon dioxide of the blood and tissues forms ammonium carbonate and possibly carbamate. Carbamic acid is probably an intermediate step in the formation of urea from amino-acids. The ammonium carbonate is converted into carbamate by the removal of one molecule of water and when another is removed, the carbamate becomes urea.

Up to the present the only organ that is known to form urea is the liver. Whether other organs assist is yet to be seen, but there seems to be little doubt that there are others. Pawlow, Zaleski, Salaskin, and others have found by extirpation and atrophy experiments, that sometimes a marked increase of ammonia and a diminution of urea occurred after the

operation; in some cases irrespective of the pronounced atrophy, an abundance of urea was formed without any noticeable change in the ammonia proportion. Kauffmann found after shutting off the organs of the dorsal part of the body from the circulation, especially the liver and the kidneys, an important increase of urea in the blood, thus showing that in the animals operated upon, the liver was not the only seat of urea formation. In human beings suffering from cirrhosis of the liver, acute yellow atrophy of the liver and phosphorus poisoning showed the same result.

Uric Acid.—The bulk if not all the uric acid in man and animals is derived from nucleins or their purin bases. These nucleins are derived from the destroyed cells of the body or from the nucleins or purin bases in the food. The uric acid is both *endogenous* and *exogenous* in origin. Its formation seems to be due to some enzymotic action. In some animals, man included, the liver contains the ferments *adenase*, *guanase*, *xanthine*, and *oxidase* by means of which the transformation is produced, while others contain only one ferment and yet form uric acid. Minkowski has shown that in birds the liver is the only organ in which uric acid is formed and von Mach has shown that most of the uric acid is synthetically formed and only a small part derived from the purin bases. Whether uric acid is synthetically formed in the liver of man and mammals is still in question.

By various experimental means, as *excision*, *short-circuiting*, and *perfusion through the excised liver*, the connection of this organ with urea and uric acid formation has been worked out.

By the application of *excision* and *short-circuiting* it has been shown that urea is formed in the liver, and considerable information has also been gleaned concerning the end products of nitrogenous metabolism from which it is here synthesized. The surgical difficulties standing in the way of the removal of the liver in mammals were for a long time regarded as insuperable, for if the organ be simply removed without making provision for the continuance of the portal circulation, the stasis of the blood in the whole intestinal area gives rise to such severe shock that the animal succumbs almost immediately as a result of the operation. In birds, however, the vein of Jacobson gives rise to an anastomosis between the portal vein and the vena advehens of the kidney, so that when the portal vein is tied between the liver and the junction of this vein, the blood coming from the intestinal area can be carried through the vena advehens and hence stagnation does not occur.

Minkowski took advantage of this anatomical relationship and tied the portal vein in this situation in geese. In some animals the portal vein only was tied, and in others the liver was subsequently excised. As a result of the operation, the uric acid in the urine, which in birds takes the place of the urea of the mammal, fell from representing sixty to seventy per cent. of the total nitrogen as in normal animals, until it represented only three to six per cent., while at the same time ammonium lactate, which is not present in normal bird's urine, appeared in sufficient amount to account for the deficit in urates. The lactic acid simultaneously produced is sarcolactic acid and is produced in somewhat greater quantity than is necessary to combine with the ammonia, so that the urine becomes acid. When the uric acid has reached the minimum given above, the ammonium lactate forms more than half the total solids. No change took place in the urea, showing that the small amount of this substance present in bird's urine is not formed in the liver, and the kreatinin also remained undisturbed. Lactic acid, leucin, and tyrosin were found in the blood. Injected urea was not changed in the blood but appeared in the urine as such, whereas in the normal goose it appears again as uric acid.

The ligation of the hepatic artery alone, in birds or mammals, leads to a temporary replacement of uric acid and urea respectively by ammonium lactate, this result being probably due to defective oxidation.

The total removal of the liver from the circulation or eventually from the animal was first rendered feasible by the operative procedure of Eck, a Russian surgeon, who found it possible to establish a fistula between the portal vein and inferior vena cava, whereby the portal blood system is drained directly into the vena cava without first passing through the liver. The liver could then either be left *in situ* or afterward removed. In those animals in which it was left *in situ* no great disturbance of nitrogenous metabolism occurred except immediately after the operation, or when the animals were given either excess of protein food or ammonium salts in their food. Then it was found that convulsions ensued, and excess of ammonium salts and carbamate of ammonium appeared in the urine. In those animals in which the liver was also removed results similar to those given by Minkowski were obtained, viz., decrease in the urea and its replacement by ammonium compounds.

The *perfusion experiments* are performed by placing cannulæ in portal vein and hepatic vein, and running whipped blood (which is arterialized each time after passing through) under a pressure somewhat greater than that of the portal vein during life through the blood-vessels of the excised liver. The effects of adding different chemical substances to the whipped blood can then be determined.

The percentage of urea in whipped blood taken from an animal recently fed upon protein, is increased when it is led through an excised liver, and Schröder, who by applying this method first conclusively proved that urea is formed in the liver and not in the kidneys, found that when ammonium compounds were added to whipped blood which was afterward circulated round an excised liver, the ammonium compounds so added became decreased in amount and were replaced by urea. Similar results were not obtained by perfusion through the limbs or other organs, and hence it was proven that urea is formed in the liver, and further that it is formed from ammonium compounds, a result which corresponds with that obtained by studying the effects of excision of the gland.

Toxins are formed by the putrefaction of proteins in the intestines and these toxins are first acted upon by the liver, rendered innocuous, and then eliminated by the kidneys. These toxins are carried to the liver by the portal vein, whereby the action of the liver cells and potassium sulphate they are rendered harmless. Such substances are *indol*, *skatol*, *phenol*, and *cresol*. The *indol* and *skatol* are oxidized to *indoxyl* and then *potassium indoxyl sulphate* and *potassium skatoxyl sulphate;* the *phenol* and *cresol* combine with the potassium sulphate directly. They are all then carried by the blood to the kidneys and there eliminated. Other toxic compounds undergo an analogous fate.

Fibrinogen Formation.—The *liver* seems also to be concerned in the formation of fibrinogen. Nolf found that the quantity of fibrinogen in the blood was greatly diminished after extirpation of the liver, while Corin, Morel, Kareff, and others found it totally absent from the blood in phosphorus poisoning. The liver is also important in *preventing intravascular coagulation* of the blood. Peptone blood does not coagulate for two reasons; (1) This blood contains an *antithrombin*. (2) *Thrombin* is absent, although *thrombogen* and *kinase* are present. Nolf believes that the peptone (proteoses) causes an alteration in the walls of the vessels and the leucocytes resulting in the secretion of a substance that forms antithrombin in the liver. Delezenne believes that the proteoses cause the destruction of the leucocytes setting free one substance that *accelerates coagulation* and another that *retards coagulation*. The liver destroys the former and the latter, antithrombin, remains. Gley and Pachon have proven that the liver takes part in *retardation of clotting*.

Hematopoietic Function.—During early intrauterine life the sluggish circulation of the liver lends that organ very readily to the *formation of red blood cells.* This *hematopoietic function* continues during the middle of the developmental period, diminishing rapidly as the red bone-marrow increases and assumes this function.

H. E. Radasch.

Liver, Syphilis of the.—The existence of syphilitic disease of the liver was denied by Morgagni. Dittrich, in 1849, gave the first comprehensive description of the disease, the tumor-like formations of which had been previously confused with malignant and other new growths. Virchow materially advanced our knowledge of hepatic syphilis. The discovery of the *Spirochæta pallida* in lesions in the liver and the development of the Wassermann reaction have made of syphilis of the liver a very positive condition.

Classification.—As with syphilitic affections in general we recognize the acquired and congenital lesions. Apart from the early reaction seen in the livers of syphilitic infants, and the occasional jaundice in early acquired syphilis, the lesions of syphilis in the liver belong to the tertiary period of the disease.

Pathology.—*Acquired Syphilis.*—Two forms are most commonly met with: (*a*) A diffuse syphilitic inflammation affecting the interstitial tissue, not readily distinguished from ordinary cirrhosis. The cell proliferation is markedly interacinous, and is said to run between the columns of liver cells oftener than is the case with alcoholic cirrhosis. The same tendency to shrinking (atrophy) is seen.

(*b*) The much more common gummatous hepatitis occurs in the form of numerous nodules, varying in size from a millet seed to a walnut, of a reddish-gray to whitish-yellow color, irregular, often striated, more or less sharply outlined. The centers of the syphilomata are yellowish-white, caseous, dry, but firm, much more so than a tuberculous caseous mass. These growths tend to develop on the upper surface of the liver, at the attachment of the ligamentum suspensorium, and in the connective-tissue prolongations of Glisson's capsule (perihepatitis syphilitica, Schüppell). Microscopically, the fresh red-gray growths consist of round and spindle cells in a homogeneous ground substance; the older caseous areas show masses of fatty necrotic material. By suitable staining methods the *Spirochæta pallida* can be demonstrated in the lesions. Alterations of the blood-vessels in these areas, consisting of marked thickening of the medial and adventitial coats, are constant features. Hepatic scars, usually considered to be healing fibrosing gummata, are among the common lesions of acquired syphilis; the extent to which they may deform a liver by their contraction is well known. The possibility, however, of these scars being due to causes other than syphilis is now admitted (Flexner). The gummatous form may be found in connection with the interstitial form. Thickening and adhesions of the liver capsule (perihepatitis) occur constantly with the former condition, and fat infiltration and amyloid degeneration of the liver cells are common. By many, amyloid degeneration of the liver is classed as a form of syphilitic alteration.

Congenital Syphilis.—The diffuse infiltration is the form most frequently met with; it may occur at any time after the sixth month of fetal life. The liver is usually much enlarged, often equalling six per cent. of the body weight, firm and tough, gray-red to dirty yellow-gray in color, and the lobular markings are usually obliterated. Occasionally the organ may be excessively icteric (brimstone liver). If the infants survive for a sufficient length of time cirrhotic changes may ensue, with consequent atrophic appearances. Syphilis hereditaria tarda affecting the liver, and appearing first in adolescence, can hardly be distinguished from atrophic cirrhosis. Microscopically there is first hyperemia with capillary engorgement, massing of leucocytes, and proliferation of the capillary endothelium; later, in the widened interstices of the lobules, are seen round cells in newly formed connective tissue, and the same cells are frequently found inside the lobules, between the capillary walls and rows of liver cells, and in the walls of the blood-vessels. In the later stage connective tissue replaces the round-cell infiltration, and the liver cells, after some nuclear proliferation, shrink and atrophy. If (which is rather rare) the gummatous form occurs, the liver presents multiple miliary formations. An increase of connective tissue, in the form of small circumscribed areas in addition to the diffuse process, may resemble a gummatous condition. As already mentioned, with the exception of a transient jaundice seen occasionally in the secondary stage, syphilitic hepatic affections are distinctly tertiary, and are usually met with years after the formation of the primary lesion; cases of hepatic syphilis developing six and nine months respectively after infection are reported by Key and Biermer. In both the acquired and the congenital disease the liver is one of the organs of the body most frequently affected.

Symptomatology.—Jaundice has been mentioned as a symptom in the secondary stage. Many cases of hepatic syphilis are revealed only at autopsy; the more marked cases of the gummatous form show the familiar enlarged knobby and deformed liver, the symptoms in fact being frequently only such as are dependent upon pressure; jaundice is rare in this form of the affection; ascites, due to compression of the portal vein, occurs, and may give the picture of hypertrophic cirrhosis. It may be stated that ascites does not occur in the gummatous form unless the portal circulation is obstructed or the kidneys are vitally affected, but it is more or less to be expected in the general cirrhotic form. The general condition usually suffers, and anemia and cachexia are more or less marked, sometimes so much so that malignant disease may be suspected. The general diffuse form (syphilitic cirrhosis) presents the picture more or less absolutely of alcoholic cirrhosis, though it is said to be more acute and more rapid in its course, and may speedily terminate fatally. It is remarkable, however, to what an extent a liver may be deformed without giving rise to symptoms. Periods of improvement apart from specific treatment are not infrequently seen; and, on the other hand, even after a supposed cure, relapses and severe after-effects may develop.

In the *congenital form* the symptoms are those of malnutrition, and the infants die after a short existence. Enlarged liver and spleen, anemia, and cachexia are always present (see above).

Diagnosis.—Gummata may be confused with subcapsular and other cysts and with carcinomatous nodules; the diffuse cirrhosis gives rise to conditions not to be distinguished from an alcoholic affection; congenital hepatic syphilis is usually unmistakable. A positive Wassermann reaction in a case with symptoms of hepatic cirrhosis or with signs of irregular hepatic enlargement is of course highly suggestive and a therapeutic test may clinch the diagnosis.

Treatment.—Specific treatment (mercury and iodides, salvarsan, neosalvarsan) is always indicated, and even in late stages mercury should be employed. Under the influence of these drugs gummata may completely vanish, an ascites may disappear, and other severe symptoms may quickly subside. Scar tissue and amyloid change naturally cannot be affected by any treatment. Iron and arsenic are necessary for the anemic conditions.

Norman B. Gwyn.

Liver, Tuberculosis of the.—Without exception all writers agree as to the rarity of primary tuberculosis of the liver. Such an apparent immunity on the part of this organ to tuberculous infection cannot be explained by any lessened opportunities for infection, as compared to other organs, such as the kidneys, testicles, etc., in which a primary tuberculosis of clinical importance is not so rare. Indeed, it would appear that the liver with its large extent of vascular surface and the relatively slow circulation in its blood spaces would stand a very good chance of infection from tubercle bacilli that have gained a cryptogenic entrance into the blood stream. Further, the fact that tubercle bacilli may be taken into the alimentary canal in the food and drink would lead to the supposition that the portal veins might constitute one of the avenues of tuberculous infection. These considerations would make it seem probable that primary hepatic tuberculosis might occur more often than we actually find to be the case. It is the opinion of the writer that small healed primary tubercles not infrequently occur in the liver. As is well known to every pathologist, small nodules of hyaline connective tissue varying in size from that of a pinhead to that of a pea are not rare in this organ. By the majority of writers they have been regarded as small fibromata or healed gummata. The fact that some of these little nodules consist of a caseous center surrounded by a connective-tissue capsule, and that others present an earlier stage of caseating epithelioid tissue with beginning encapsulation, has led the writer to regard the majority of such nodules as healed tubercles. Similar small fibroid nodules are also frequently seen in the spleen and kidneys and are similarly interpreted. If the probabilities of infection, the not infrequent occurrence of healed tubercles, and the extreme rarity of primary hepatic tuberculosis of clinical importance be considered, it would seem that the liver possesses a relatively high resistance to tuberculosis.

Such a relative immunity undoubtedly exists in the fetal liver. A number of cases have been reported of maternal tuberculosis in which the liver of the fetus contained great numbers of tubercle bacilli (as shown by staining and animal inoculation) without histological lesions of tuberculosis. Such a case has recently been reported by the writer. The seven-months fetus of a woman dying from acute miliary tuberculosis was examined carefully for evidences of congenital tuberculosis. The placenta presented a marked miliary tuberculosis. Tubercle bacilli were found in the hepatic vessels of the fetus, and the inoculation of a guinea-pig with an emulsion of fetal liver gave positive results. Agglutination thrombi were found in the liver capillaries, but no histological evidences of tuberculosis. Several cases, however, have been reported of probable congenital tuberculosis in which tuberculous lesions were found in the liver, the infection being regarded as taking place through the umbilical vein from the placenta. These cases are therefore to be classed as primary hepatic tuberculosis.

If primary tuberculosis of the liver is rare, secondary involvement of this organ is one of the most common pathological findings. Not only in cases of acute miliary tuberculosis are great numbers of tubercles found in this organ, but also in all advanced cases of chronic pulmonary and bone tuberculosis. Even in cases in which the disease of the lung is not very extensive scattered secondary tubercles may be found throughout the liver. As a rule, these secondary tubercles are very small, and as it is rarely possible to recognize them by the naked eye at autopsy, they are frequently overlooked. In the great majority of cases their presence can be demonstrated only by microscopical examination. The larger ones (size of a mustard seed to that of a pea) are grayish, semitranslucent, with yellowish opaque centers. They can be best seen in the livers of children where they often are several millimeters in diameter. The infection is usually hematogenous, and the microscopical picture presented is that of a disseminated miliary tuberculosis of the organ. Occasionally larger caseous nodules are found in connection with miliary tubercles, and more rarely tuberculous cavities or abscesses. Still more rarely there are found large solid caseous nodules in the liver resembling the solitary tubercles of the brain. These may be mistaken for cancer nodules or gummata. Such large nodules may not show any especial connection with the bile ducts, and it is probable that in some cases they represent primary tubercles.

The number of the miliary tubercles may be so great that each section may be full of them; in other cases it may be necessary to examine many sections before a tubercle is found. In the case of pulmonary and bone tuberculosis and general miliary tuberculosis the infection of the liver is usually through the heaptic artery; in the case of intestinal tuberculosis it may take place through the portal vein or lymphatics. The tubercles, in infection either through the hepatic artery or through the portal vein, are found chiefly at the periphery of the lobule and in the interlobular connective tissue. A small number may be found in the intermediate and central zones of the lobule. As the nodules increase in size they extend in from the periphery and cause a destruction of the liver cells.

The writer believes that in the great majority of cases the earliest step in the formation of a liver tubercle is an agglutination thrombosis in the liver capillary. The deposit and growth of tubercle bacilli upon the endothelium of the capillary wall and the consequent injury to the endothelial cells are probably chiefly responsible for this thrombosis. As a result of the thrombosis and of the injury to the endothelium, as well as from the formation of toxins, the neighboring liver cells undergo degeneration or necrosis. There is a collection of leucocytes at the affected point, and these may also undergo necrosis. Following the degenerative changes there is a proliferation of the endothelium and of the neighboring connective tissue leading to the formation of an epithelioid tubercle which sooner or later shows a central caseation. The smallest tubercles may show no inflammatory reaction about them. Giant cells may be present in large or small numbers, or may be entirely absent. They arise from the proliferating endothelial and connective-tissue cells, and possibly also from the leucocytes. As the nodules increase in size they may become confluent. As the result of an interstitial infiltration about the tubercles the picture of a diffuse cirrhosis may be presented, newly formed connective tissue being found not only between the lobules, but also growing into the latter. The greater the number of tubercles the closer the resemblance to a cirrhosis. An increase of the small bile ducts may be observed in the neighborhood of the tubercles. A true atrophic cirrhosis may result, but usually death occurs before this condition has time to develop. It should be remembered also that the tuberculosis may occur secondarily in a cirrhotic liver. Many writers comment upon a close relationship between hepatic cirrhosis and tuberculosis, particularly of the omentum and peritoneum, and certainly the coincidence of the two processes is very striking. Microscopic examination of the cirrhotic liver shows in a large proportion of cases miliary tubercles at the periphery of the lobules and upon the capsule. Peritoneal tubercles are always present. The condition is probably to be explained as a terminal infection from some older focus, due to the locally lowered resistance, portal stasis and ascites.

In very acute cases of general miliary tuberculosis with a high degree of virulence the only lesions found in the liver may be areas of focal necrosis of the liver cells. These areas may be so large as to be easily seen with the naked eye. The blood spaces of the

necrotic areas are filled with fibrin and agglutinated red cells. Large colonies of tubercle bacilli may be found in the necrotic foci. No proliferation of the endothelium or connective tissue may be present; giant cells are entirely absent. The process can be recognized as tuberculosis only by staining for tubercle bacilli. The writer has seen two cases of this kind which were diagnosed as typhoid fever; the autopsy showed large focal necroses in liver, spleen, and kidneys, those in the liver and spleen being most numerous and largest. No epithelioid proliferation or giant cells were found about these areas, and the tuberculous nature of the process was recognized only on staining for tubercle bacilli, when each caseous focus was found to contain great numbers of the latter. In general miliary tuberculosis of a less virulent type small focal necroses of this kind are also found in association with epithelioid, lymphoid, and caseating tubercles. It is also to be noted that in such cases the lesions in the liver are usually smaller than in other organs, and this fact may also be taken as an indication of a greater resisting power on the part of the liver to tuberculosis.

Acute pylephlebogenous miliary tuberculosis of the liver has been reported by the writer. In one of these cases the clinical diagnosis was Weil's disease; the same diagnosis was at first considered in the second case but later changed to typhoid fever because of the occurrence of blood in the stools. The clinical picture of both was that of acute infectious jaundice. At autopsy both cases showed a primary tuberculosis of mesenteric glands with involvement of branches of the portal vein, and a unique miliary tuberculosis of the liver. The two cases showed clinically high fever, intense jaundice, and a typhoidal state ending fatally in three weeks.

In the case of hepatic tubercles occurring secondarily to chronic tuberculosis of other organs the liver may show such changes as amyloid and fatty infiltration. The latter change is practically always present. In chronic pulmonary tuberculosis the liver shows usually a more or less marked chronic passive congestion (nutmeg liver). In acute miliary infections the liver cells show cloudy swelling, fatty degeneration, or simple necrosis.

Hanot and Gilbert distinguish the following forms of hepatic tuberculosis:

1. Acute: Hépatite tuberculeuse graisseuse hypertrophique.

2. Subacute: (*a*) Hépatite tuberculeuse graisseuse atrophique ou sans hypertrophie; (*b*) hépatite tuberculeuse parenchymateuse nodulaire.

3. Chronic: (*a*) Cirrhose tuberculeuse; (*b*) foie gras tuberculeux (without tubercles).

A rare complication of hepatic tuberculosis is secondary carcinoma of this organ. Several cases of this kind have been reported, and the writer has seen a similar case in which both the tuberculous infection and the metastasis of the carcinoma were through the portal vein.

More rare than secondary miliary tubercles of the liver are larger caseous nodules, the centers of which contain cavities filled with bile-stained caseous material. These cavities may be of the size of a walnut. The process represents a tuberculosis of the bile ducts the walls of which become caseous. The infection is probably lymphogenous, and has the character of a *tuberculous periangiocholitis*. In very rare cases the infection may take place through the bile ducts themselves. In the great majority of these cases, however, the tuberculous process begins around the bile duct and invades its mucosa only secondarily. Hematogenous hepatic tubercles may or may not be associated with this condition.

Still more rare is the occurrence of large *solitary tumor-like tubercles* in the liver that may reach the size of an orange or still larger. Numerous miliary tubercles are found microscopically around the main nodule, which in itself is often a mass of confluent miliary nodules.

The liver and the peritoneum may be involved at the same time, but this organ is rarely involved from the latter or from the omentum.

In experimental hepatic tuberculosis in animals the process runs a more acute course, being characterized by larger areas of necrosis.

The clinical symptoms of hepatic tuberculosis are slight, and the condition can but rarely be distinguished from the miliary or chronic process with which it is associated. The occurrence of icterus or the rapid development of a painless ascites points to the development of tuberculosis of this organ. In children the organ may become enlarged and sensitive.

ALDRED SCOTT WARTHIN.

Livingston Mineral Springs.—Sumter County, Alabama.

POST-OFFICE.—Livingston. Hotels.

Livingston, the county seat of Sumter County, is located on the Alabama Great Southern Railroad, a part of the Queen and Crescent route operating, with numerous connections, between Cincinnati, Ohio, and New Orleans, La. The town is situated on a sandy plateau with perfect under-drainage. The climate at Livingston furnishes a fair type of the atmospheric conditions prevailing in central Alabama. The warmest weather recorded by standard signal service instruments for many summers has been 97° F., and this elevation has been very rare. The coldest weather noted in winter has been 20° above zero. The average temperature of the year is 63° F., and the average rainfall fifty-six inches. Geologically, the well is located at the extreme southern outcrop of the cretaceous limestone, which forms the basis of the rich belt of prairie land extending through middle Alabama. It pierces the entire thickness of the limestone stratum to reach the underlying sandstone formation in which the water is procured. The depth of the well is 1,087 feet and the flow of water one gallon per minute. It was bored with a view to obtaining a supply of good drinking-water, but it proved decidedly saline, and at first the venture was thought to have been a useless expenditure of time and money. By degrees, however, the citizens began to use it, and though at first disagreeable to the taste, it soon became a favorite beverage. Certain medicinal effects were observed, especially in dyspepsia and chronic bowel disorders, and little by little the well finally acquired considerable local celebrity. The water is beautifully clear and limpid and effervesces actively when drawn from the spout. The specific gravity of the water is 1.003, and its temperature, which does not vary at any season, is 68° F. From the circular issued by the town authorities we have obtained the following analysis by an unnamed chemist:

ONE UNITED STATES GALLON CONTAINS.

Solids.	Grains.
Silicic acid and silicates	1.14
Iron bicarbonate	0.20
Magnesium bicarbonate	2.32
Calcium bicarbonate	7.14
Iron perchloride	0.19
Magnesium chloride	1.84
Calcium chloride	2.98
Potassium chloride	0.33
Sodium chloride	295.43
Strontium chloride	Trace
Sodium bromide	0.98
Total	312.55

Gases.	Cu. in.
Free carbonic acid (in solution)	21.47
Carbonic acid in combination as carbonates	9.32
Total gases	30.79

This water possesses aperient, tonic, and diuretic properties. It is said, furthermore, to have a decided alterative influence on the economy. According to Dr. R. D. Webb, of Livingston, who made a special study of the water for many years, it is highly beneficial in cases of chlorosis, malarial anemia, affections involving the alimentary tract, the kidneys, and the bladder, and in nervous exhaustion.

EMMA E. WALKER.

Loa.—*Dracunulus.* A division of the great genus of parasitic round worms. *Filaria.* It includes a single species, *Filaria (Loa) loa,* which is a parasite in the superficial connective tissues—conjunctiva, subcutaneous fat, aponeuroses. It is distinguished morphologically by the presence of bosses on the cuticle and caudal papillæ. The larvæ may occur in the blood. These worms attain a length of twenty-four to thirty-four millimeters. Their presence usually gives rise to no very serious trouble, though they move rather quickly and may cause itching, creeping sensations, or irritation of the eyes, glottis, etc. See *Nematoda.*

A. S. PEARSE.

Lobelia.—INDIAN TOBACCO. "The leaves and tops of *Lobelia inflata* L. (fam. *Lobeliaceæ*) collected after a portion of the capsules have become inflated" (U. S. P.). This is an annual herb from twenty to fifty centimeters (eight to twenty inches) high, with an upright, branching, leafy stem and thin, ovate, nearly or quite sessile, slightly hairy leaves. Inflorescence composed of spike-like racemes, terminating the stem and branches, and forming a lax pyramidal, leafy panicle. Flowers small, consisting of a five-toothed calyx adherent to the ovary and becoming markedly inflated in fruit; a labiate corolla with a narrow tube open on the apparently upper side to its base, and a five-lobed border of which the two lobes next the fissure are erect, narrow, and pointed, the other three broader and spreading; stamens, five syngenesious; ovary two-celled with innumerable microscopic ovules. Seeds very fine, light-brown, oblong, with a handsome reticulated testa. All parts of the plant contain, when fresh, an acrid, milky juice, and have an exceedingly sharp, peppery, tobacco-like taste. The seeds are rather more active than the rest of the plant and have been used separately. Lobelia is an abundant pasture weed, growing in most parts of the United States. The knowledge of its use was received from the aborigines, and is several centuries old.

FIG. 3774.—Lobelia inflata; Flowers and Fruit. (Baillon.)

COMPOSITION.—The most important ingredient of lobelia is the alkaloid *lobeline* ($C_{16}H_{24}NO$), "an oily yellowish fluid with a strong alkaline reaction, especially when in solution. In the pure state it smells slightly of the plant, but more strongly when mixed with ammonia. Its taste is pungent and tobacco-like, and when taken in minute doses it exercises in a potent manner the poisonous action of the drug. It dissolves in water, but more readily in alcohol or ether. It neutralizes acids and forms, with some, crystalline salts." Several of these salts are listed by manufacturers. Although volatile, it is decomposed by a high heat. Lobelia contains also *essential oil* and a doubtful substance, *lobelacrin,* probably a compound of lobeline and *lobelic acid.*

ACTION AND USE.—This herb has had in times past an extensive employment in this country at the hands of irregular practitioners of the "Thompsonian" school, and the more modern "Eclectics." Despite its very active and dangerous qualities, it is still not infrequently called for as a family medicine. Regular physicians have never used it extensively, but neither has it been altogether neglected by them. It was in far more frequent demand by the preceding than it is by the present generation. It is a nauseating expectorant, or a depressing emetic, much resembling tartar emetic. The nausea is primarily due to gastric irritation, and full doses are liable to be promptly vomited. Smaller doses produce burning and pain in the stomach, followed by nausea, lassitude, or depression, commonly cold perspiration and pallor, dizziness, rapid and weak respiration following temporary slowing. These systemic symptoms bear a general resemblance to those of tobacco sickness, whence the common name of the plant. The secondary nausea, often with painful and obstinate vomiting, is at least partly of central origin. There is no considerable increase of respiratory secretion, but spasmodic conditions, as of asthma, are relaxed. When the action is prolonged, as by repeated doses, the depression is profound, and there is paralysis of respiration, frequently with convulsions, dependent thereon. In children there are sometimes earlier convulsions, due to abdominal pain. Respiratory failure is the common cause of death. Gastric perforation has frequently occurred, with other indications of intense abdominal inflammation.

There have been two uses for lobelia, namely, as an emetic and as an antispasmodic of the depressing sort, applied chiefly to respiratory affections. As an emetic, it was formerly a common household remedy, used for the most trivial purposes, and fatal poisoning was common. This use is almost obsolete, being only occasionally resorted to in spasmodic croup. Its use in very small doses, combined with expectorant drugs, is still considerably resorted to, and is of advantage. If vomiting is desired, a full dose (gr. xx.–xxx.) should be given; otherwise the dose should be small (gr. i. to iij. or v.). Undesirable or dangerous results are most likely from doses just insufficient to cause vomiting, or from moderate doses repeated, so as to produce a cumulative effect. The official preparations are the fluid extract (doses as above, minims for grains), and the twenty-per-cent. tincture, used almost altogether as an expectorant in doses of ℥ v. to xxx. (0.3–2.0).

HENRY H. RUSBY.

Lochia.—This term signifies the fluid discharge from the uterus, or the uterus and vagina, which follows the termination of an impregnation whether mature or immature. It is the expression or evidence of the involution of the uterus, which takes place after the organ has fulfilled its physiological function. It is a discharge which is similar to that which occurs in the healing process in general when tissues which have been injured are undergoing repair and restitution. The term is a very old Greek one and was used by the ancient writers to indicate the *cleansings* or *purgations* which, as they observed, always took place after childbirth.

When the contents of the impregnated uterus have been expelled, particularly at term, a very extensive wounded surface is left, and the muscular fibers of the organ are many times larger than in the unimpregnated state. In the process of labor wounds are also inflicted upon the vagina and external genitals, especially in primiparous labors, and in cases in which the fetus is large relatively to the passage through which it is forced. The discharge from these various wounded surfaces is made up of disintegrated tissues, blood, serum, leucocytes, and mucus.

In cases of abortion before the second month, the amount of injury to the tissues is small, the discharge correspondingly small, and it is usually sero-sanguinolent in character, lasting only for three or four days.

In abortions during the subsequent months it partakes more of the character which occurs after labor at term.

The duration of this discharge is from one to two weeks, but when involution goes on slowly it may be profuse and very purulent, and may continue as long as six weeks.

If a woman nurses her baby the duration of the lochia is usually shorter than when she does not, the contraction and repair of the tissues being favored by the performance of this physiological function.

If the discharge is retained within the uterus, as in endometritis, puerperal insanity, etc., puerperal infection logically results from the absorption of decomposing and toxic material through the extensive wounded surface. In normal cases the discharge is frequently called, with reference to its gross appearance: (1) l. cruenta or rubra, (2) l. serosa, (3) l. alba, or lactea. The duration of l. rubra is two or three days and it is composed of pure blood with coagula of fibrin, normally containing no microorganisms. That of l. serosa is from three to five days, the wounded surface of the uterus exuding an abundance of serous alkaline fluid of a pale red color. With it is also an abundance of mucus from the cervix and vagina. Microscopically it is observed that this fluid contains cervical and vaginal epithelium, corpuscles of blood and mucus, decidual cells, and shreds of placenta and amniotic membrane. Its organic constituents are albumin, mucine, saponified fats, chlorides, and phosphates.

By the time the third stage has been reached granulation has begun, both within the uterus and in the wounded tissues of the vagina and external genitals. To the end of the second week there is therefore an increase in leucocytes and a more or less abundant flow of pus. Usually the discharge is thin, the red corpuscles are less abundant than they were, and the pus cells and fat globules are increased.

In some cases the pus becomes grayish white or greenish yellow and contains epithelial cells, connective-tissue cells, fat granules, free fat, and cholesterine. The reaction of this fluid is sometimes neutral and sometimes acid. It gradually diminishes in quantity until it finally becomes transparent and then ceases.

When the discharge first appears it is odorless, by the fourth day an odor becomes perceptible, and if a napkin containing it is allowed to stand a short time it will have the odor of decomposition.

The flow from the uterus is normally sterile, but if bacteria are found, as is usually the case after the fourth day, they will be derived from the vagina and external genitals, unless decomposition has taken place within the uterus. If a woman leaves her bed before the wounded surfaces are healed, a discharge of fresh blood is likely to appear as would be the case with any wound, in which the healing process was disturbed.

The quantity of the lochia is larger in multiparæ, in those who do not nurse their babies, in those whose tissues are flabby, and in those who are accustomed to menstruate abundantly, than in others.

Lusk states that the average weight of the lochia rubra to the fourth day, is two and a quarter pounds, of the lochia serosa, from the fourth to the sixth day, a fraction over nine ounces, and of the lochia alba, from the sixth to the ninth day, six and two-thirds ounces, the total for eight days thus averaging three and a quarter pounds.

It is interesting and important in view of the relation between the lochia and puerperal infection to note the bacterial content which has been observed. Whitridge Williams found many varieties of bacteria in the lochia in cases in which the temperature had reached 101° F., or more during the first ten days of the puerperium. He was able to identify among them the streptococcus, staphylococcus, gonococcus, *Bacillus coli*, *B. diphtheriæ*, *B. typhosus*, the gas bacillus, and numerous others, either single or in combination. He calls special attention to the importance of studying the lochia in cases of septic endometritis.

The infection in such cases may take place two or three days after labor; some of the symptoms being headache, chill, and a temperature of 103° or more. The lochia may be increased and be bloody or purulent but it is important to notice that it may be devoid of odor.

In pure streptococcus infection it has little or no odor, and hence the absence of odor does not indicate the absence of a very virulent condition, in fact it may indicate quite the contrary.

When the temperature runs very high it is not unusual for the lochia to be diminished or wanting altogether. ANDREW F. CURRIER.

Locomotion.—Locomotion (L. *locus*, place, and *motio*, motion) is the act of moving from place to place. This power is manifested in all forms of animal life, and varies in its complexity from simple ameboid movement to that of the highest developed organisms. Locomotion of the human body is a complex and reciprocal series of movements executed by the lower extremities simultaneously, in such a manner that a double step of the right leg overlaps the double step of the left limb for one-half its length, and *vice versa;* by these means the body as a whole is propelled.

The mechanics of locomotion comprise lifting, propulsion, and equilibrium. In the process of lifting and propulsion the human body makes use, almost entirely, of the laws governing the levers of the "third order," in which the force is between the fulcrum and resistance, the skeletal muscles, for the most part, being arranged to act on the bones and joints as on levers.

The movements of the body are chiefly concerned in moving comparatively light weights through a great distance or through a certain smaller distance with the greatest precision, rather than in the moving of heavy weights through a short distance. The fulcrum is usually a joint, and one end of the acting muscle is made fast either by attachment to a fixed point or by a point that is fixed for the time being by the contraction of other muscles.

In the physics of equilibrium it is necessary that the line of gravity fall within the base of support, in this case the plantar arches. In the erect posture the line of gravity falls as follows: in the head it falls in front of the occipital articulation, in the combined head and trunk it lies at about the level of the ensiform cartilage, in front of the tenth thoracic vertebra, and a line of gravity drawn from it passes behind a line joining the centers of the two hip-joints. The line of gravity of the combined head, trunk, and thighs, falls a little behind the knee-joints. The line of gravity of the whole body passes in front of a line drawn. between the two ankle-joints, the center of gravity of the whole body being at the end of the sacrum. Therefore in the erect posture the joint-centers are in the same vertical plane.

The joints dealt with are the hip, knee, ankle, and phalanges. The hip-joint is of the enarthrodial type capable of adduction, abduction, flexion, extension, rotation, and circumduction, so that movement in all directions is possible. The knee-joint is a combination of the condyloid, partial arthroidal, and gliding types, capable of a hinge-motion of flexion and extension; when the knee is flexed there is a limited movement of rotation. The ankle-joint is of the ginglymus type, capable of flexion and extension. The metatarsophalangeal articulations are of the condyloid type capable of flexion, extension, abduction, and adduction.

It is readily seen from the various types of joints entering into the articulations of the lower extremities that there are extensive arthrodial movements permitted by their combination. In walking we have periods of both double and single limb-supports, the double limb-support varying with the single limb-support in ratio to the speed. In the process of walk-

ing, the leg after being lifted from the gound is pushed forward by muscular action, and falls again by its own weight to the ground; during this period the body has the single limb-support of the opposing leg; here it is in a relaxed condition and remains so until it receives the weight of the body, when there is a double support for a slight period. The middle gluteus muscle contracts preventing the rotation of the pelvis by the swinging leg. The middle gluteus and the gluteus minimus directly oppose the lateral fall of the pelvis, aided by the action of the gluteus maximus and the tensor fasciæ latæ. Meanwhile the whole of the gluteus maximus contracts during the whole of the posterior or passive step, thus preventing the falling of the body forward. As soon as the leg reaches the vertical line, the contraction of the gluteus maximus ceases, to be resumed again, in the opposite leg in the next step when the leg is brought from the posterior position to the vertical line. The first muscle of the supporting leg to contract is the quadriceps femoris; by its contraction it maintains the extension of the weight-bearing or active leg; the quadriceps femoris becomes inactive during the anterior step. During the posterior step the muscles of the leg are all slightly relaxed, but as soon as the leg reaches the vertical position the muscles contract vigorously, this contraction being continued until the finish of the anterior step.

The contraction of the gastrocnemius, peroneus longus, and peroneus brevis, aided by the soleus and plantaris, raises the heel, thus raising and pushing the body forward at the same time; these muscles act then as the propulsive agents. The peroneus longus and brevis also act as strong supporters of the arch of the foot, preventing its flattening. The "hamstring" muscles (biceps femoris, semitendinosus, and semimembranosus), together with the flexors (popliteus, flexor longus hallucis, flexor longus digitorum) of the supporting leg, begin to contract during the anterior step, and this movement continues and flexes the leg off of the ground. The supporting leg now becomes the swinging leg; at this time the gastrocnemius, peroneus longus, and peroneus brevis relax, and simultaneously the extensor propius hallucis, extensor longus digitorum, and tibialis anticus contract, thus raising the toes from the ground, so preventing their touching it as the unsupporting leg oscillates. The flexors of the leg are contracted while the flexors of the thigh on the pelvis contract in order to draw the leg and the thigh forward. In this manner the swinging leg advances; as it passes the vertical line the quadriceps femoris contracts vigorously, in order to extend the leg from the thigh; the contraction of the quadriceps femoris is a quick movement and is finished before the advancing leg has stopped. In ascending either an incline or a flight of steps the period of double support is prolonged, the oscillating leg engages the surface by means of the entire foot and continues so until the body has passed the vertical plane. The quadriceps femoris is the principal muscular factor employed in lifting the body, while in addition the muscles of the posterior thigh contract vigorously. At the beginning of the anterior step the body is lifted upward and forward simultaneously. In descending an incline or flight of stairs, the process is the reverse, the quadriceps femoris again being the muscular factor. These two processes are comparable, in ascending, to mechanical force lifting a body, in descending, to the action of a clutch or brake.

During locomotion the spinal muscles, muscles of the back, contract on the side of the oscillating leg; the deltoid controls the natural swinging of the arms, the arm on the side opposite the anterior step swinging anteriorly and alternating with the progressive steps and swaying of the body.

In running and jumping the movements are much the same as in walking except that there is more propulsive muscular force, greater rapidity of action, and a period at which both feet are entirely off the ground at the same time, the gastrocnemius and peronei muscles being the propulsive factor.

In the muscle fibers, muscle tendons, and synovial membranes are specialized nerve end-organs, kinesthetic receptors. These kinesthetic receptors are constantly receiving impulses from the muscles, joints, and tendons, and by means of these kinesthetic afferent impulses the organism is constantly informed as to its posture, its molar movements both active and passive, as well as its resistance to movement.

When the body is in the erect position kinesthetic impulses of a tonic type are constantly being sent to the coordinating centers, maintaining coordination of the muscles, their tonus, and bodily equilibrium. In conjunction with this kinesthetic or muscle sense, the nerves of the semicircular canals designated as labyrinthine sensations, mediate analogous sensations and aid materially in the maintenance of the body-equilibrium.

The nerve-centers related to locomotion are found in the motor area of the cortex of the brain, around the fissure of Rolando, in the posterior central convolutions, the cerebellum, the pons Varolii, corpora striata, and in the spinal gray of the cord. In the pons and corpora striata are associating centers of afferent and efferent impulses; and there are some in the cerebellum, which not only aids in keeping the body equilibrium, but which is also the great coordinating center for all muscular movement, whether voluntary or reflex; the spinal gray coordinating reflex movement, is constantly receiving and coordinating afferent impulses, and in a most complex manner helps in coordinating the proper innervations to the particular sets of muscules and joints involved in the afferent impulse received. If the initiative impulse be voluntary, coming from the brain cortex, the motor impulses transmitted will become automatic and direct the movement of the limbs in the proper manner without any further voluntary act; it has now become a purely reflex act, and remains so until a voluntary impulse is again received.

After the age of three years the act of locomotion becomes almost a reflex one. The functional associations effected in the pons for the performance of locomotion are the result of embryological development; the act of keeping in equilibrium is developed by education, as seen in a young child learning to walk, the necessary kinesthetic impulses being developed and coordinated by practice. If a person is descending a flight of stairs rapidly, and each motion is by volition, the movements will neither be made as accurately nor with as much safety as in case of a pure reflex, in the spinal gray. In the act of walking, the kinesthetic receptors are pressed upon by the muscles, tendons, bones, and joints in varying degrees, sending afferent impulses to the coordinating centers and the cortex. In return efferent impulses are sent to the muscle fibers, tendons, and joints, regulating each movement with the greatest accuracy and nicety, as to the contraction of muscles and the extent of the arthrodial movement needed, thus controlling their extent of contraction and duration. Since these afferent impulses are constantly passing to the coordinating centers and the cortex we are made aware of the nature of the path we are walking. This kinesthetic sense in turn aids greatly the reflex efferent impulses to produce motor functions with greater accuracy than would otherwise be possible.

The motor pathway is as follows: the efferent impulses, perhaps originating in the cortex of the brain (motor area), would pass thence to the corona radiata, to the internal capsule, to the peduncle of the cerebrum, to the pons Varolii, to the anterior pyramids, to the decussation of the pyramids; here also would be impulses passing along the anterior and lateral direct pyramidal pathway, these ending in the motor nuclei of the spinal or cranial nerves, a new set of

neurons continuing the pathway, leaving the cord by the anterior roots and passing to the muscles involved. In general the muscles of the hip are innervated by nerves from the sacral plexus (mixed fibers); the muscles of the thigh by both the lumbar (mixed fibers) and the sacral plexuses, and the muscles of the leg and foot by the sacral plexus.

In order that the human body may be in perfect physical health, as to its circulation, digestion, nervous and muscular systems, exercise is a prime factor. The most universal exercise is walking, for the amount, the rate, and the type are each easily regulated to the particular needs of any individual. This is a pleasant form of exercise easily obtainable, and meanwhile an abundance of fresh air and sunlight are possible. About two-thirds of the muscles of the body are involved in walking, thus exercising the larger proportion of the body muscles. The nervous system, the circulation, and the digestive apparatus each receives its proper stimulation. In the form of athletics, running, jumping, etc., various other forms of leg, trunk, and arm exercises come into play, thus benefiting the entire human economy. The various types of dancing are specialized and trained types of locomotion practised by many who would otherwise receive no form of exercises, while the pleasure involved means much for the organism. These factors are now being utilized to a greater degree than ever before in properly directed schools of physical education.

Under pathological conditions, when there is a lesion either in the cord or elsewhere in the central nervous system, the method of walking departs from the normal. The most common gaits noted are: the spastic gait, in which the individual evidences rigidity of the legs, resulting in a difficulty in lifting the feet; the knees are usually bent and the walk is a scuffing movement. In the ataxic gait the individual throws his feet about irregularly, and is not conscious of their position or the location of the ground; here the motor nerves are not affected, kinesthetic sensations are destroyed. In the gait of paralysis agitans, the body is bent forward and is rigid, with an accentuated senile gait. Alcoholic intoxication produces a gait somewhat similar to that of locomotor ataxia. Diseases of the cerebellum and of the ear interfere with the equilibrium in standing and walking; there is also a tendency to stagger in one direction, accompanied by vertigo.

ROYAL KNIGHT JOSLIN.

Locomotor Ataxia.—See *Tabes Dorsalis.*

Loèche-les-Bains (Leukerbad). — Loèche-les-Bains is situated in Switzerland at the foot of the Gemmi Pass, at an altitude of 4,600 feet. The nearest railway station is distant three and a half hours' drive. The little village of Loèche or Leukerbad is picturesquely situated in a narrow valley about a mile and a half wide and twelve miles long, open to the south and surrounded on the northwest and east by lofty snow mountains, and hills on whose spurs flourish the pine and fir. Through the valley runs the glacial stream, the "Dala," on one bank of which is situated the village and on the other the baths. The climate is a mountain climate, changeable as to weather and temperature with cool mornings and evenings. Sometimes snow falls in June and August. Patients should, therefore, be provided with warm clothing. The mean temperature for June, July, and Aguust is about 30° F., the mean minimum 6.8° F., and the maximum 45.7° F.

There are various mountain excursions in the vicinity of greater or lesser extent, and from here a bridle path leads over the Gemmi Pass to Kandersteg, affording impressive views of Alpine scenery. The season lasts from June 18th to September 30th.

The waters of Loèche are classed as simple thermal waters, the natural temperature being from 102° to 104° F. They contain, however, 1.9 solids per liter, of which 1.4 is calcium sulphate, and hence could be classed with the *earthy* group.

They are employed for both drinking and bathing, chiefly the latter. Both the short and the prolonged baths are used, particularly the latter, which are a specialty of Loèche. They are taken at a temperature of 93° to 95° F., and last from one to six hours. For the most part piscines or large tanks are employed where members of both sexes, clothed in woolen garments, bathe, a partition separating the sexes. Games, such as chess, dominoes, checkers, etc., are played on small floating tables, and the same are used for serving light refreshments.

Patients are advised to wait a few days before beginning the baths in order to become acclimatized and recover from the fatigue of the journey. After taking these baths for ten or eleven days, a sort of dermatitis appears on the skin, varying in intensity and accompanied sometimes with a rise of temperature and anorexia. This eruption usually persists from ten to fourteen days; it is called the "poussée."

The prolonged baths are beneficial in chronic skin affections, such as eczema, psoriasis, chronic urticaria, lichen, acne, etc. They are also employed in cases of chronic rheumatism and gout in combination with douche massage. Affections of the pelvic viscera, chronic catarrhal conditions of the mucous membranes of the digestive, respiratory, and sexual organs, anemia, and some nervous disorders are also said to be benefited by these waters, and in these cases the short baths are indicated.

July and August are the chief months for the cure, and during this period the patients arrive at the baths at five o'clock in the morning and generally take a cup of tea or coffee in the bath. After the bath they go to bed for half an hour, subsequently take a short walk, and at eleven o'clock take a regular meal. At about three P.M. the bath and rest in bed are repeated, and at six the principal meal of the day is taken. The duration of the day's bathing is but an hour at first, which is gradually increased.

In the internal use of the waters from one to five glasses are drunk daily; the effect is diuretic and sometimes sedative to gastric irritability.

The baths are all near the hotels, with which they are generally connected by covered corridors. There are arrangements for the different varieties of douche, inhalation, pulverization, massage, etc.

The contraindications are the same in general as those of other thermal baths.

The accommodations are good and reasonable.

EDWARD O. OTIS.

Lombroso, Cesare.—Born in Verona, Italy, in November, 1836. He pursued his studies at the universities of Turin, Pavia and Vienna, largely

FIG. 3775.—Cesare Lombroso.

as a pupil of Panizza and Skoda, and received his doctor's degree in 1856. He went through the campaign of 1859 as a military surgeon, and in 1862 he

accepted the Chair of Psychiatry in the University of Pavia. Shortly afterward he was made Director of the Pesaro Hospital for the Insane, and, still later, Professor of Medical Jurisprudence and Psychiatry in Turin. He died October 19, 1909.

Lombroso's celebrity rests largely upon his maintenance of the doctrine that the causes of crime are to be found in the bodily conditions of the individual who manifests such a tendency, and that heredity and atavism play a more or less important part in the affair. The more important treatises which he has published upon this theme are the following: "L'uomo delinquente in rapporto all' antropologia, alla giurisprudenza ed alla psychiatria," Milan, 1876 (5th edition, 1896); and "Le più recente scoperte ed applicazioni della psychiatria ed antropologia criminale," Turin, 1893. A. H. B.

Londonderry Lithia Springs.—Rockingham County, New Hampshire.

Location.—Londonderry.

Access.—By rail to Nashua, thence by team about seven miles to the springs.

The spring is not used as a resort but its waters have become widely celebrated and are extensively sold. The spring is situated far from any habitation and is in the center of a tract of land of about seventy acres owned and controlled by the proprietors and not used for any farming purposes whatever. Thus all danger from surface contamination is eliminated. The spring and spring house are kept in a sanitary condition.

The following analyses were made by R. L. Emerson, M. D.:

Cremical Examination.

Gases (number of cubic centimeters per liter at 0° C. and 760 millimeters pressure):

Carbon dioxide (free) 6.67.

Carbon dioxide (set free from bicarbonates on evaporating to dryness) 8.23.

	Parts per 1,000,000
Silica	10.07
Sulphuric acid radicle	8.46
Bicarbonic acid radicle	22.4
Nitric acid radicle	0.1
Nitrous acid radicle	none
Phosphoric acid radicle	none
Meta boric acid radicle	none
Arsenic acid radicle	none
Chlorine	2.97
Bromine	none
Iodine	none
Iron and aluminum	0.24
Manganese	none
Calcium	8.07
Magnesium	0.93
Potassium	1.23
Sodium	2.07
Lithium	trace

Sanitary Analysis.

	Parts per 1,000,000
Free ammonia	0.000
Albuminoid ammonia	0.001
Nitrogen as nitrites	0.000
Nitrogen as nitrates	0.040
Oxygen required	0.161

Hypothetical Form of Combination.

	Parts per 1,000,000
Sodium nitrate	0.1
Potassium chloride	2.3
Sodium chloride	3.1
Lithium chloride	trace
Sodium sulphate	2.5
Magnesium sulphate	4.6
Cacium sulphate	4.4
Calcium bicarbonate	27.4
Ferrous bicarbonate	0.8
Silica	10.07
Total	55.27

An examination was made for bacteria growing at 20° C. for seventy-two hours. Another examination was made for bacteria capable of development at the body temperature, 37° C., grown for twenty-four hours. A further examination was made for the presence of intestinal organisms or pollution and tubes were incubated for twenty-four hours at 37° C.

All tests for intestinal organisms were negative. The results may be tabulated as follows:

	20° C.
Sample No. 1	10 per cubic centimeter
Sample No. 2	90 per cubic centimeter
Sample No. 3	66 per cubic centimeter
Sample No. 4	1260 per cubic centimeter
Sample No. 5	1 per cubic centimeter

37° C.	Presumptive tests.
0	negative
1 per cubic centimeter	negative
4 per cubic centimeter	negative
4 per cubic centimeter	negative
1 per cubic centimeter	negative

The results of the sanitary and bacteriological examinations show that it is a water of exceptional purity, both in its freedom from organic matter and bacteriologically and that such care has been used in the handling and bottling of the water preparatory to putting it on the market for the public that its purity is preserved.

This water possesses the virtues of an antacid, diuretic, and ferruginous tonic. It has been found beneficial in a wide range of diseases, but notably those due to the uric-acid diathesis. The best effects of the water have been observed in gout and rheumatism, in neuralgic pains, in gravel, and in giddiness, headache, insomnia, and other manifestations denoting the lithemic state. The water is well adapted for domestic use. Although not used as a resort, the proprietors of the spring extend a welcome to visitors and are pleased to show them through their extensive bottling plant. Emma E. Walker.

Long, Crawford Williamson.—Born in Danielsville, Georgia, November 1, 1815. He received the degree of M. D. from the University of Pennsylvania, in 1839. After practising in Jefferson, Ga., for the next twelve years he removed to Athens, in the same State,

Fig. 3776.—Crawford Williamson Long.

and remained there, in the general practice of his profession, until the time of his death, June 16, 1878.

Dr. Long's claim to have been the first person to have deliberately administered (March 30, 1842) an anesthetic for the purpose of rendering a surgical operation painless, is thus characterized by Dr. Stephen Smith in his "Evolution of American Surgery."*

* American Practice of Surgery, vol. i., p. 65. Wm. Wood & Co., New York, 1906.

"In the light of the preceding facts we conclude that Dr. Crawford W. Long, a surgeon, first used ether as an anesthetic in the practice of surgery, but did not publish the fact until others had independently repeatod his experiment." On March 30, 1912, there was unveiled, at the University of Pennsylvania, a bronze medallion in memory of Dr. Long and of the important contribution which he made to the practice of surgery. A. H. B.

Longet, François Achille.—Born at St. Germain-en-Laye, near Paris, France, in 1811. He received the degree of Doctor of Medicine in 1835, and afterward devoted himself to experimental research work in the department of physiology. For a period of ten years he also gave courses of instruction in physiology, these courses being attended by large numbers of pupils. While he was conducting these courses he devoted a great deal of time to the study of questions relating to the nervous system, and as a result of these investigations he was able to confirm the correctness of Bell's law. About this time (1841) he published an important treatise bearing the title: "Recherches sur les propriétés et les fonctions de faisceaux de la moëlle epinière et des racines des nerfs rhachidiens." Not long afterward, in the same year, he published two other treatises, which bore the following titles: "Recherches sur les fonctions des muscles et des nerfs du larynx," and "Recherches sur les fonctions de l'epiglotte et sur les agents de l'occlusion de la glotte"—treatises in which he discusses the part played by the accessory nerve of Willis in phonation. In 1842 he published a work which deservedly ranks as a classic, viz., that entitled: "Traité d'anatomie et de physiologie du systeme nerveux de l'homme et des animaux vertébrés;" and in this same year the Académie des Sciences conferred upon him the Monthyon prize for experimental physiology. In 1844 the same instutition awarded him the Monthyon prize for medicine and surgery. In the years 1850–1852 he published his "Traité de physiologie," three volumes (4th edition in 1873). He died April 20, 1871, in Bordeaux. A. H. B.

Loomis, Alfred L.—Born in Bennington, Vermont, October 15, 1831. He received his degree of M. D. from the College of Physicians and Surgeons, New York, in 1852. Immediately after graduation he entered the hospitals on Ward's and Blackwell's Islands, as assistant physician, and retained this position for two years. He then established himself in practice in New York, his attention being specially devoted to diseases of the heart, lungs, and kidneys. In 1859 he was appointed Visiting Physician first to Bellevue Hospital and then, shortly afterward, to Charity Hospital on Blackwell's Island. In 1868 he was made Professor of Pathology and Practice of Medicine in the University of New York. His death occurred in 1895.

Among Dr. Loomis' more important writings the following deserve special mention: "Physical Diagnosis" (at least ten editions between 1893 and 1903) and "A Text-book of Practical Medicine," 1884.

A. H. B.

Loranthaceæ.—(*The Mistletoe Family.*) A peculiar family of some twenty genera and five hundred species of parasitic plants, mostly of the tropics. They are of great interest to botanists and a number are quite ornamental, but they are of little economic importance. The extremely viscid berries of *Viscum album* L., the European mistletoe, and of other members of the family, are used for making bird-lime. The herbage of this plant has been employed as an antispasmodic from ancient times, but its repute is largely mythical and it is now scarcely used. It contains no substance worthy of note as a physiological agent. American mistletoe, *Phoradendron flavescens* (Pursh) Nutt., of the southern United States, has been considerably employed in doses of gr. xv. to lx. (1.0–4.0), either in infusion or in the fluid extract form, as a substitute for ergot, in labor, as an emmenagogue, and for cerebral congestion. The writer has found various other species of the genus similarly employed, and also as galactagogues, by the natives in various parts of South America.

Henry H. Rusby.

Lordosis (Gr. a bending backward) is the term used to designate a curve in the spine with its convexity forward, or more correctly an exaggeration of the normal forward curve of the lumbar spine. The normal spine possesses two curves with convexity forward, the lumbar and the cervical, and any increase in these curves is to be regarded as the result of a disturbance of the balance of the body, very often as compensatory to an increase in the thoracic curve in the opposite direction. Hence lordosis or "increased lordosis" is a frequent symptom of thoracic Pott's disease, of pseudohypertrophic muscular dystrophy, and of lesions in the hip-joint characterised by flexion deformity or by upward and backward displacement of the head of the femur. It is marked therefore in congenital hip dislocation, and in tuberculous hip-joint disease. A pendulous abdomen compels its possessor to throw his body backward, and increases his lumbar lordosis. Lordosis is not a disease in itself, probably never becomes fixed, and disappears when the cause is removed. It is apt to be an attitude of weakness, and is often assumed purposely by persons in an attempt to "stand up straight." It is the "sway back" of the quadrupeds.

Properly speaking no treatment of lordosis is necessary. The causal deformity is what must occupy our attention. In the weak backs of children and adolescents, muscle training, or in rare cases, a spinal brace may be thought advisable. Leonard W. Ely.

Los Angeles and Pasadena.—Los Angeles is the largest city in Southern California, containing 419,096 inhabitants, and is the great business center of this region. It has grown with great rapidity since 1880, when it had only about 11,000 inhabitants. It lies in a valley upon the western bank of a small river, 17 miles from the Pacific coast. To the northwest is Santa Barbara, 80 miles distant; to the south, San Diego, 125 miles distant; and 350 miles northwest is San Francisco. Many railroads converge here, and it is within easy access of attractive resorts in the mountains, valleys, and on the seacoast. Los Angeles and its suburbs, of which Pasadena is one, possess all the attributes and charm of a town situated in such a climate as that of Southern California—a luxuriant and varied vegetation, flourishing to a greater or lesser extent the year through, mild winters with a long duration of daily sunshine, comparatively cool summers, a great preponderance of cloudless weather, and a low rainfall.

The city itself contains many fine buildings, public and private; boulevards shaded by many varieties of tropical and semitropical trees, numerous parks, 350 miles of street railway, and a sewer system emptying into the Pacific Ocean. "It is a beautiful and interesting place, full of architectural and social contrasts. Several elements go to make up the city, the Southern or Spanish, and the American; and brown faces, betraying Castilian and Indian ancestry, mingle on the busy streets with those of the fairer-skinned Yankee type. Low adobe quarters and American country houses are found near each other, within a few minutes' walk, although the old-fashioned 'adobe' is

growing more rare. Modern office-buildings appear within sound of the bells of the early missions" (Solly). The water-supply is obtained from the Owens River and delivered through an aqueduct 217 miles long into a reservoir situated 25 miles from Los Angeles. The aqueduct is capable of delivering 258,100,000 gallons of water daily into the reservoir. The watering-places of Long Beach, Santa Monica, San Pedro, and Redondo are within easy access of Los Angeles.

The climate of Southern California as a whole has been already discussed in this HANDBOOK under the title *California, Southern*, and the reader is referred to that article.

CLIMATE OF LOS ANGELES, CAL., LATITUDE, 34° 3′: LONGITUDE, 118° 15′

	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature—					
Average mean	58.4°	67.5°	62.7°	53.5°	60.5°
Average daily range	20.6	23.1	24.5	20.1	22.0
Mean of warmest	69.4	81.3	76.1	64.2	72.7
Mean of coldest	48.8	58.2	51.6	44.1	50.7
Highest or maximum	97.6	100.4	95.3	85.4	94.7
Lowest or minimum	37.9	49.4	40.2	29.3	39.2
Humidity—					
Mean relative	70.4%	69.1%	63.2%	63.6%	66.6%
Precipitation—					
Average in inches	4.28	0.02	1.57	8.65	14.52
Wind—					
Prevailing direction	W.	W.	W.	N. E.	W.
Average hourly velocity in miles,	5.3	4.8	4.8	5.4	5.1
Weather—					
Average number of clear days,	36.2	34.9	52.3	47.9	171.3
Average number of fair days,	38.1	50.6	32.5	26.6	144.8
Average number of clear and fair days,	71.3	85.5	84.8	74.5	316.1

The preceding table, in connection with what is given in the article referred to, will be sufficient to indicate the principal climatic features of Los Angeles.

"In Pasadena," says Dr. McBride, "the temperature falls steadily from the warmest period, usually 1 P.M., until sunrise next morning. The temperature and humidity, referred to in the following table, were always taken on a northeast porch."

The general characteristics of the climate are those of all this region—one resort differing from another only by modifications of its situation; warmth, equability, a large amount of sunshine, and a small amount of annual rainfall are the main features. The temperature is somewhat higher in summer and lower in winter than it is at the resorts on the coast. There are frequent fogs in the morning and at night during the spring and summer. The average number of days with foggy nights and mornings for the year is fifty-seven. The highest recorded temperature is 108° F., and lowest 28° F. The humidity is very moderate, 66.6 per cent. for the year. A large number of tourists visit Los Angeles during the year, many of them in search of health; but for the consumptive a large city, however favorable the climate may be, is obviously not the most desirable place. In the outskirts of the city, however, is the Barlow Sanatorium which shows excellent results in pulmonary tuberculosis; and at Monrovia, not far away, is the Pottinger Sanatorium. The best season for visiting Los Angeles is said to be from November to May. Some 60,000 eastern tourists visit the city annually.

Pasadena, a suburb of Los Angeles, is situated in the beautiful San Gabriel Valley, about nine miles distant, at an elevation of nine hundred feet. It is an attractive residential city of about twelve thousand inhabitants. It is twenty miles from the sea and five from the mountains. The soil is sandy and porous, and there is a good supply of water. The climate is essentially the same as that of Los Angeles, though the temperature is a little higher, and the humidity somewhat lower. The mean average temperature for January is 54° F.; for December 58° F. The winter is said to be especially agreeable. From the beauty of its location, the attractiveness of the surrounding country, its social and educational advantages, the excellence of its architecture, its orange groves and vineyards, it is considered one of the most eligible places of residence in Southern California. The accommodations are abundant and good.

PASADENA: AVERAGE MONTHLY TEMPERATURE, HUMIDITY, AND WEATHER FOR THE WINTER MONTHS AND THE MONTH OF JULY FOR ONE YEAR.

	Jan.	Feb.	March.	July.	Nov.	Dec.
Temperature—						
Average at sunrise	52.1°	51.5	55	63	56.3	54
Average at 1 P. M	65.2	67.3	71	83.8	73.2	68.3
Midday humidity, relative.	53.3%	54 4	62	55.5	46.2	44.8
Weather—						
Clear, fair, fine days	19	19	15	16	22	28
Cloudy or partly cloudy	12	8	10	3	2	3
Raining or misty	1	0	6	1	6	0
Fog	0	0	0	5	0	0
Slight or early fog	0	1	0	14	0	0

The data for the preceding table, in which are given the average monthly temperature, humidity, and weather of Pasadena for the winter months and the month of July of the year 1900, was kindly furnished the writer by Dr. J. H. McBride of that place.

"The year 1900 was very dry," says Dr. McBride, "only about eight inches of rain (I think). The usual rainfall is sixteen. In the winter of 1900–1901 we had twenty-three inches."

Sierra Madre, 1,700 feet above sea level, twelve miles northeast of Los Angeles, at the base of the foothills, has a climate considered particularly healthful, and was the location selected by the State Board of Health in 1880 as the one most favorable for consumptives in Southern California.

There are various other places in the sheltered San Gabriel Valley favorable for invalids suffering from tuberculous, renal, or cardiac affections. Such are San Gabriel, Monrovia, where is the Pottinger Sanatorium, Duarte, and others.

Echo Mountain, 3,500 feet high; Mount Lowe, 5,650 feet; Mount Wilson, 5,400 feet, all easily reached from Los Angeles or Pasadena, command wide and extensive views. Hotels are found on the summits of these mountains, and the climate, besides possessing the characterisites of that of Southern California, has also the peculiarities of altitude. For further information upon this region see Articles by S. D. Fick, M. D., and Norman Bridge, M. D., Transactions of the American Climatological Assoc., 1901.

EDWARD O. OTIS.

Losophan.—(Tri-iodo-meta-cresylic acid.) An antiseptic preparation said to contain eighty per cent. of iodine. It forms in white needles, insoluble in water, slightly soluble in alcohol, and readily soluble in ether, benzene, and chloroform. At 140° F. it is freely soluble in fatty oils.

It is recommended in parasitic skin affections. It may be used in tinea tonsurans, scabies, pityriasis versicolor, also in prurigo, in chronic eczema, acne, and sycosis. It is contraindicated in all acute inflammatory conditions of the skin, as it is liable to

increase the irritation and intensify the disease. The remedy may be applied in a solution of the strength of one per cent., or in an ointment of one to three per cent.

BEAUMONT SMALL.

Lotiones.—A lotion or wash (*lotio*) is a solution or mixture of medicinal substances, intended for external application. There are no *lotiones* in the United States Pharmacopœia; the British Pharmacopœia has 2, and the National Formulary 4.

		Composition.
LOTIO ADSTRINGENS (Astringent lotion; Warren's styptic).	N. F.	Sulphuric acid (U. S. P.), 38; oil of turpentine, 31; alcohol, 31.
LOTIO FLAVA (Yellow lotion; yellow wash; aqua phagedænica flava.	N. F.	Corrosive mercuric chloride, 3, solution of lime (U. S. P.), and boiling water, of each to 1,000.
LOTIO HYDRARGYRI FLAVA (Yellow mercurial lotion; yellow wash).	B. P.	Mercuric chloride, 20 grains; solution of lime, 10 ounces.
LOTIO HYDRARGYRI NIGRA (Black mercurial lotion; black wash).	B. P.	Mercurous chloride, 30 grains; glycerin, ½ ounce; mucilage of tragacanth, 1½ ounces; solution of lime, 2 ounces.
LOTIO NIGRA (Black lotion; black wash; aqua phagedænica nigra).	N. F.	Mild mercurous chloride, 8.75; water, and solution of lime (U. S. P.), of each, to 1,000.
LOTIO PLUMBI ET OPII (Lotion of lead and opium; lead and opium wash).	N. F.	Lead acetate, 17.5, tincture of opium (U. S. P.), 35, water, to 1,000.

R. J. E. SCOTT.

Louis, Antoine.—Born at Metz, Februay 13, 1723. In early manhood, after receiving a thorough general education in his native city, he visited Paris and was soon able to compete successfully for one of the subordinate positions in the Salpêtrière Hospital. He spent five years in this institution and was then (1749) chosen Professor of Physiology in the Paris College of Surgery—a position which he held for over forty years. In 1757 he was elected a substitute for the Surgeon-in-Chief of the Charité Hospital. He experienced so many annoyances, however, in the performance of the duties of this position that, in 1761, he gave it up and accepted the office of consulting Surgeon-Major in the Army of the Upper Rhine. After an absence of two years he returned (1763) to Paris, and was soon (1764) chosen to fill the place of Perpetual Secretary of the Royal Academy of Surgery. Under his able management five volumes of the Transactions of this Society were published, but, after that, he seemed to lose courage, and for eighteen years no further volumes were issued. His death occurred May 20, 1792.

Louis was a prolific contributor to medical literature. The titles of only a few of his published writings may here be enumerated: "Cours de chirurgie pratique sur les plaies d'armes à feu," Paris, 1746; "Essai sur la nature de l'âme, où l' on tâche d' expliquer son union avec le corps," Paris, 1747; "Lettre sur la certitude des signes de la mort, où l'on rassure les citoyens de la crainte d'être enterrés vivans, avec des observations et des expériences sur les noyés," Paris, 1752; and "Précis sur l'histoire, les effets et l'usage de la saignée," Amsterdam, 1778.

A. H. B.

Louis, Pierre Charles Alexandre.—Born April 14, 1787, at Aï, Champagne, France. After obtaining his doctorate in Paris in 1813, he went to Russia where he lived for a time, returning to Paris in 1820. He was connected for several years with the Hôpital de la Charité, where he assiduously cultivated pathological anatomy, making, it is said, more than 5,000 autopsies. In 1828 he became physician to the Hôpital de la Pitié, where he remained until 1854, at which time he practically retired from practice. He lived, however, until August 22, 1872.

Louis was a firm believer in the value of statistics founded upon a comparison of clinical observation and autopsical findings, and in furtherance of this study he founded the "Société médicale d'observation." He was one of the first clinicians to distinguish clearly between typhus and typhoid fevers, and promoted greatly the science of diagnosis in other directions. Among his contributions to medical literature the most important were: "Recherches anatomiques, pathologiques et thérapeutiques sur la maladie connue sous le nom de fièvre typhoïde, putride, dynamique," etc., 2 vols. Paris, 1829 and 1841; "Mémoires ou recherches anatomico-pathologiques sur la ramollissement de l'estomac," etc., Paris, 1826: "Recherches sur les effets de la saignée dans quelques maladies inflammatoires," etc., Paris, 1835.

FIG. 3777.—Pierre Charles Alexandre Louis.

T. L. S.

Louisville Artesian Well.—Jefferson County, Kentucky.

Location.—On the corner of Tenth and Rowan streets, Louisville.

This well is 2,086 feet deep by 3½ feet in diameter, and occupied sixteen months in boring. The temperature of the water, as it issues from the orifice of the well, is 76.5° F. A self-registering thermometer sunk to the bottom of the well indicated 86.5° F. The point of constant temperature immediately beneath the surface at Louisville is 53° F. This result shows an increase of temperature of one degree for every sixty-seven feet until the bottom is reached. The following analysis was made by Dr. J. Lawrence Smith:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	621.52
Calcium chloride	65.72
Magnesium choride	14.77
Potassium chloride	4.22
Aluminum chloride	1.21
Lithium chloride	0.10
Sodium sulphate	72.29
Calcium sulphate	29.43
Magnesium sulphate	77.33
Aluminum sulphate	1.80
Potassium sulphate	3.22
Sodium bicarbonate	2.72
Calcium bicarbonate	5 99
Magnesium bicarbonate	2.75
Iron bicarbonate	0.35
Sodium phosphate	1.54
Magnesium iodide	0.35
Magnesium bromide	0.46
Silica	0.88
Organic matter	0.70
Loss in analysis	8.12
Total	915.47

Gases.	Cu. in.
Sulphureted hydrogen	2.00
Carbonic acid	6.17
Nitrogen	1.36

The water is quite similar to that of the Kissingen Springs in Bavaria, and to that of the Kentucky Blue Lick Springs. It has been found very beneficial in cases of dyspepsia and constipation and in functional liver complaints. EMMA E. WALKER.

Lovage.—See *Levisticum*.

Lower, Richard.—Born at Tremer, County of Cornwall, England, about 1631. He studied medicine at Oxford, where he became a warm friend of Willis, the distinguished anatomist. He received the degree of Doctor of Medicine in 1665, and during the next year he followed Willis to London and made his home in that city. Upon the death of the latter, Lower was able to step into his friend's practice and to accumulate, in the course of a few years, a large fortune. His own death occurred January 17, 1691.

The published writing which chiefly contributed to Lower's reputation is that which bears the following title: "Tractus de corde; item de motu et colore sanguinis, et chyli in eum transitu," several editions published in London between 1669 and 1749.

A. H. B.

Lucas-Championnière, Just Marie Marcellin.—Born at St. Léonard in the Department of Oise, France, August 15, 1843. He was the son of a well-known physician and from early youth looked upon medicine as his chosen vocation. He was graduated from the University of Paris with the degree of M. D.

FIG. 3778.—Just Lucas-Championnière.

in 1870, after a five-year term of service in the Paris hospitals, gaining the gold medal of the interneship in 1869. He was appointed surgeon to the hospitals in 1874 and directed the surgical services in six of the Paris institutions in succession until his retirement in 1906. Lucas-Championnière was the first to preach the gospel of antiseptic surgery to the French, having very early in his career studied under Lister in Glasgow and become an ardent convert to his doctrines. He was also a pioneer in the practice of massage and methodical mobilization in the treatment of fractures. He was not so successful in convincing his colleagues of the value of this as he was finally in the case of antiseptics, yet he continued to urge its adoption and in 1908 read a paper on it before the surgical section of the British Medical Association, and again in 1909 made it the subject of an address at the annual meeting of the Cardiff Medical Association. He was a member of the Paris Académie de Médecine, of the Académie des Sciences, and of other societies, and an honorary member of a great number of foreign associations. He was well known to English-speaking surgeons, being a constant attendant at international gatherings of medical men, where he frequently delivered addresses in English as well as French.

Lucas-Championnière, in the midst of his surgical activities had always been connected with medical journalism, being editor of the *Journal de Médecine et de Chirurgie pratiques*, founded in 1840 by his father. He was president of the International Association of the Medical Press at its meeting in London in 1913. He was also a prolific writer on many surgical subjects in addition to antisepsis and fractures, such as hernia, cerebral localization, gymnastics, trephining, etc. In 1876 he was awarded a prize for an essay on prehistoric trephining and had been invited to deliver an address on the same subject before the Institut de France in October, 1913. Three days before this meeting, on October 22, 1913, he had just finished reading this essay to a committee of the Institute when he suddenly died from failure of the heart, which organ had shown evidences of disease for some years.

Although a voluminous writer on medical subjects, Lucas-Championnière was the author of few formal treatises, the most important of these being "Chirurgie opératoire," Paris, 1892, and "Traitement des fractures par le massage et la mobilisation," 1895. T. L. S.

Lucilia.—A genus of flesh-eating flies. *L. cæsar* and *L. sericata* deposit their eggs on ulcers; *L. cæsar* and *L. regina* have caused intestinal myiasis; *L. nobilis* has been found in the auditory meatus. See *Insects, Parasitic.* A. S. P.

Ludwig, Karl Friedrich Wilhelm.—Born at Witzenhausen, Germany, December 29, 1816. He studied at the universities of Marburg and Erlangen, and received his doctor's degree from the former institution in 1839. In 1842 he began to teach physiology in the same university; in 1846 he was called to Zürich to occupy the position of Professor Extraordinary of Comparative Anatomy; and in 1849 he was given the regular Chair of Anatomy and Physiology in the same university. In 1855 he was made Professor of Physiology and Zoölogy in the Josephinum at Vienna. He held this position for ten years, and then (1865) accepted a call from the University of Leipzig to occupy the Chair of Physiology and to be the Director of the Physiological Institute in that city. During the period of his connection with this university Ludwig's reputation became so great that pupils flocked to hear him from all parts of the world. He died April 24, 1895.

According to Pagel, Ludwig deserves to be placed in the front rank of modern physiologists, by the side of such men as Johann Mueller, DuBois-Reymond, Bruecke, and Helmholtz. He adds that there is scarcely a department of physiology which Ludwig has not enriched by some important investigations and discoveries. From the following titles of a few of his published writings some slight idea may be obtained of the great extent of territory which Ludwig's investigations covered: "Beiträge zur Lehre vom Mechanismus der Harnabsonderung," Marburg, 1842; "Ueber endosmotische Acquivalente und endosmotische Theorie," Zeitschrift für rationelle Medicin, viii.; "Ueber den Druck, den das fliessende Wasser senkrecht zu einer Stormrichtung ausübt," Sitzungsberichte der Wiener Akad. d. Wissenschaften, 1858; "Ueber den Einfluss des Halsmarks auf den Blutstrom" (in association with Thiry), Ibidem, 1864; "Neue Versuche ueber die Beihülfe der Nerven zur Speichel-absonderung;" and, finally, his great treatise "Lehrbuch der Physiologie der Menschen," Leipzig, 1852–1856, two volumes (2nd edition, 1858–1861.)

A. H. B.

Lungs, Anatomy of the.—General Situation and Attachments.—The lungs (Pulmones) are two irregularly conical shaped organs which are situated one in each lateral half of the thorax. With the exception of the middle portion in which the heart interposes they fill the thorax within which they lie free save for the structures which form the radix pulmonis and for the ligamentum pulmonale. They are indirectly connected with each other by means of the trachea and the two main bronchi into which it divides.

Color.—At birth and for the first three weeks of life the lungs are nearly white in color, showing a delicate pink to a decided red tint on section; this is due to the contained blood. According to Shingu after the twenty-third day of life the lungs show a beginning pigmentation which increases with the age of the individual.

The adult lungs vary in color, depending on the amount of blood which they contain and the amount of pigmentation present. If there be but little blood present they have a yellowish gray color, but when they contain a considerable quantity of blood they are of a reddish-gray color.

The surfaces of the lungs are often marbled with blue or black lines especially in individuals who live in a smoky or dusty atmosphere. When extreme pigmentation is present (be it from particles of carbon or dust) it may give a light bluish-black color to the surfaces of the lungs on which appear lines or patches of more intense pigmentation. As a rule the external surface of the lung shows a greater amount of pigmentation than the mediastinal surface or the base of the lung; the surfaces within the fissures show the least pigmentation.

Weight.—It is difficult to determine the weight of the lungs owing to the variable quantity of fluid present. Krause gives 1,300 grams as the weight in the male and 1,023 grams in the female, with a moderate amount of blood present. Under the same conditions the author has found the average weight somewhat less; 1,058 grams in the male and 924 grams in the female. The average weight of the right lung in the male was found to be 568.75 grams; in the female 500 grams. The average weight of the left lung in the male was 486.88 grams; in the female 424 grams. From these figures it is seen that the right lung materially exceeds the left in weight.

Spitzka found the weight of the lungs still lower in the case of six criminals executed by electricity. In age, they varied from twenty-three to forty-one years. The right lung averaged 281 grams; the left lung 253 grams giving a total weight of 534 grams for both lungs. This is practically half the average weight found by the author. Spitzka attributes the low weights in his cases to the mode of death which, by causing strong contraction of the thoracic cavity and other phenomena, "brings about a bloodless condition of the lungs, so that we are enabled to ascertain the actual weight of lung tissue only, not, as in ordinary death, of a variable amount of blood and serum as well."

Specific Gravity.—Before respiration has taken place the specific gravity of the lungs is greater than that of water; they sink, therefore, when placed in it. The same is true when only a few inspirations have been taken place and the lungs have collapsed with the death of the individual. Waters gives 1,062 and Wilmart 1,068 as the specific gravity before the establishment of respiration. After the establishment of respiration the lungs become filled with air and their specific gravity may be as low as 0.342 (Dwight).

Dimensions.—Owing to variations in the size and form of the thorax and to variations in distention, any measurements of the lungs are of little value. Krause gives 271 millimeters as the length of the right lung in males and 216 millimeters in females; of the

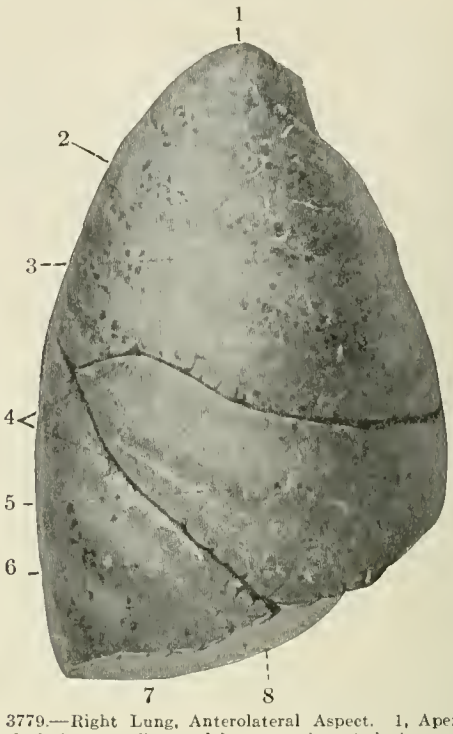

Fig. 3779.—Right Lung, Anterolateral Aspect. 1, Apex pulmonis; 2, facies costalis; 3, lobus superior; 4, incisuræ interlobares; 5, lobus medius; 6, lobus inferior; 7, margo inferior; 8, facies diaphragmatica. (Spalteholz.)

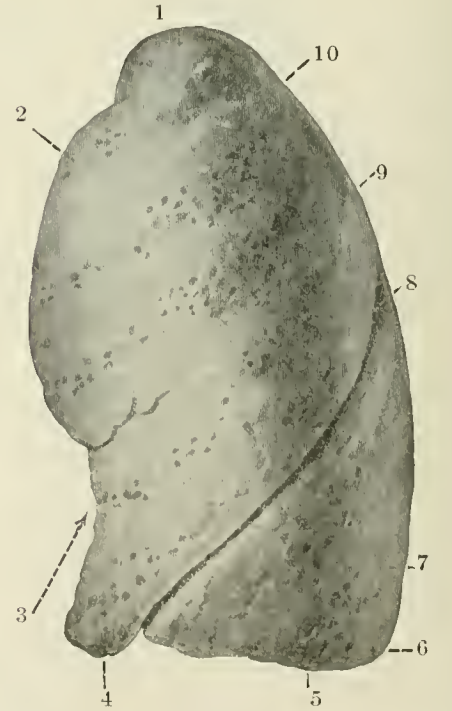

Fig. 3780.—Left Lung, Anterolateral Aspect. 1, Apex pulmonis; 2, margo anterior; 3, incisura cardiaca; 4, lingula pulmonis; 5, margo inferior; 6, basis pulmonis; 7, lobus inferior; 8, incisura interlobaris; 9, lobus superior; 10, facies costalis. (Spalteholz.)

left lung 298 millimeters in males and 230 millimeters in females. Measured transversely at the base the right lung is 135 millimeters, the left lung 129 millimeters in diameter in males; in females the right lung measures 122 millimeters, the left lung 108 millimeters.

The right lung is shorter and broader than the left lung. This is due to the liver (hepar) causing the arch of the diaphragma to rise to a higher level on the right side than on the left and to the inclination of the heart to the left side.

Capacity.—In a well-developed male, of from thirty to thirty-five years of age, at the end of a full inspiration the lungs contain about 5,000 c.c. of air; in a female somewhat less. After death and collapse of the lungs have taken place, the lungs contain about 1,500 c.c. of air. According to Hutchinson the vital capacity, which is the greatest amount of air that can be expelled after a full inspiration, is 3,770 c.c. Rosenthal gives 3,200 c.c. for males and 2,500 c.c. for females.

Schäfer, as the result of a series of experiments, found that with a respiration of thirteen per minute the amount of air exchanged per minute was 5,850 c.c., giving 450 c.c. as the amount of tidal air.

Form.—When the lungs are hardened *in situ* they are, as stated above, irregularly conical in shape and there can be distinguished on each an apex, a base, three surfaces and two margins.

Apex.—The apex pulmonis (Fig. 3779) is rounded and occupies the cupula pleuræ. It is not situated over the center of the basis pulmonis, but mesial and somewhat posterior to it. Below the apex pulmonis runs a groove occupied by the arteria subclavia, the sulcus subclavius (Fig. 3782).

Base.—The basis pulmonis is broad and concave, the concavity corresponding to the curve of the liver (hepar), from which it is separated by the diaphragma. The arch of the lobus hepatis dexter extends to a higher level than that of the lobus hepatis sinister, consequently the concavity of the basis pulmonis of the right lung is deeper than that of the left lung.

Surfaces.—The *facies costalis* (Figs. 3779 and 3780) is the most extensive of the three surfaces and is deeper posteriorly than anteriorly. It is convex and corresponds in general to the form of the cavum pleuræ. As it is closely applied to the pleura costalis the ribs give rise, in specimens hardened *in situ*, to shallow oblique grooves between which slightly rounded ridges appear that correspond to the intercostal spaces. These intercostal ridges often show, especially in early life, a greater amount of pigmentation than the costal grooves.

The *facies mediastinalis* (Figs. 3781 and 3782) is in contact with the pleura mediastinalis and the pericardium. It is nearly vertical in direction and presents a deep concavity, the impressio cardiaca, which is larger and deeper on the left lung than on the right because of the oblique position which the heart occupies and its projecting further beyond the midline on the left side than on the right side. This surface possesses near its posterior border, above and behind the impressio cardiaca, a triangular depression, the hilus pulmonis, in which the bronchi, the blood-vessels and nerves are situated as they enter and leave the lung, and in which lymph nodes, lymphoglandulæ pulmonales, are not infrequently found (Fig. 3782). Collectively these structures are called the root of the lung, radix pulmonis, and form the only place where the lung is connected with adjoining structures with the exception of the triangular fold of the pleura pulmonalis which extends from the lower border of the hilus pulmonis to the pleura mediastinalis and forms the ligamentum pulmonale (Figs. 3781 and 3782). Situated behind the hilus pulmonis of the right lung and arching slightly above it is a groove for the vena azygos (Fig. 3781). In some instances a vertical groove can be recognized below that for the vena azygos and behind the ligamentum pulmonale for the esophagus. In front of the hilus is a wide shallow groove which runs upward with a lateral curve for the vena cava superior and the vena anomyma dextra (Fig. 3781). On the left lung above and behind the hilus pulmonis and the ligamentum pulmonale is a broad deep groove produced by the arcus aortæ and the aorta thoracalis (Fig. 3782). Running upward from the arched portion of this groove toward the apex pulmonis is a groove for the arteria subclavia sinistra, the sulcus subclavia (Fig. 3782).

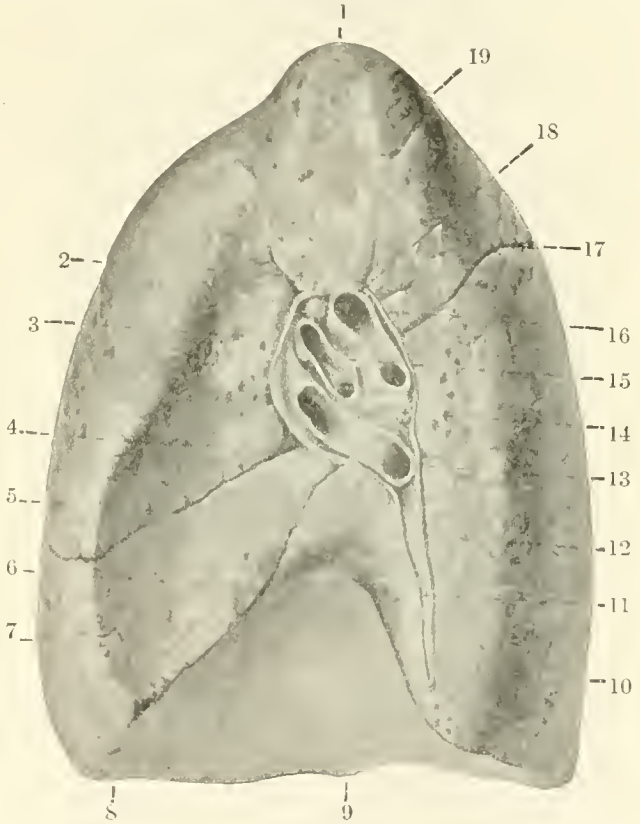

Fig. 3781.—Right Lung, from the Medial Side. 1, Apex pulmonis; 2, facies mediastinalis; 3, groove of the vena cava superior; 4, lobus superior; 5, impressio cardiaca; 6, lobus medius; 7, margo anterior; 8, margo inferior; 9, facies diaphragmatica; 10, lobus inferior; 11, ligamentum pulmonale; 12, groove for the vena azygos; 13, venæ pulmonales dextræ; 14, lymphoglandula pulmonalis; 15, ramus dexter of the arteria pulmonalis; 16, bronchus dexter; 17, incisura interlobaris; 18, hilus pulmonis with cut edge of the pleura; 19, facies costalis. (Spalteholz.)

Radix Pulmonis.—The radix pulmonis is situated slightly above the center of the facies mediastinalis and nearer its posterior than its anterior border. The arrangement of the bronchi and vessels entering and leaving the lung differ on the two sides. On the right lung (Fig. 3781) the main bronchus enters near the middle of the hilus and its first branch near the upper border of the hilus. As a rule, however, in dissecting the lung the bronchus is divided obliquely before it branches and then it appears as an irregular oval situated in the upper and posterior quadrant of the

hilus. In front and somewhat below the bronchus is the ramus dexter arteria pulmonalis, while below the bronchus and artery are the venæ pulmonales dextræ. On the left lung (Fig. 3782) the bronchus enters the hilus behind and slightly above its center; the ramus sinister arteria pulmonalis is situated above the bronchus while the venæ pulmonales are situated in front of and below the bronchus. This variation in the arrangement of the structures forming the radix pulmonis causes the hilus of the right lung to have an ovoid outline while that of the left lung is triangular in outline.

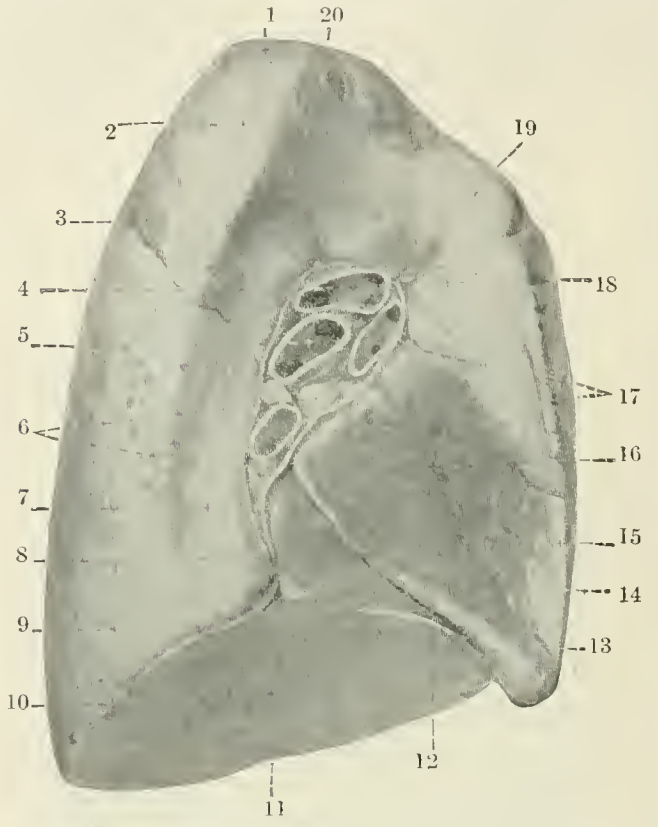

Fig. 3782.—Left Lung from the Medial Side. 1, Apex pulmonis; 2, facies costalis, 3, incisura interlobaris; 4, ramus sinister of the arteria pulmonalis; 5, bronchus sinister; 6, lymphoglandulæ pulmonales; 7, groove for the aorta thoracalis; 8, ligamentum pulmonale; 9, lobus inferior; 10, margo inferior; 11, facies diaphragmatica; 12, incisura interlobaris; 13, lingula pulmonis; 14, lobus superior; 15, margo anterior; 16, impressio cardiaca; 17, venæ pulmonales sinistræ; 18, facies mediastinalis; 19, hilus pulmonis with cut edge of the pleura; 20, sulcus subclavius. (Spalteholz.)

The *facies diaphragmatica* (Figs. 3781 and 3782) corresponds to the basis pulmonis and has been described under that heading. The encroachment of the heart gives the facies diaphragmatica of each lung a crescentic outline, that of the left lung being the more typical on account of the oblique position of the heart.

Margins.—The *margo anterior* is thin, sharp and somewhat irregular. Above, the margo anterior of each lung projects into the sinus costomediastinalis; below, that of the left lung presents a deep concavity, the incisura cardiaca, where it curves around the heart (Fig. 3780). This prolongation of the lung below the heart toward the mid line is called the lingula pulmonis.

The *margo inferior* (Fig. 3779) along the junction of the facies costalis and the facies diaphragmatica is thin and sharp, especially where it is prolonged into the sinus phrenicocostalis; mesially along the junction of the facies mediastinalis and the facies diaphragmatica it is thicker and more rounded. The thick, rounded dorsal portion of the lung at the junction of the facies costalis and the facies mediastinalis is sometimes described as a margo posterior.

Fissures.—The lungs are divided into lobes by deep fissures (incisuræ interlobares). On the left lung the incisura interlobaris passes obliquely from behind and above, forward and downward to the basis pulmonis (Figs. 3780 and 3782). A similar incisura interlobaris is present on the right lung from which a second incisura, more horizontal and shallower, passes across the anterior surface, so that there can be recognized on the right lung two incisuræ interlobares. By means of these incisuræ, three lobes are marked off on the right lung: a lobus superior, a lobus medius, and a lobus inferior; on the left lung only two lobes are present: a lobus superior and a lobus inferior.

Lobes.—The *left lung* is divided by the incisura interlobaris into a lobus superior and a lobus inferior. The lobus superior is situated above the incisura interlobaris. It is conical in form with an oblique base which corresponds to the course of the incisura. The apex pulmonis, the whole of the margo anterior, a considerable portion of the facies costalis and the greater part of the facies mediastinalis belong to this lobe. Below the incisura cardiaca it is prolonged toward the midline forming the lingula pulmonis. The lobus inferior comprises the remainder of the lung. Nearly the whole of the facies diaphragmatica (basis pulmonis) and a large part of the facies costalis belong to this lobe. (Fig. 3780.)

The *right lung* is divided by two incisuræ interlobares into three lobes. One of the incisuræ occupies practically the same position as that of the left lung except that it is more vertical in direction and does not terminate as near the midline. It separates the lobus inferior from the lobus medius and the lobus superior. The second incisura separates the lobus superior from the lobus medius. It leaves the main incisura near the dorsal part of the lung, passes horizontally forward to the level of the fourth costal cartilage, where it cuts the margo anterior, and then passes across the facies mediastinalis to terminate at the hilus pulmonis.

The lobus medius is wedge shaped and is the smallest of the three lobes. Interposed as it is between the lobus superior and the lobus inferior it gives to the lobus superior the form of a truncated cone the apex of which is formed by the apex pulmonis. In like manner the lobus inferior has the form of a truncated cone when viewed from in front and laterally, the base being formed by the facies diaphragmatica (Fig. 3779).

Bronchi.—The trachea divides into the right and left bronchus at about the level of the fourth thoracic vertebra. According to Bianchi and Cocchi this division seldom takes place lower than the upper part of the fifth thoracic vertebra.

Of these two bronchi the right is the shorter and wider and is usually described as having a more horizontal direction than the left. Pansch in 1884, followed by Jössel in 1889, began to advance the opposite view, and Aeby in his admirable monograph showed conclusively that the right bronchus is the more oblique. Schrötter also expressed wonderment at the constantly repeated error. Fig. 3783, taken from Birch-Hirschfeld, shows a Röntgen-ray photograph of an injection of Wood's metal into the trachea and

bronchi *in situ*, and brings out clearly the more horizontal position of the left bronchus.

If the fact be taken into account that the *carina* is situated to the left of the center of the lumen of the trachea, that the right bronchus is the larger and the more oblique, and that there is a special arrangement of the muscle at the carina, it is easily seen why foreign bodies pass so readily into the right bronchus and lung.

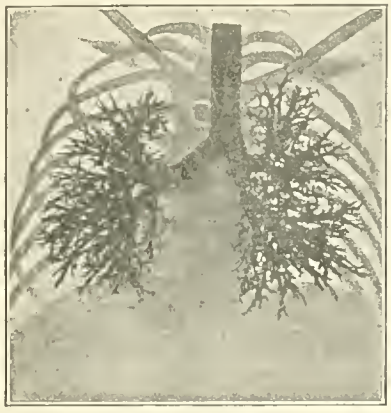

Fig. 3783.—A Röntgen-ray Photograph of the Trachea and Bronchi Injected with Wood's Metal *in situ*. The very oblique direction of the right and the horizontal direction of the left bronchus are clearly shown. View from behind. (After Birch-Hirschfeld.)

Aeby demonstrated that there is a main bronchus, gradually diminishing in size, which extends through each lung. These main bronchi are direct continuations of the two bronchi into which the trachea divides. From each main bronchus lateral branches, rami bronchiales, are given off in a monopodial manner; these lateral branches were named by Aeby dorsal and ventral bronchi. The dorsal bronchi are usually shorter and more slender than the ventral bronchi (Fig. 3784).

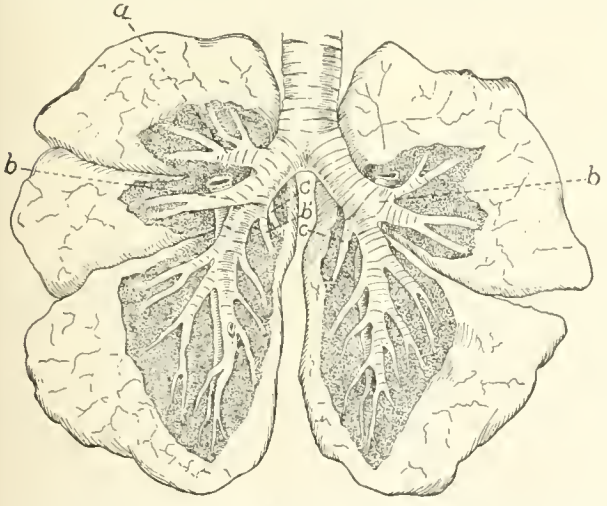

Fig. 3784.—Lung and Bronchial Tree of Man. *a*, Eparterial bronchus; *b*, first ventral hyparterial bronchus; *b'*, cardiac bronchus; *c*, first dorsal hyparterial bronchus. The cut ends of the pulmonary artery can be seen just above the first ventral hyparterial bronchi. (After Aeby.)

According to Aeby the arteria pulmonalis, as it passes to each lung, crosses the main bronchus near its upper part and, running along its lateral side, gradually comes to lie dorsal to the bronchus (Fig. 3784). All lateral bronchi which arise from the main bronchus, below the place where the arteria pulmonalis crosses, were called by Aeby hyparterial bronchi. On the right side in man a single, rather large bronchus arises from the main bronchus, above the place where the pulmonary artery crosses, and was called by Aeby the eparterial bronchus (Fig. 3784, *a*).

Occasionally in man the eparterial bronchus arises directly from the trachea; this point of origin is constant in sheep and in the ox. Below the point where the arteria pulmonalis crosses the main bronchus the arrangement of the lateral bronchi is the same on each side. This peculiarity of the bronchi leads to the formation of three lobes for the right lung, but of only two for the left lung. Aeby reasons that as the eparterial bronchus is not present on the left side, the lobe to which it is distributed is absent, and that the upper lobe of the left lung and the middle lobe of the right lung are homologous.

This conception of Aeby, which he evolved from his studies of the comparative anatomy of the lungs, received confirmation from His, who studied the development of the lungs in human embryos of various ages. His showed that from the first there was an unsymmetrical arrangement of the lung buds, there being three on the right side but only two on the left. His agreed with Aeby that the mode of branching for the main bronchus was monopodial, but disagreed as to the lateral bronchi, which he claimed were dichotomous in their mode of branching.

Ewart, in his work on the bronchi and blood-vessels of the human lung, differs from Aeby. He believes in dichotomy; not the even dichotomy of the older authors, but uneven dichotomy. He says "The further dissection is carried within the lung the less rarely does even dichotomy occur." In another place he says "The products of a dichotomy which had been carried through with mathematical precision would have fitted ill within the pleural boundaries. Nay, even the more elastic principle of 'monopodial branching' requires, in its working, to be allowed some latitude. All so-called principles, or laws, are over-ruled by a higher law, the law of adaptation."

Narath denies that the arteria pulmonalis influences the development of the bronchial tree. He claims that the eparterial bronchus on the right side is homologous with the dorsal branch arising from the first ventral bronchus on the left side. The eparterial bronchus, according to Narath, is therefore a dorsal lateral branch of the first ventral bronchus which has migrated up the main bronchus. In a later communication Narath studied the problem from the embryological side and found confirmation of his previously expressed opinion.

As the result of a series of comparative anatomy studies Huntington reaches the conclusion that "the right and left lungs agree, morphologically, in the type of their bronchial distribution." This leads to the following proposition:

Right side.		Left side.
Upper + middle lobe	=	Upper lobe.
Lower + cardiac lobe	=	Lower lobe.

Huntington agrees with Narath that migration and not the arteria pulmonalis is the active principle in modifying the architecture of the lung, but disagrees with Narath in the derivation of the apical bronchus. The type of bronchial division is given by Huntington as being "practically dichotomous."

In a number of contributions, d'Hardiviller opposes the theory of dichotomy, supporting Aeby in this respect, but strongly opposes him in the manner in which the bronchi arise from the main stem. The

lungs are at first symmetrical and have on each side an eparterial bronchus. Deviations from this type are to be referred to the result of atrophy. The eparterial bronchus is not a lateral branch of a hyparterial bronchus as described by Narath, but is a special bronchus.

Birch-Hirschfeld has investigated the bronchial tree of adults and agrees with Narath that the upper part of the left lobe corresponds to that part of the right lung which is supplied by the "eparterial bronchus." From a pathological standpoint Birch-Hirschfeld thinks that only such branches should be designated "apical" as are exclusively distributed to the upper portion of each lung.

A recent study by Justesen of the division of the bronchi leads him to the conclusion that the mode of division is a modified dichotomy in which one branch becomes much more highly developed than the other. This type of division is designated by Justesen "sympodial," a name applied by botanists to a similar mode of branching in plants.

Flint has made an extended study of the development of the bronchial tree and he finds that the growth of the main series of bronchi is monopodial in character; subsequent division of the branches may be either monopodial or dichotomous, the type depending on the space in which the bronchi have to divide.

Miller has also studied the mode of division in the adult lung and finds that "the mode of division for the main series is monopodial, but that the mode of division for the smaller bronchi is a mixed dichotomy and monopody."

Blood-vessels.—The blood-vessels of the lung consist of two sets which originate from different sources and perform functions of a different character. One set, derived from the arteria pulmonalis, gives origin to the respiratory or functional circulation; the other set, derived from the arteria bronchialis, furnishes the nutritive vessels of the lung.

The *arteria pulmonalis* arises from the ventriculus dexter of the heart, passes obliquely along the left side of the aorta ascendens and divides under the arcus aortæ into a ramus dexter and a ramus sinister. The ramus dexter passes behind the aorta ascendens and the vena cava superior and beneath the arcus aortæ to gain a position in front of the bronchus dexter at the hilus pulmonis. The ramus sinister runs in front of the bronchus sinister and the aorta thoracalis and enters the hilus pulmonis above the bronchus sinister. Within the lung the arteria pulmonis follows the bronchi in all of their subdivisions and is situated behind and slightly lateral to the bronchi. The branches of the arteria pulmonalis break up into a network of capillaries which is situated in the walls of the air spaces. From this capillary network the blood is returned to the atrum sinistrum of the heart by the *venæ pulmonales;* these are usually four in number, two for each lung. In some instances the vein coming from the lobus medius of the right lung empties into the atrum sinistrum independently; in other instances the two veins arising from the left lung unite and form a common trunk before entering the atrum sinistrum. The finer arrangement of the pulmonary blood-vessels will be considered in connection with the histology of the lung (see below).

The *arteriæ bronchiales* vary in number and origin; the right arteria bronchialis arises either direct from the aorta thoracalis or from the first or third arteria intercostalis; the left arteriæ bronchiales, two in number, arise from the anterior wall of the aorta thoracalis at the level of the fifth vertebra thoracalis. The blood which the arteriæ bronchiales convey to the lungs is largely returned by the venæ pulmonales. True venæ bronchiales are found only at the hilus pulmonis; they empty into the vena azygos or the vena hemiazygos.

Lymphatics.—Grossly the lymphatics of the lung can be divided into a superficial and deep set. The former are situated in the pleura pulmonalis; the latter accompany the rami bronchiales, the arteria pulmonalis and the venæ pulmonales. The two sets communicate in the pleura and at the hilus pulmonis. A more extended description will be found in connection with the histology of the lung (see below).

Nerves.—The lungs receive their nerve supply from the nervi vagi and the rami pulmonales of the pars

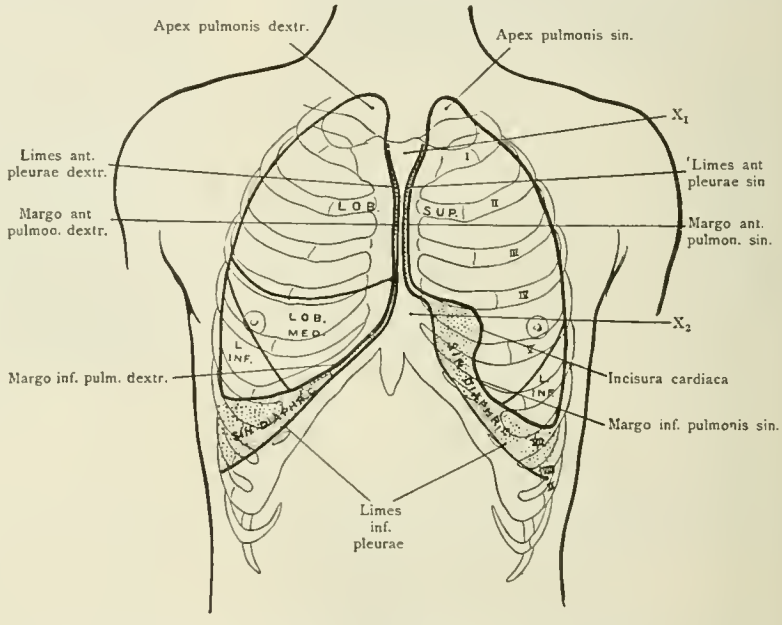

Fig. 3785.—Limits of the Lungs and of the Pleura; seen from before. X_1, The triangular area on the posterior surface of the sternum uncovered by the pleura; X_2, area in which the pericardium is in contact with the anterior chest wall. Sin. diaphr. c. = Sinus phrenicocostalis. (Corning.)

thoracalis systematis sympathici. The nervus vagus forms on the posterior surface of the radix pulmonis a plexus, plexus pulmonalis posterior; from this plexus branches pass to the anterior surface of the radix pulmonis where they form a second plexus, plexus pulmonalis anterior. The plexus pulmonalis posterior is joined by branches from the second, third, and fourth ganglia thoracalia. The plexus pulmonalis anterior is joined by a few fibers from the plexus cardiacus profundus of the same side. The anterior plexus supplies the constituents of the radix pulmonis while the posterior plexus sends branches which contain fibers from both the nervus vagus and systema sympathica into the substance of the lung.

Topographical Anatomy.—Apex pulmonis.—If a horizontal line be drawn across the upper border of

the cartilages which connect the first pair of ribs (costæ) with the sternum, the apex pulmonis will be found to extend above this line and to correspond to the conformation of the cupula pleuræ. Viewed from in front (Fig. 3785), the apex pulmonis falls within the cervical region, if we consider the upper border of the clavicula and the incisura jugularis sterni as forming its lower boundary.

In front of the cupula pleuræ are found the scalenus anterior and scalenus medius muscles, the vena and arteria subclavia. The arteria subclavia gives origin to a depression in the apex pulmonis, the sulcus subclavius (Fig. 3782), as it arches over the cupula pleuræ. The main trunks of the plexus brachialis pass over the lateral and anterior border of the cupula pleuræ on their way to the axilla. Other structures are in relationship with the cupula pleuræ but, since they belong more properly to the pleura, they will be considered in that connection.

The topographical relations of the lungs are quite different in the living individual than in the cadaver, for in the latter they are in the condition of extreme expiration. Corning has, by combining the conditions found in the cadaver with those found in the living individual, obtained the following outlines (Figs. 3785 to 3788) which represent the position of the normal lungs when percussed during gentle respiration.

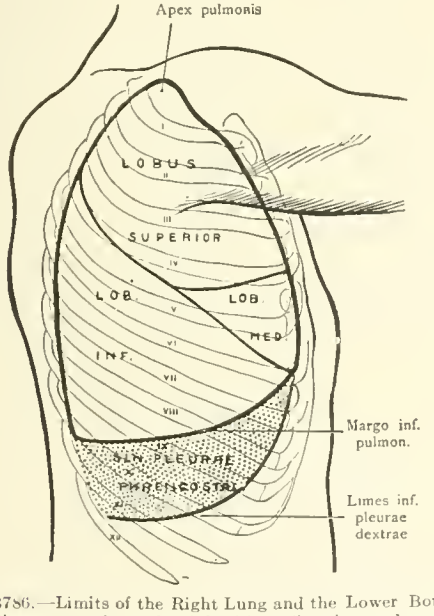

Fig. 3786.—Limits of the Right Lung and the Lower Boundary of the Pleura; seen from the right side. Sin. pleuræ phrenicostal., sinus phrenicocostalis. (Corning.)

The incisura interlobaris dextra begins from six to eight centimeters below the apex pulmonis just above and behind the hilus pulmonis between the processus spinosi of the second and third vertebræ thoracales; it then runs a short distance upward and backward, then swings around over the convex facies costalis forward and downward following the curve of the fourth costa. At the linea axillaris it descends to the level of the fourth spatia intercostalia but at the linea mammillaris it has again ascended to the level of the fourth costa which it now follows to the junction of its cartilago costalis with the corpus sterni; it then cuts through the margo anterior and, passing obliquely upward and backward along the facies mediastinalis, ends in front of the hilus pulmonis nearly opposite to the point from which it began.

As the incisura interlobaris dextra reaches its lowest level at the fourth spatia intercostalia it gives off a secondary incisura which passes obliquely downward, forward and mesially, crossing the fifth costa in the linea mammillaris, and at the outer third of the sixth cartilago costalis cuts through the margo inferior; it then passes obliquely upward and backward along the facies diaphragmatica and facies mediastinalis to end at the hilus pulmonis just below and behind the primary incisura.

The incisura interlobaris sinistra follows the same course as the incisura interlobaris dextra as far as the linea axillaris. From this point it passes obliquely downward and forward and cuts through the margo inferior at the outer third of the sixth cartilage costalis somewhat nearer its junction with the sixth costa than on the right side, about thirty millimeters from the margo anterior, and then passes obliquely upward and backward across the impressio cardiaca to end at the hilus pulmonis.

The margo anterior of each lung corresponds to the anterior boundary of the pleural cavity in which it is situated, and has practically the same relation to the exterior of the thorax as far as the junction of the fourth cartilago costalis with the corpus sterni. From the apex pulmonis each margo anterior passes obliquely toward the linea sternalis as far as the junction of the manubrium and corpus sterni which is at the level of the second cartilago costalis. From this point they run parallel to each other to the union of the fourth cartilago costalis with the corpus sterni where they diverge.

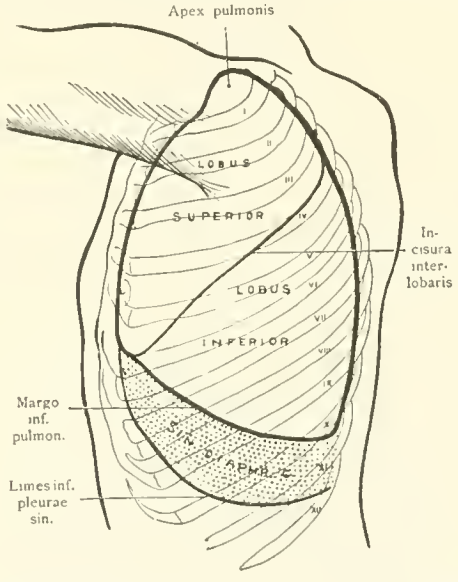

Fig. 3787.—Limits of the Left Lung and the Lower Boundary of the Pleura; seen from the left side. Sin. diaphr. c., sinus phrenicocostalis. (Corning.)

Between the sternal end of the fourth cartilago costalis and the fifth spatia intercostalia the margo anterior sinister presents a deep notch, the incisura cardiaca, which extends as far as the linea parasternalis. At the level of the sixth cartilago costalis the incisura cardiaca passes over into the margo inferior.

The margo anterior dextra extends perpendicularly from the second cartilago costalis to the sixth cartilago costalis where it passes, as on the left side, into the margo inferior. Occasionally a small notch is present which corresponds to the incisura cardiaca of the left side.

The margo inferior of each lung passes with an easy curve from the sixth cartilago costalis, lateral and backward to the articulation of the eleventh costa with the eleventh vertebra thoracalis.

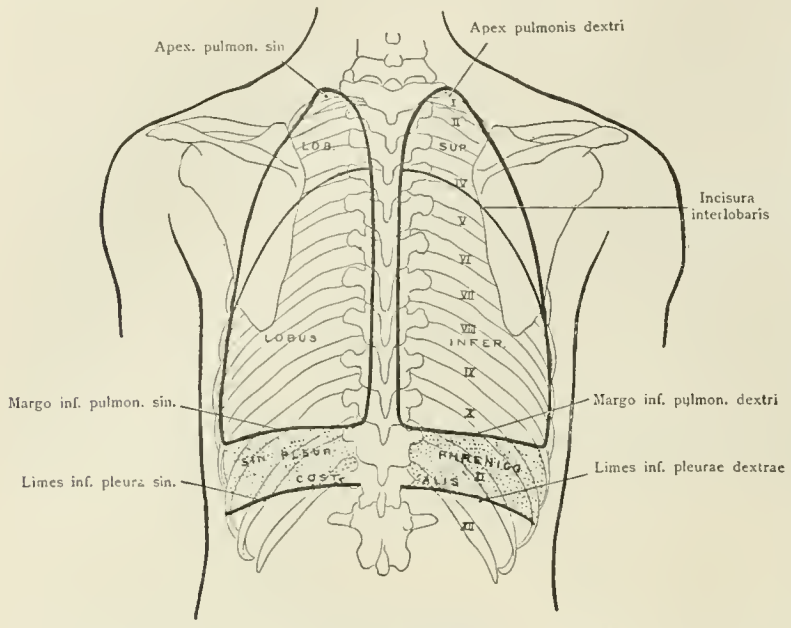

Fig. 3788.—Limits of the Lungs and Lower Boundary of the Pleura; seen from behind. (Corning.)

It will be noted (Fig. 3785 $x_1 x_2$, and Fig. 3789) that there are two places where no lung tissue is situated beneath the sternum; also that if the lung be percussed from in front alone, a pneumonia, for example, involving the lobus inferior of either side may be overlooked.

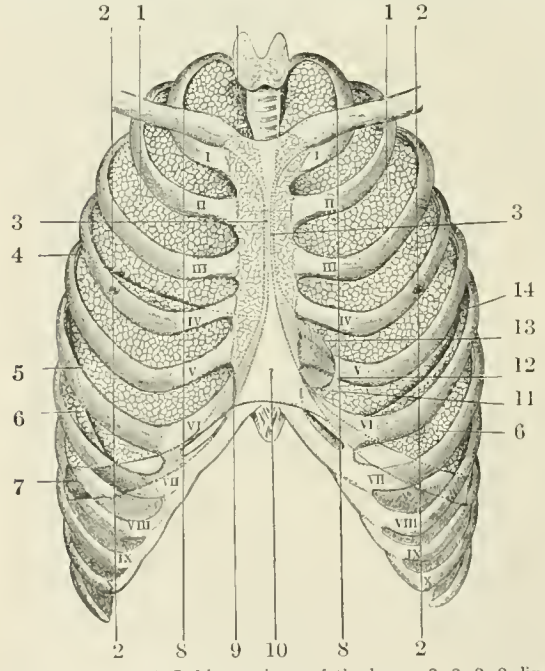

Fig. 3789.—1, 1, Lobi superiores of the lungs; 2, 2, 2, 2, linea mammillaris; 3, 3, sinus mediastino-costalis; 4, incisura interlobaris dextra; 5, lobus medius; 6, 6, lobi inferiores; 7, sinus phrenicocostalis; 8, 8, linea parasternalis; 9, linea sternalis; 10, area in which the pericardium is in direct contact with the sternum; 11, lobus lingualis; 12, sinus pericardiocostalis; 13, incisura cardiaca; 14, incisura interlobaris sinistra. (Joessel.)

It is not my intention in this article to take up the topographical relations of the pleura, but attention should be called at this point to the fact that the pleura extends considerably lower than the corresponding lung (Figs. 3789 to 3791) and that even in forced inspiration the lungs do not completely fill the cavum pleuræ. This reserved space is called the sinus phrenicocostalis. According to Luschka the height of the sinus in quiet respiration is, on the right side, in the linea sternalis, two centimeters; in the linea parasternalis, two centimeters; in the linea mammillaris, two centimeters; in the linea axillaris, six centimeters and at the side of the columna vertebralis, two and a half centimeters. On the left side from the linea parasternalis the sinus has the same height as on the right side of the body.

Variations in Position due to Age.—Mehnert has studied the change in position of the lungs due to advancing age. He found that the basis pulmonis in the new-born child corresponded to the upper border of the fifth costa; at thirty-six years it corresponded to the sixth spatia intercostalia and at seventy-two years it cor-

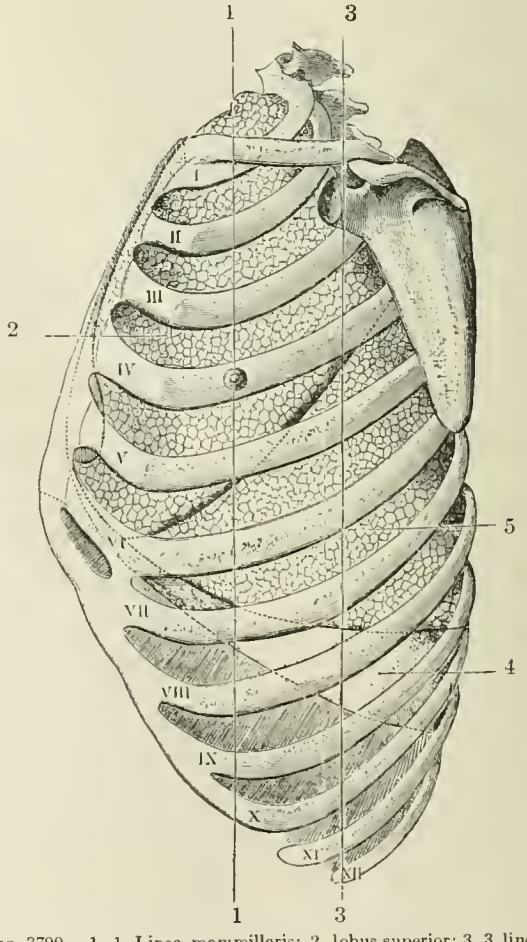

Fig. 3790.—1, 1, Linea mammillaris; 2, lobus superior; 3, 3, linea axillaris; 4, sinus phrenicocostalis; 5, lobus inferior. (Joessel.)

responded to the seventh spatia intercostalia thus showing a progressive sinking downward of the lung.

The factors leading to these changes he sums up as follows:

1. In childhood and youth: the elasticity, extensibility and growth of the musculo-connective-tissue suspensory apparatus by which the trachea and indirectly the lungs are connected with the base of the skull.

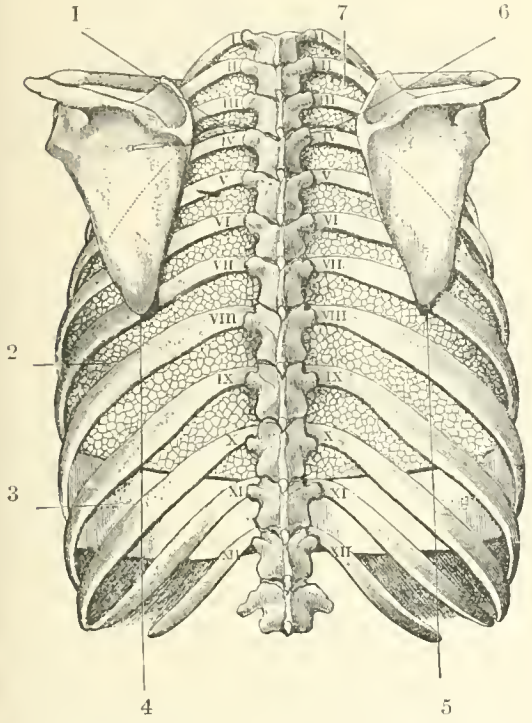

Fig. 3791.—Relation of the Lung to the Posterior Thoracic Wall. 1, Incisura interlobaris sinistra; 2, lobus inferior; 3, sinus phrenicocostalis; 4, 5, linea scapularis; 6, incisura interlobaris dextra; 7, lobus superior. (Joessel.)

2. After growth of the individual has ceased: relaxation of the musculo-connective-tissue suspensory apparatus.

Other factors favoring the descent of the lung are:

3. Forward inclination of the base of the skull due to loss of erect carriage and advancing age.

4. Shortening of the columna vertebralis due to senile bending forward and absorption of the fibrocartilagines intervetebrales.

5. Sinking down of the arch of the diaphragma in consequence of the senile inclination of the costæ.

Variations.—Scattered through the literature of the lung are descriptions of lungs with accessory lobes, lungs with less than the normal number of lobes, absence of the lung on one side and total absence of both lungs. Where one lung is absent the individual may live the normal number of years; absence of both lungs, naurally, causes death of the fetus.

The lobus inferior on either side is frequently subdivided, the extra lobe being known as the lobus inferior accessorius; this may comprise one-fourth of the basis pulmonis. The vena azygos may be displaced outward and give rise to a deep fissure in the upper part of the right lung which marks off an extra lobe. The lobus medius of the right lung frequently appears more or less fused with the lobus inferior, due to imperfect development of the secondary fissure.

Histology.

The bronchi, in their finer structure, have the same histological structure as the trachea up to their entrance into the lung. With the division of the bronchi within the lung we find changes in their structure. The cartilage which has been in the form of incomplete rings is now found in the form of angular plates, which are placed at longer and longer intervals, until at last it is found only as a small plate at the fork of the smaller branches. Bronchi which have a diameter of one millimeter and under rarely have cartilaginous plates. At the same time that the cartilage begins to disappear, the smooth muscle which has been in the form of rings gradually spreads out into a uniform layer, which

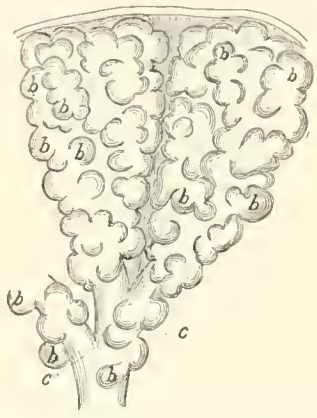

Fig. 3792.—Two Small Pulmonary Lobules, with the air-cells, *b*, *b*, and the finest bronchial twigs, *c*, *c*, which also possess air-cells. From a new-born child. Half schematic. (From Kölliker.)

diminishes in thickness with the diminution in the caliber of the bronchus. Distal to the ductulus alveolaris smooth muscle is not found. In the larger bronchi the mucosa is arranged in longitudinal folds and consists of at least two layers, the innermost of which is made up of ciliated epithelium and goblet cells. In the smaller bronchi the ciliated epithelium is replaced by a single layer of non-ciliated columnar epithelium; in the ductuli alveolares the epithelium gradually becomes cubical and finally passes over into the thin, flat "respiratory epithelium."

The elastic fibers of the bronchi are arranged in a single layer in which the fibers run parallel. Where this layer is pierced by the ducts of the glands the fibers take a crossed arrangement, which gives additional strength to the otherwise weakened layer.

The Lobule.—The term lobule is used at the present time to describe two different areas in the lung. Following the majority of investigators, and because the author of this article believes it to be the correct usage of the term, the lobule of the lung may be defined as being composed of a ductulus alveolaris, the air spaces connected with it, and their blood-vessels, lymphatics, and nerves. This must be considered the unit of the lung.

Laguesse and d'Hardiviller call those large areas, faintly marked out on the surface of the human lung, distinctly marked out on the lung of the ox, the lobules, and give the name acinus to the structures connected with a ductulus alveolaris (terminal bronchus). Councilman thinks the unit should be called an acinus.

The author cannot agree with these statements. The acinus of a gland does not correspond to the lobule as here described; it might have been applied with some degree of justice to the conception of the lobule as described by Kölliker. If any part of the lobule of the lung is to be compared to an acinus it is an atrium with its air-sacs; but until "acinus" is used to

describe a more definite portion of a gland than its present usage does, no intelligent comparison can be made.

Air Spaces.—If we follow the main bronchus or one of its branches toward its distal extremity, we finally reach a point where the smooth tubular character of the bronchus disappears and we find small pro-

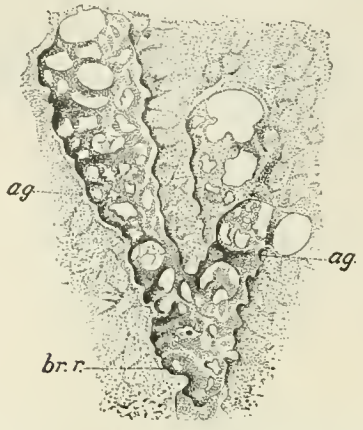

Fig. 3793.—Lung of a Dog. *br.r.*, Bronchiolus respiratorius; *ag*, two alveolar passages, one of which is continued into an infundibulum. (From Kölliker.) This practically represents Fig. 3792 in section.

jections appearing on all portions of the bronchus. These projections (alveoli) were first described by Rossignol and shortly afterward confirmed by Kölliker. Alveoli are also present on the succeeding and final division of the bronchus (Fig. 3803).

Up to this point there is a general agreement of investigators, but they disagree in regard to the structure distal to the ductulus alveolaris. That this

Fig. 3794.—Ultimate Bronchial Tube with its Air-Sacs (cat). *a*, Ultimate bronchial tube; *b*, its dilated end the *point de reunion* of all the air-sacs; *c*, *c*, *c*, air-sacs; *d*, *d*, alveoli; *e*, *e*, openings leading to other air-sacs; *f*, part of the wall of two air-sacs which are cut off. (After Waters.)

should be the case is not surprising, in view of the difficulties which attend the study of this part of the lung.

The most familiar description and diagram of the ending of the bronchi in the parenchyma of the lung is that of Kölliker. In his earlier work he rejects the very misleading term "infundibulum," introduced by Rossignol, but in his later publication he returns to its use.

He figures (Fig. 3792) the final division of the bronchus as ending in a single elongated cavity into which a variable number of alveoli open; these alveoli appear as elevations on the central cavity (infundibulum).

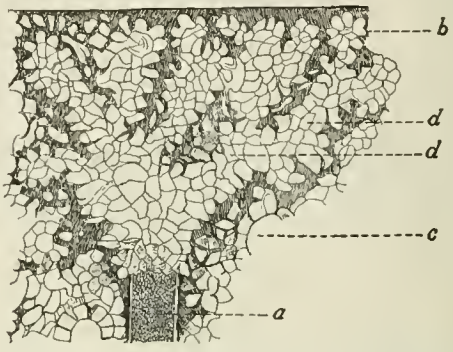

Fig. 3795.—Section of a Cat's Lung Filled and Hardened with Alcohol. *a*, Bronchiolus; *b*, infundibulum; *c*, transverse section of an alveolar passage; *d*, *d*, longitudinal section of an alveolar passage. (After Schulze.)

The "alveolar passage" of his later publication has also numerous alveoli opening into it (Fig. 3793).

It is important to note one significant point in Kölliker's description of this alveolar passage, and that is the presence of smooth muscle. He says that it is easy to recognize smooth muscle in the walls of the alveolar passages; that it generally has a circular

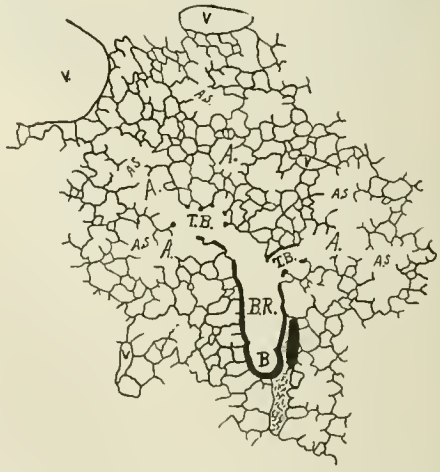

Fig. 3796.—Camera Lucida Tracing of a Section of a Cat's Lung *B*, Bronchiolus; *B.R.*, bronchiolus respiratorius; *T.B.*, *T.B.*, ductuli alveolares (terminal bronchi); *A*,*A*, atria; *A.S.*, *A.S.*, sacculi alveolares (air-sacs); the remaining spaces are sections of sacculi and alveoli; *V*,*V*, venæ pulmonales. Observe the relation which they bear to the lobule. The large vein at the left upper corner of the illustration is not completely outlined. The arteria pulmonalis is shown in solid black, cut obliquely, in the connective tissue beside the bronchiolus respiratorius. One of the atria is not directly connected with its ductulus alveolaris in this section, but in another section of the series the connection is shown. The heavy lines indicate the position of smooth muscle. (After Miller.)

arrangement around the alveolar passage, and that it forms a ring-like sphincter about the opening into each infundibulum. Kölliker found no smooth muscle in the walls of the alveoli or in those of the infundibulum.

The work of Waters is not so well known to American readers as it deserves to be. He introduced the

term "air-sac" in the place of the misnomer "infundibulum," and showed that a group of air-sacs communicate with each "ultimate bronchial tube" (Fig. 3794). Each air-sac communicates with the ultimate bronchial tube by means of a circular orifice. More than one air-sac may terminate at one of these openings. The group of air-sacs which communicate with a given ultimate bronchial tube form a "lobulette." Some of the air-sacs bifurcate as they pass toward the periphery of the lobulette. Alveoli were present on air-sacs and ultimate bronchial tubes. Smooth muscle was present in the bronchial tubes but wholly absent in air-sacs and alveoli.

Fig. 3797.—Camera Lucida Tracing of a Section of a Dog's Lung. The plane of the section lies through the distal part of a ductulus alveolaris (*T*). Three atria (*A*) are shown and a number of sacculi alveolares (*S*). The arteria pulmonalis and two of its branches are shown in solid black; the venæ pulmonales are shown checked. Note the small venous twig close to *T*; it is one of the small veins which corresponds to 2 in Fig. 3803. The broken lines indicate smooth muscle in longitudinal section; it is also seen in transverse section about the openings from the ductulus alveolaris into the atria. Two other atria not shown in this section belong to the lobule. (After Miller.)

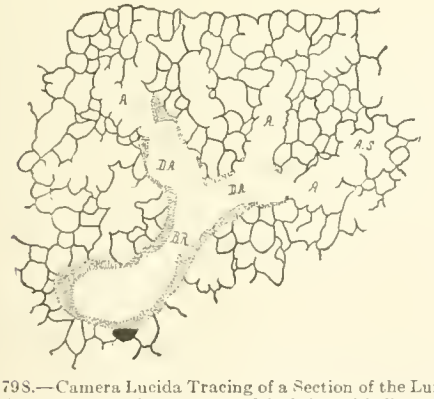

Fig. 3798.—Camera Lucida Tracing of a Section of the Lung of a Calf. The stippling indicates the nuclei of the epithelium and the position of smooth muscle. The section was a thick one and the plane was such that two ductuli alveolares (*DA*), connected on the one hand with the bronchiolus respiratorius (*BR*), on the other with the atria (*A*), were cut longitudinally; *A.S*., sacculus alveolaris. The arteria pulmonalis is shown in solid black. (Miller.)

The diagram of Schulze resembles that of Waters, but his subdivision of the air passages is different. Schulze introduced the term "Alveolargang" for those air passages which are covered with alveoli and lead to the air-sacs (infundibula). The alveolar passage of Schulze is not the last division of the bronchus, but is the name given by him to all those air passages which have alveoli (Fig. 3795). The alveolar passage of Schulze is, therefore, not identical with that of Kölliker, for it includes more than one division of the bronchial tree.

As the result of his investigations Miller found that the last branch of the bronchus, which he calls the "terminal bronchus," before breaking up into the parenchyma of the lung becomes somewhat dilated at its distal extremity. Connected with this expansion of the terminal bronchus (Fig. 3803) there are from three to six nearly spherical cavities, the atria. Each atrium communicates, on the one hand, by means of a nearly circular opening, with the terminal bronchus; on the other hand, by similar-shaped openings, with a variable number of larger and more irregular-shaped cavities (air-sacs), which have small projections from their surface (alveoli, air-cells).

From this description it will be seen that the air-sacs do not communicate directly with the terminal bronchus, as is usually described, but between each air-sac and terminal bronchus there is interposed a cavity, which is constant in all parts of the lung, viz., the atrium (Figs. 3796 to 3799).

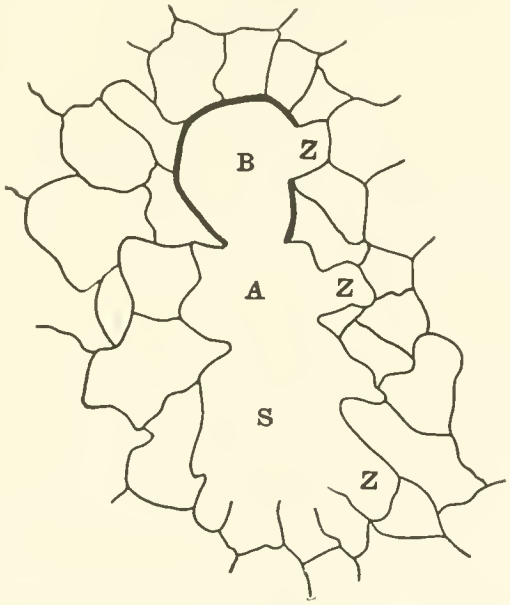

Fig. 3799.—Camera Lucida Tracing of a Section of the Lung of a Man Forty-three Years Old. *B*, Ductulus alveolaris; *A*, atrium; *S*, sacculus alveolaris; *Z*, *Z*, *Z*, alveoli. The plane of this section cuts the ductulus alveolaris transversely near its center; smooth muscle is not present except in its walls. (Miller.)

The presence of the atrium has been confirmed by Justesen in the lung of the ox; by Flint in the lung of the pig; by Councilman, who found it to be "the starting-point of most of the focal pneumonias of children." Later reconstructions by Miller have shown its presence in the lung of the cat, dog, calf, child, and man.

The atrium must not be confused with the alveolar passage of Kölliker or of Schulze. In each instance the alveolar passage contains smooth muscle, while it is absent from the walls of the atrium. The atrium is smaller than the air-sacs and, like the terminal bronchus and the air-sacs, has numerous air-cells projecting from its surface. In structure the walls of the atrium resemble that of the air-sacs.

The structure of the terminal bronchus agrees with that of the alveolar passage of Kölliker and the distal portion of that of Schulze. It is tube-like and has a large number of air-cells opening into it. It possesses

a very distinct layer of smooth muscle which forms a ring about the openings which lead into the atria, in the same manner as Kölliker described it to be present about the openings of his infundibula.

The epithelium of the terminal bronchus shows a transition from a low cubical type, in its proximal portion, to simple squmaous epithelium (respiratory epithelium) in its distal portion. As Kölliker pointed out, this transition is often quite irregular. Ciliated epithelium, goblet cells, and glands are absent in the terminal bronchi.

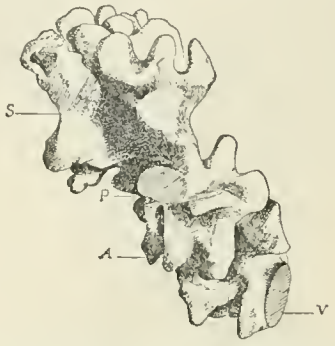

FIG. 3800.—Reconstruction in Wax of an Atrium (*A*) with a Single Sacculus Alveolaris (*S*) Attached. The surface *P* shows where the atrium was cut off from its ductulus alveolaris, and *V* shows where a second sacculus was cut off. The small projections from the atrium and sacculus are the alveoli. Five sacculi were connected with this atrium. (Miller.)

The form of the air-sacs is difficult to comprehend from the study of single sections because of their great irregularity both in size and in form. In the figures of Kölliker, Waters, and Schulze the air-sacs (infundibula) are shown as having an elongated form. Luschka states that the air-sacs just beneath the pleura are more rounded than those situated deeper in the lung. Miller did not find this to be true. Fig. 3800 presents a reconstruction of the air-sac anda trium shown in section in Fig. 3897; the other air-sacs have been cut off from the atrium. Fig. 3801 shows a reconstruction of an air-sac which presents a deep incision, a feature that is quite frequent, as Waters pointed out.

It is very difficult to harmonize the descriptions of the various parts of the lung because no sharp boundary lines have been established. The different schemes of the lung and the nomenclature are also confusing.

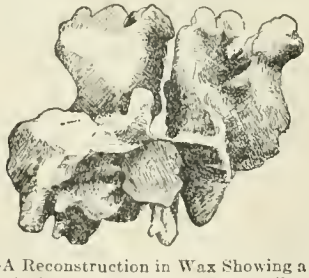

FIG. 3801.—A Reconstruction in Wax Showing a Single Sacculus cut off from its Atrium. The cut surface is easily made out in the figure. This sacculus has a deep septum extending a considerable distance into it, nearly dividing it into two separate parts. This sacculus presents a strong contrast to that shown in Fig. 3800. (Miller.)

Miller has for the first time given a definite basis for comparison by bringing together in the following table the nomenclature used by the principal authors and that of the "Nomenclatur-Commission an die Anatomische Gesellschaft" (B N A).

Miller.	B N A.	Schäfer.	Schulze.	Kölliker.
Bronchus III.	Bronchiolus respiratorius.	Bronchial tube.	Alveolar-gang.	Alveolar-gang.
Terminal bronchus.	Ductulus alveolaris.	Lobular bronchus.		
Atrium.....	.....	Air-sac...	Infundibulum.	Infundibulum.
Air-sac.....				
Air-cell.....	Alveolus pulmonis.	Air-cell.....	Alveole...	Alveole.

Recognizing that the B N A is a decided advance in anatomical nomenclature Miller recommends the discarding of all previous nomenclature, the retention of all names given under the heading "Pulmo" (B N A, p. 59) down to "Ductuli alveolares," and the insertion, then, of

"Atria"
"Sacculi alveolares."

The nomenclature would thus be made uniform and the objectionable term "infundibulum" would be discarded.

The finer divisiou of the lung would then be:

B N A.	English.
Bronchioli.	
Bronchioli respiratorii.	
Ductuli alveolares.	Alveolar ductules.
Atria.	Atria.
Sacculi alveolares.	Air-sacs.
Alveoli pulmonum.	Pulmonary alveoli.

The work of Hansemann has added fresh interest to the question of open communications between the air-sacs. Kohn called attention to the fact that in pneumonia fibers of fibrin could be traced from one alveolus into another through small openings in the walls of the alveoli. He did not consider these openings to be normal, but the result of the pathological process. The investigations of Ribbert, Hauser, Herhig, Bezzola, Aigner, von Ebner, and Miller support him in this position. Ou the other hand, Hansemann, Zimmermann, Merkel, Schulze, and Marchand maintain that these openings are normal structures.

That these openings exist was known long before the announcement of Kohn. In the first edition of this HANDBOOK (vol. ix., p. 572) Miller called attention to the statement of Henle as follows: "He (Henle) describes communications between air-cells, but considers them anomalies. He found them in the lungs of old people and attributed them to the results of atrophy and absorption of the lung tissue." The observation of Henle is correct. It is in the lungs of old individuals and animals that these so-called "pores" are best seen. In young individuals and animals they are not common. At birth, and until some unusual strain is put upon the lung, no pores are present.

The method used by Hansemann to demonstrate these pores is very faulty, as Aigner has pointed out. Moreover, but little importance should be placed on Hansemann's illustrations, because they merely show that a solution of gelatin containing a large quantity of water will easily filter through the walls of the alveoli under a low pressure.

In the discussion as to the presence or absence of pores in the alveolar walls history is repeating itself. In the earlier discussion it was "stomata," while in the present instance it is "pores." The same factors which are capable of producing the well-known artifacts, stomata, can produce these openings; namely, anything causing separation of the epithelial cells or rupture of the delicate framework of the septa, as overdistention, inflammation, desquamation of the epithelium, atrophy, and old age. Walter has shown in his recent investigations that stomata are, as al-

ready stated, artifacts. Flint has studied alveolar pores from the embryological side and states emphatically that they are not normal structures.

The study of these so-called "pores" leads naturally to the consideration of the structure of the walls of the air-sacs. These are thin and contain the capillary network of blood-vessels, elastic fibers, and reticulum, covered over by a layer of epithelium.

That the air spaces are lined with a layer of epithelium every histologist now acknowledges, although the time is not so very distant when the presence of an epithelium was strenuously denied. At present the question is not in regard to the presence or absence of a pulmonary epithelium, but as to what are the shape, size, and arrangement of the epithelium; what is its

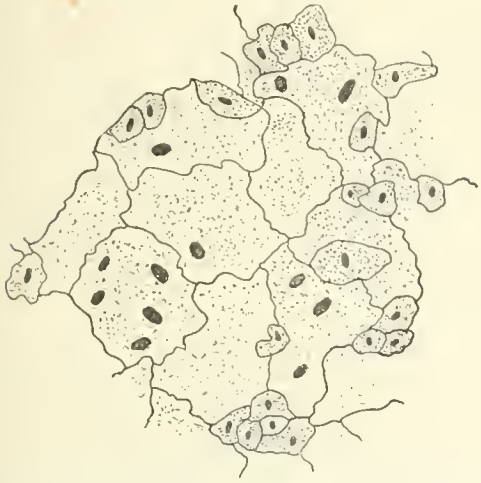

Fig. 3802.—Epithelium from an Alveolus of a Young Cat. The small granular cells and the large plates are shown. The scattered nuclei and the large plates are due to imperfect methods of staining. (Miller.)

relation to the structures it covers; is it not, after all, a continuous epithelium? It will be impossible to answer these questions in the present article.

Elenz says that in all mammals investigated by him the epithelium of the lung consisted of small cells in the form of "cell islands and large, membrane-like irregular plates." Kölliker also describes the epithelium as consisting "of two types—a small, nucleated, flat, polygonal, protoplasmic cell from 7 to 15 μ in diameter, which is situated in the mesh of the capillaries, and large, irregular-shaped, generally nucleated, quite thin plates from 22 to 45 μ in diameter, which lie over the blood-vessels, but can also extend into their mesh."

Elenz attached much importance to the clusters of small cells which he called "islands," and he described them as small, round, nucleated cells having a granular appearance; from one to fourteen cells were found in each island.

This holds true for very young animals, but in old animals, they usually occur as single cells. In young kittens, for example, from six to twelve cells form a group, while in older animals the number is less (Fig. 3802). By actual count of a large number of equal areas in the lung of kittens and that of old cats the ratio was found to be five to three, showing a lessening of nearly one-half in the old cats.

In kittens the groups of small cells were quite uniformly distributed throughout the alveoli, while in old cats they were absent from the bottom of the alveoli, being found for the most part along the edges where the alveoli open into the sacculi alveolares.

In studying the epithelium of the sacculi alveolares in connection with the question whether "pores" are normal structures, it was found by Miller that in young kittens, for some length of time after birth, no openings (pores) could be found; when they were found in young cats they gave every appearance of having been caused by violence to the animal or by overdistention of the lung. In old cats they were more numerous, and were probably due to the concomitant changes of old age. The opinion already expressed is reiterated here, namely: "pores" are not to be considered normal structures.

The description of the epithelium given above is very superficial, and is by no means to be taken as the final solution of the problem.

Arteria Pulmonalis.—The arteria pulmonalis in its ramifications within the lung follows the subdivisions of the bronchi. At first the artery and bronchus have nearly the same diameter, but the artery diminishes much more rapidly in size than the bronchus, so that by the time it reaches the lobule it is about one-fourth or one-fifth the size of the ductulus alveolaris. It is usually stated that the artery, as it approaches its ultimate ending, divides much more frequently than the bronchus. This would hold true for the old conception of the lung.

It has already been pointed out how the ductulus alveolaris gives rise to the atria, the atria to the sacculi alveolares and that these collectively form the lobule. When the artery reaches a point distal to the ductulus alveolaris it breaks up into as many branches as there are atria (Fig. 3803). Sometimes we find a special branch given off from the artery just before it enters

Fig. 3803.—Schematic Section of a Lobule of the Lung showing the Relation of the Blood-vessels to the Air Spaces. *b. r.*, Bronchiolus respiratorius; *d.al.*, ductulus alveolaris (the letters *al.* are in the widened distal end); a second ductulus alveolaris is shown cut off; *a, a, a*, atria; *s.al., s.al.*, sacculi alveolares; *a.p., a.p.*, alveoli pulmonis; *art.*, arteria pulmonalis with its branches to the atria and sacculi; *v*, vena pulmonalis with its branches from the pleura (1), the ductulus alveolaris (2), and the place where the bronchiolus respiratorius divides into the two ductuli alveolares (3). (After Miller.)

the lobule which supplies the more dependent of the air-sacs (Fig. 3804). Each of the atrial arteries, after giving off twigs to the walls of its atrium, breaks up into small branches which run in the sulci between the alveoli pulmonum, are distributed to the central* side of the sacculus alveolaris, and end in a capillary network from which most of the venæ pulmonales take their origin (Fig. 3803).

It is quite rare to find the arteria pulmonalis appearing on the periphery of a lobule or on the surface of

*I use "central" to designate that part of the air-sac which is nearest to the center of the lobule, "peripheral" for that which is most distal.

the pleura. Anastomoses between branches of the arteria pulmonalis occur very exceptionally.

Capillaries.—The capillaries into which the arteria pulmonalis breaks up form within the lung a very close network, the mesh of which, as Schulze has pointed out, is exceedingly small, often less than the diameter of the capillaries that bound it.

From this capillary network venous radicles are formed which are situated on the opposite side of the sacculus alveolaris from the artery. From the last point where the arterial radicles can be recognized to

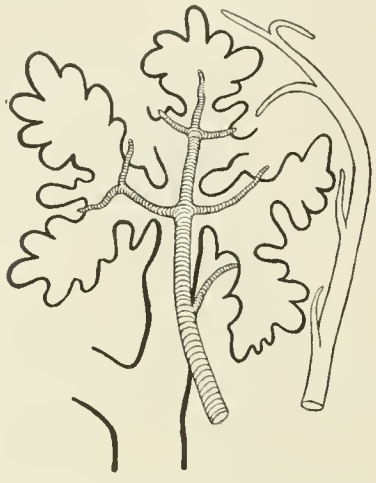

Fig. 3804.—Scheme of the Lobule of the Lung cut at Right Angles to Fig. 3803. The artery is shaded; the vein on the periphery is in outline. The first scheme of the lung constructed by Miller. It shows the same arrangement of air spaces as in Fig. 3803, and also a small branch of the pulmonary artery that is frequently given off just as the artery enters the lobule. (After Miller.)

the first point where the venous radicles can be distinguished there are usually from twenty to twenty-five capillary loops.

This network of capillaries is situated within the walls of the sacculi alveolares and, as already stated, forms a part of them. As Rainey pointed out, only a single network is found in any given wall; the network is, therefore, common to two or more adjacent sacculi alveolares.

Just beneath the pleura the mesh of the capillary network is much wider than that within the lung, the proportion being nearly four to one.

Venæ Pulmonales.—The veins are, with an exception to be noted later, always situated on the periphery of the lobule, while the arteries are within the lobule (Figs. 3803 and 3797).

The vena pulmonales can be traced to three separate sources.

(*a*) The capillary network into which the arteria pulmonalis breaks up.

(*b*) The capillary network of the pleura.

(*c*) The capillary network in the walls of the bronchi.

Veins Arising from the Capillary Network of the Arteria Pulmonalis.—The radicles of these veins arise from the capillary network just described and are situated on the peripheral side of the sacculi alveolares. They do not run between the alveoli pulmonum as the arterial radicles do, but over the air-cells. The greater part of the venæ pulmonales have their origin from this network, and the trunks thus formed are found on the periphery of the lobule (Figs. 3797 and 3803).

Veins Arising from the Capillary Network of the Pleura.—Exceptionally, the arteria pulmonalis reaches the pleura; when this occurs it at once breaks up into capillaries which take part in the formation of the network to be described; usually, the arteria pulmonalis breaks up into capillaries before it reaches the pleura. These capillaries unite to form a wide-meshed network on the pleural side of the sacculi alveolares and give rise to venous radicles. As a rule two, three, sometimes four, of these radicles unite to form a small vein just beneath the pleura, which at once passes along the periphery of a lobule to the deeper part of the lung, receiving on its way small veins which come from the sacculi alveolares (Fig. 3803, 1). Anastomoses between the capillaries of the pleura are very numerous; consequently blood brought to the pleura by any given artery may be returned by several different veins.

This pleural network of capillaries has been described as being derived from the bronchial artery by Küttner, Zuckerkandl, and others. This is true of the pleura of man and of animals with a thick pleura as the horse, the ox, and the whale; but in animals with a thin pleura as the dog, the cat, and the rabbit, the pleural network of capillaries is derived from the arteria pulmonalis.

Along the margins of the lung the radicles of the venæ pulmonales are very distinct and superficial, and are often mistaken for other vessels.

Arteria Bronchialis.—The discovery of this artery is usually ascribed to Ruysch. According to Hyrtl, Galen knew of its existence but had no name for it and, as Columbo denied its existence, it was forgotten until it was again described by Marchettis.

Following the announcement by Ruysch of the presence of arteriæ bronchiales the existence of these

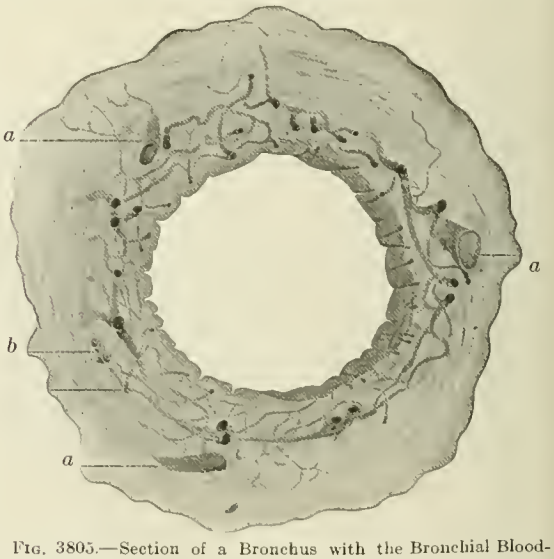

Fig. 3805.—Section of a Bronchus with the Bronchial Blood-vessels injected. *a*, *a*, *a*, three principle branches of the arteria bronchialis; *b*, *b*, branches of the arteria bronchialis passing to the surrounding connective tissue. × 50. (Miller.)

arteries was the main question discussed. This having been settled in the affirmative, attention was next directed toward their distribution within the lung, the relation of the bronchial blood-vessels to the pulmonary blood-vessels and the presence of venæ bronchiales.

Up to the time of Guillot there was a general agreement that the arteria bronchialis formed an anastomosis with the arteria pulmonalis. Guillot found as the result of his studies that the two arterial systems were independent, and that injections made into the arteria bronchialis returned by the venæ pulmonales. This radical change of opinion at first met with strong opposition, but later investigations have supported his statement.

The origin, number, and gross distribution of the arteriæ bronchiales has already been considered; their distribution within the lung and relation to the pulmonary circulation will now claim our attention.

As soon as the arteria bronchialis has entered the hilus pulmonis it penetrates into the outer fibrous coat of the bronchus where it divides into two, sometimes three, main branches (Fig. 3805). As the bronchus divides corresponding division of the artery takes place. Smaller branches are given off from the main trunks while it is in the fibrous coat and these unite to form an irregular plexus which is in general arranged at right angles to the circular layer of smooth muscle (Fig. 3806, 4). From these smaller branches arterioles are given off which pass to the tunica mucosa where they form a very rich network of capillaries. In some instances arterioles pass directly from the main trunks to the tunica mucosa. Beside the branches which pass to the tunica mucosa other branches are given off which are distributed to the connective tissue septa, glands and, in animals with a thick pleura, to the pleura. The vasa vasorum of the pulmonary blood-vessels are also derived from the arteria bronchialis.

The arterioles which give origin to the capillary network in the tunica mucosa (Fig. 3806, 5) pass from the larger vessels situated in the fibrous layer obliquely through the muscular layer, and having reached a position just beneath the epithelial layer, turn and

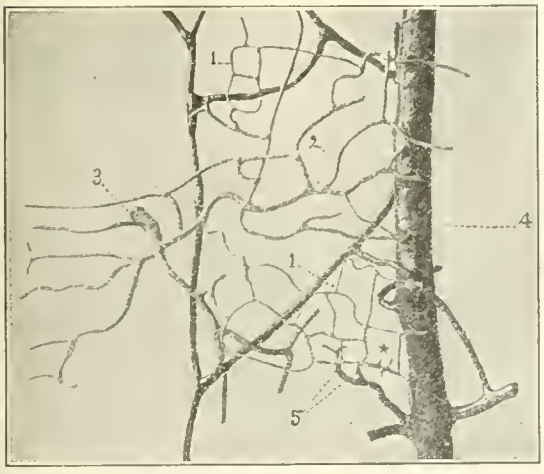

Fig. 3806.—Reconstruction Model of the Bronchial Blood-vessels. Two only of the arterial radicles passing to the mucosa are shown. 1, Superficial venous plexus in the mucosa; 2, deeper venous plexus along the boundary line between fibrous and muscular layers; 3, venous radicle leaving the fibrous layer to become one of the radicles of origin of a pulmonary vein; 4, one of the main bronchial arteries giving rise to smaller branches which form a plexus in the fibrous layer; 5, arterial radicles passing to the mucosa; *, one of the units of distribution; only the beginning of few of the capillaries is indicated: this unit is shown complete and more highly magnified in Fig. 3807. (Miller.)

run for a short distance parallel to the muscular layer giving off a number of capillaries which run parallel to each other and to the long axis of the bronchus (Fig. 3806* and Fig. 3807). At intervals these capillaries join small venous radicles and there is thus formed a plexus the mesh of which is irregularly rectangular in shape the long axis of which corresponds to the long axis of the bronchus (Fig. 3806, 1). From this superficial plexus branches pass through the muscular layer and form a second plexus (Fig. 3806, 2) which is situated along the boundary line between the fibrous and muscular layers. From this second plexus venous radicles arise (Fig. 3806, 3) which, in the deeper portion of the lung, form one of the sources of origin of the vena pulmonalis. These radicles leave the smaller bronchi and the bronchioli respiratorii at the place where they divide (Fig. 3806, 3), but along the course of the larger bronchi they may leave at other points. The venous radicles which arise from the first two or three divisions of the bronchi do not join the vena pulmonalis but form true venæ bronchiales which empty into the vena azygos, the vena hemiazygos or one of the venæ intercostales.

When the arteria bronchialis has reached the bronchioli respiratorii it can no longer be recognized as an independent artery for it is now reduced to a single network of capillaries which can be traced as far as the distal end of the ductuli alveolares. The blood

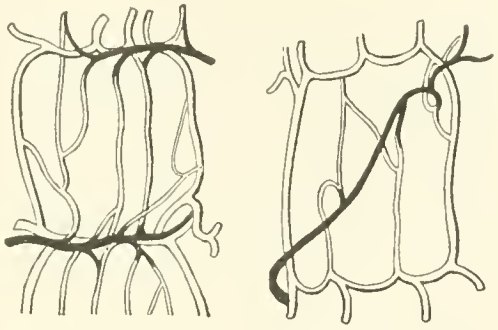

Fig. 3807.—*A*, The Unit of Distribution Indicated by the * in Fig. 3806; *B*, a variation of the unit shown in *A*, occasionally met with. (Miller.)

in this network of capillaries is carried away from these terminal divisions of the bronchial tree by two small veins which arise one on either side of the bronchioli respiratorii and by analogous veins which arise from the distal end of the ductuli alveolares (Fig. 3803, 2, 3). These latter are the only veins found within the lobule.

In studying the question of anastomoses between the arteria pulmonalis and the arteria bronchialis, Miller made use of the lungs of the dog and of man. Five sets of injections were made in each case and the results are summed up as follows:

1. Berlin blue in arteria pulmonalis, vena pulmonalis open. Result: bronchial blood-vessels uninjected.
2. Berlin blue in vena pulmonalis, arteria pulmonalis open. Result: slight injection of bronchial vessels.
3. Berlin blue in arteria pulmonalis, vena pulmonalis clamped. Result: imperfect injection of bronchial vessels.
4. Berlin blue in vena pulmonalis, arteria pulmonalis clamped. Result: complete injection of bronchial vessels.
5. Berlin blue in vena pulmonalis until it flowed freely from the arteria pulmonalis. The vena pulmonalis was then clamped and a ten per cent. solution of gelatin containing vermillion granules in suspension was forced into the arteria pulmonalis. Result: bronchial blood-vessels and venæ pulmonales blue; arteria pulmonalis red. No anastomoses between the arteria pulmonalis and the arteria bronchialis.

These experiments demonstrated conclusively that the bronchial blood-vessels were in direct connection with the venæ pulmonales and can only be partially injected from the arteria pulmonalis when the venæ pulmonales are clamped and then only by a backward flow of the injection through the venous radicles which arise from the bronchi.

Veins Arising from the Capillary Network in the Walls of the Bronchi.—The arteria bronchialis forms within the walls of the bronchi a network of blood-vessels, the mesh of which is elongated in the long

axis of the bronchi. Wherever a branch is given off from the main bronchus or from any of its subdivisions, some of these capillaries unite on opposite sides of the bronchus to form small radicles, and these in turn unite to form a small vein, which immediately receives other radicles coming from the adjoining sacculi alveolares. Two veins are thus formed, one on either side of the bronchus, which, running between the lobules, soon join one of the venous trunks (Fig. 3803, 3).

By the giving off of these venous radicles at each place where the bronchus divides, the bronchial network of capillaries becomes so diminished that when the ductuli alveolares (terminal bronchi) are reached

Fig. 3808.—Lymphatics in the Wall of a Bronchus 1.125 Millimeters in Diameter. The bronchus is cut open at the point where it divides into two smaller branches. In the upper left corner a still smaller branch is seen opening out of one of the primary branches. (Miller.)

it is reduced to a few capillaries, which at the distal end of each ductulus take part in the formation of two small veins in the same manner as those just described at the branching of the bronchi. The two small veins thus formed are the only ones found within the lobule; all others are on the periphery of the lobule. These also receive, on their way out, small branches from the adjoining sacculi alveolares and eventually join one of the veins on the periphery of the lobule (Fig. 3803, 2). The bronchial vessels do not extend beyond the ductuli alveolares.

Zuckerkandl has described blood-vessels arising from the bronchi, but their course is quite different from the above-described veins; and it is quite apparent he has mistaken the identity of some of the vessels which he describes.

In an article on "Lobar Pneumonia" Smith advances some peculiar views in regard to the pulmonary circulation. He describes two sets of capillaries as being present in the septa between the sacculi alveolares; one, the "functional capillaries," derived from the pulmonary artery; the other the, "nutritive vessels," derived from the bronchial artery.

That a very grave error is contained in the above statement every one who has made a study of the lung will recognize. It is difficult to understand how the error was made. A careful consideration of the preceding description of the blood-vessels will make the relation which they bear to the sacculi alveolares and to each other clear, and show the fallacy of his statement.

Lymphatics.—Olof Rudbeck first described the lymphatics of the lung in 1651–54. He saw them on the lung of a dog and thought that they opened into the cavity of the heart. Willis saw the superficial lymphatics of the lung of a calf and gave a very good illustration of them.

Mascagni and Cruikshank described two sets of lymphatics as being present in the lung—a superficial and a deep set, which communicated with each other. Both confine their description almost wholly to the superficial set, saying but little about the deep set.

Wywodzoff studied the lymphatics of the lung of the dog and the horse. He described the lymphatics as arising from fine lymph capillaries situated in the walls of the air spaces. These lymph capillaries ran at an angle to the blood capillaries. He also described lymph spaces in the walls of the sacculi alveolares in which lymph collected. The larger lymphatics were situated in the walls of the blood-vessels and bronchi; these two sets of deep lymphatics communicated with each other. The superficial lymphatics formed a network which was destitute of valves; only the deep set possessed valves. The two sets of lymphatics were connected with each other by branches which followed the course of the pulmonary vein from the pleura into the interior of the lung, where they joined other lymphatics coming from the bronchi or from other blood-vessels.

Sikorsky described the lymphatics of the bronchi as originating from fine vessels situated between the ciliated epithelial cells lining the bronchi. These vessels united to form a network, which in turn gave rise to the main trunks which passed out of the lung at the hilus. In the walls of the air spaces a network of fine canals and lacunæ was found, which gave rise to a system of lymphatics which ran in the walls of the blood-vessels. In his second paper he made no reference to his previous statements and evidently abandoned them. The pleural lymphatics he described as arising from the subpleural air spaces, and eventually formed trunks which passed to the hilus pulmonis.

Sappey does not favor the division of lymphatics into superficial and deep sets; for, he says, the two sets are in close communication everywhere. Each

Fig. 3809.—Lymphatics Following Branches of the Venæ Pulmonales which Originate in the Pleura. The lymphatics communicate in the pleura with the network of pleural lymphatics seen in Fig. 3912. (Miller.)

lobule of the lung is surrounded by lymph vessels, which are arranged in such a manner that they form a network between adjacent lobules in much the same manner as the blood capillaries do between adjacent sacculi alveolares.

Klein divides the lymphatics into three sets:

(*a*) Lymphatics of the alveoli.

(*b*) Lymphatics of the bronchi.

(*c*) Lymphatics of the pleura.

Most of the lymphatics belonging to the first set accompany the branches of the arteria pulmonalis

and vena pulmonalis. They arise from irregular spaces in the walls of the air-sacs and are "provided with a special endothelial wall."

The lymphatics of the second set are found in the

Fig. 3810.—Lymphatics of the Pleura. Note the irregularity of size and the numerous constrictions indicating the positions of valves. (After Miller.)

walls of the bronchi and communicate with the larger lymphatic trunks about the blood-vessels.

The third set are found in the pleura and connect with those of the first set on the one hand, and on the other with the pleural cavity by means of stomata.

von Wittich found that if he allowed a solution of

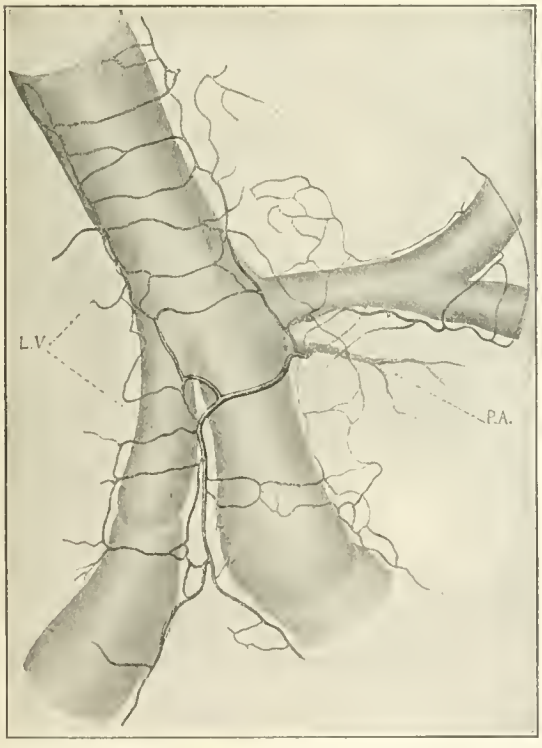

Fig. 3811.—From a Section Taken Parallel to and Including the Pleura of the Lung of a Dog. Thickness of section 100 micra. The lymph vessels are fully distended. *L.V.*, lymph vessel; *P.A.*, arteria pulmonalis situated beneath the pleura; a radicle can be seen arising from the artery, and giving origin to the network of vessels about the lymphatics. × 35. (Miller.)

sulphindigotate of soda to drop slowly into the trachea of living animals and killed them after an interval of two hours, removing the lungs in the stage of deep expiration, a network of blue lines with here and there lacunæ similar to those described by Sikorsky could be seen. The injection of a solution of silver nitrate, on the other hand, failed to demonstrate stigmata or stomata between the epithelial cells lining the air spaces, although the intercellular substance was well stained. He considered the network of blue lines which he obtained by the first method to be a coloration of the intercellular substance and referred the results obtained by Küttner to the same cause.

Councilman found a set of lymphatics accompanying the arteria pulmonalis, and a second set which was situated in the connective-tissue septa and joined the lymphatics of the pleura. Valves were found which opened toward the pleura. He failed to find any lymphatics about the veins. He considered that the second set of lymphatics "play an important part in the pathology of the lung, for it is undoubtedly

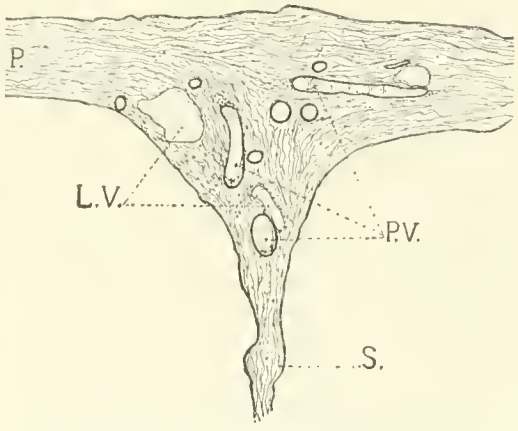

Fig. 3812.—Section of the Human Lung Taken at Right Angles to the Pleura; semi-diagrammatic. *P.*, Pleura; *S.*, septum; *L.V.*, lymph vessels; *P.V.*, vena pulmonalis; the branches of the arteria bronchialis are represented by heavy black lines. × 50. (Miller.)

by this route that infections in the center of the lung extend to the pleura."

The latest investigations of the lymphatics are those of Miller.

He classifies them as follows:

(*a*) Lymphatics of the bronchi.
(*b*) Lymphatics of the arteries.
(*c*) Lymphatics of the veins.
(*d*) Lymphatics of the pleura.

Lymphatics of the Bronchi.—In preparations in which the lymphatics have been successfully injected and occasionally in uninjected specimens a number of large-sized lymphatics can be seen coming from the hilus of each lung between the bronchus and blood-vessels. These lymphatics pass along the right and left bronchus to form a network on the posterior wall of the trachea and eventually become connected with a number of lymph nodes which are situated about the bifurcation. Valves are present in these vessels in large number and open toward the lymph nodes.

Within the lung the bronchial lymphatics have a different arrangement, depending on the presence or absence of cartilaginous rings. Where the rings are present there is a double network of lymphatics present which encloses the cartilage. That part of the lymphatic network which is situated just beneath the epithelium is composed of finer vessels, as Teichmann pointed out many years ago.

In the finer rami bronchiales and bronchioli only a single plexus of lymphatics is present; the vessels of the plexus vary greatly in size and shape, and the mesh of the network which they form is elongated in the long axis of the bronchioli (Fig. 3808). In the ductuli alveolares the lymphatics have been reduced to three

small vessels which in transverse sections of the ductuli alveolares are placed nearly equidistant from one another. Of these three lymphatics two pass to the small veins which arise at this place, while the third passes to the artery. Distal to the ductulus alveolaris no lymphatics are present. This statement of Miller has been confirmed by Teichmann.

Lymphatics also pass from the bronchial network to the veins which arise from the place where the bronchi divide and to the arteria pulmonalis. We have then, at the place where bronchi divide the same arrangement as at the terminal bronchus, namely, two lymphatics passing to the veins and one to the artery. This emphasizes the fact that in order to comprehend the distribution of the lymphatics the arrangement of the blood-vessels must be fully understood.

Fine lymphatics have been described by Sikorsky as being found between the epithelial cells lining the bronchi and communicating on the one hand with the deeper lymphatics of the bronchi and on the other with the lumen of the bronchus. Sikorsky in his later paper evidently abandoned the theory of open communication between the lymphatics and the bronchial cavity. A somewhat similar condition has been described by Klein under the name of "pseudostomata." Neither of these statements has been confirmed by Miller.

Wherever lymphatics unite triangular enlargements (lacunæ) are found. These lacunæ are especially well developed at the forking of the bronchi and seem to be associated with the small aggregations of lymphoid tissue found at this place by Arnold, Klein, Miller, and others.

Pigment, when present, is found along the lymphatics of the bronchi; at the forking of the bronchi it is associated with the lacunæ and lymphoid tissue found here, often completely obscuring them from view.

Valves are present in the lymphatics of the larger bronchi, but are absent in those of the finer divisions of the bronchial tree.

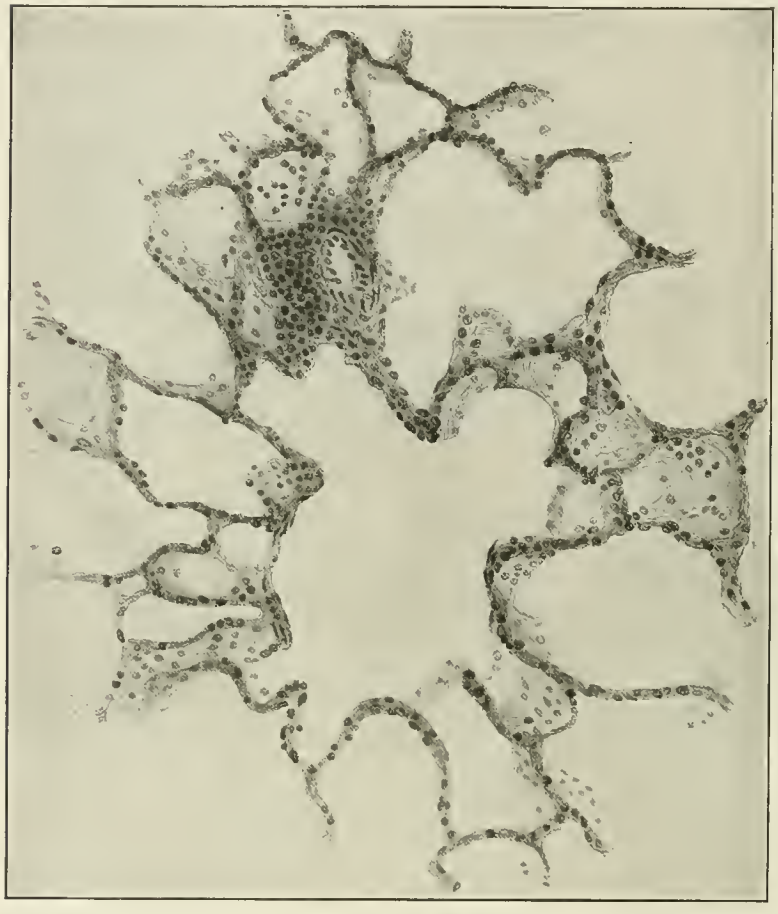

Fig. 3813.—Transverse Section through a Ductulus Alveolaris. A small mass of lymphoid tissue is seen lying between the arteria pulmonalis and the air spaces. The larger air space just above the artery and opening into the ductulus is a portion of an atrium. × 200. (Miller.)

Lymphatics of the Arteries.—We have seen in the preceding account that the network of lymphatics in the walls of the bronchi gradually diminishes until in each ductulus alveolaris there remain only three small vessels, one of which joins the lymphatics about the artery.

Not only is there a communication between the bronchial and arterial lymphatics at the terminal bronchi, but there is also one at the place where branching of a bronchus takes place.

The larger branches of the arteria pulmonalis have as a rule two main lymphatics accompanying them. These are situated on opposite sides of the artery, and are so placed that one of them lies between it and the bronchus. The two main lymphatics are connected together by numerous loops, and in this way a long-meshed network is formed about each artery.

As the artery divides the lymphatics also divide, but the size of the lymphatics does not diminish so rapidly as that of the artery. When we come to the smaller arteries only a single lymphatic is found accompanying them. This generally runs parallel to the artery, between it and the bronchus.

Lymphatics of the Veins.—The two remaining lymphatics which arise from the ductulus alveolaris pass, one on either side, to the smaller veins which arise at this place, and have usually more of a spiral course than those about the artery. Lymphatics also pass from the bronchial network to the veins which arise at the place where the bronchi divide. We have, therefore, at the place where bronchi divide, the same relation of lymphatics to blood-vessels as at a ductulus alveolaris; that is, there are three lymphatics, one of which passes to the artery, the other two to the veins.

Finally, there are lymphatics which accompany those venæ pulmonales which go to the pleura; these join the network of pleural lymphatics (Fig. 3809). There is always a well-marked lacuna at the junction of this vessel with the pleural network, and if pigment is present anywhere on the surface of the lung it is found about this lacuna.

The smaller veins, like the arteries, have but a single lymph vessel accompanying them, while the larger venous trunks have two, and often three, main lymphatics. These are connected by numerous loops, and there is thus formed a network with a long mesh.

Pigment may be present about the lymph vessels accompanying the veins, but not so abundantly as about the arterial lymph vessels.

Fig. 3814.—Section Showing the Junction of One of the Veins Taking Its Origin from the Distal End of a Ductulus Alveolaris (Fig. 3803) with One of the Main Branches of the Vena Pulmonalis Situated on the Periphery of a Primary Lobule. Note the mass of lymphoid tissue at the right of the vein. × 400. (Miller.)

Wywodzoff, Klein, and other authors describe the lymphatics about the arteria pulmonalis and venæ pulmonales as having their origin in fine canals, which are situated in the walls of the sacculi alveolares. In the study by Miller, already referred to, he shows that the appearances on which they based their conclusions, as shown in their illustrations, are artifacts, and says he has never found in the walls of the sacculi alveolares anything which he could call a lymphatic or lymph capillary.

Lymphatics of the Pleura.—The lymphatics of the pleura are irregular in size and form a plexus which has no definite relation to the lobule of the lung (Fig. 3810). Many of these lymphatics are of quite large caliber, as Sappey has pointed out. Sometimes these large lymphatics form an incomplete network in the mesh of which smaller lymphatics are situated, thus giving the appearance of a double network of lymphatics.

The lymphatics of the pleura have numerous valves (Fig. 3810), though Wywodzoff says valves are present only in the deep lymphatics. The fact that there are free anastomoses between the pleural lymphatics allows them to be easily filled with the injecting mass. While the presence of valves does not prevent the injection of the pleural lymphatics, they do prevent to a certain extent the injection of lymphatics within the lung from the pleura.

Pappenheim has described two layers of lymphatics in the pleura of the horse. If his observation is correct, the condition is quite different from that in man. Klein, as already observed, describes the pleural lymphatics as communicating with the pleural cavities by means of "true stomata."

Miller denies the presence of stomata in the pleura pulmonalis, and von Ebner confirms his observation.

The lymphatics of the pleura are surrounded by a network of fine blood-vessels. The source of this network differs in different animals. In the dog and other animals with a thin pleura this network is derived from the arteria pulmonalis (Fig. 3811). In man and animals with a thick pleura it is derived from the arteria bronchialis (Fig. 3812). In each instance the blood is returned by the venæ pulmonales.

The ordinary method of attempting to inject the lymphatics by the very unscientific "puncture method" leads to many erroneous observations. Miller has given a method by which they can be injected by inserting a specially devised cannula directly into one of the large lymph trunks. The reader is referred to the original paper for the details of the procedure.

Lymphoid Tissue.—The distribution of lymphoid tissue within the lung, the situations in which it is to be sought and the relation which it bears to the air passages, the blood vessels, the lymph vessels, and the pleura is of interest not only to the histologist but also to the pathologist and clinician for these masses frequently serve as centers to which, by means of the lymph vessels, disease processes may be conveyed.

For convenience of description I shall consider lymphoid tissue in its relation to the bronchi; in its relation to the blood and lymph vessels; in its relation to the pleura.

Lymphoid Tissue in the Bronchi.—In 1803 Loder published an illustration of the lymph nodes situated along the trachea at its bifurcation and the two main bronchi into which it divides. In 1903 Sukiennikow published an illustration of the lymph nodes in the same region which resembles quite closely that of

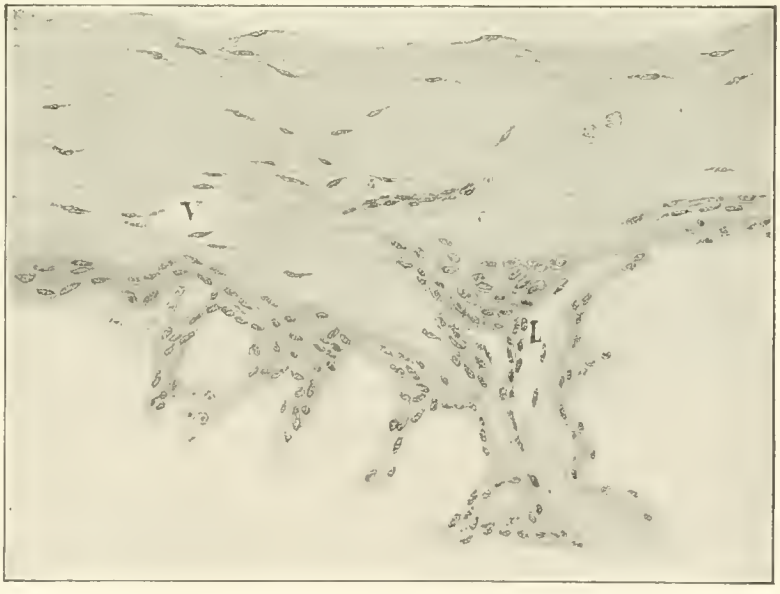

Fig. 3815.—Section of the Pleura of a Child Four Days Old. No pigment is present. A small mass of lymphoid tissue is seen lying beside the lymph vessel, *L*. In the center of the section is a section of a small branch of the vena pulmonalis *V*. Just above the lymphoid tissue a small branch of the arteria bronchialis is seen cut longitudinally. × 300. (Miller.)

Loder; in each the lymph nodes are shown at the place where branches are given off. Miller has more recently studied this problem and the following account is based on his work.

In bronchi which have cartilages in their walls the lymphoid tissue may be situated between the cartilage and the tunica muscularis, or outside of the cartilage in the peribronchial connective tissue, or in the space between two adjacent cartilages; the position seems to depend on the quantity of lymphoid tissue present. In non-cartilaginous bronchi (bronchioli respiratorii and ductuli alveolares) of man and all animals examined, no distinct lymph follicles (germ centers) were found in normal lungs, but in each lying between the artery and the adjoining air spaces, which in this instance are portions of atria. We have seen (Fig. 3803, 2, 3) that veins arise from the distal extremity of the ductuli alveolares and from the place where bronchi divide. If one of the former be followed there will usually be found at the place where it unites with one of the main venous trunks, on the periphery of the lobule, a small mass of lymphoid tissue (Fig. 3814). The same relation of lymphoid tissue will also be found in the latter instance.

Lymphoid Tissue in Its Relation to the Pleura.—The amount of lymphoid tissue in the pleura is considerable but the lymph follicles and lymph nodes

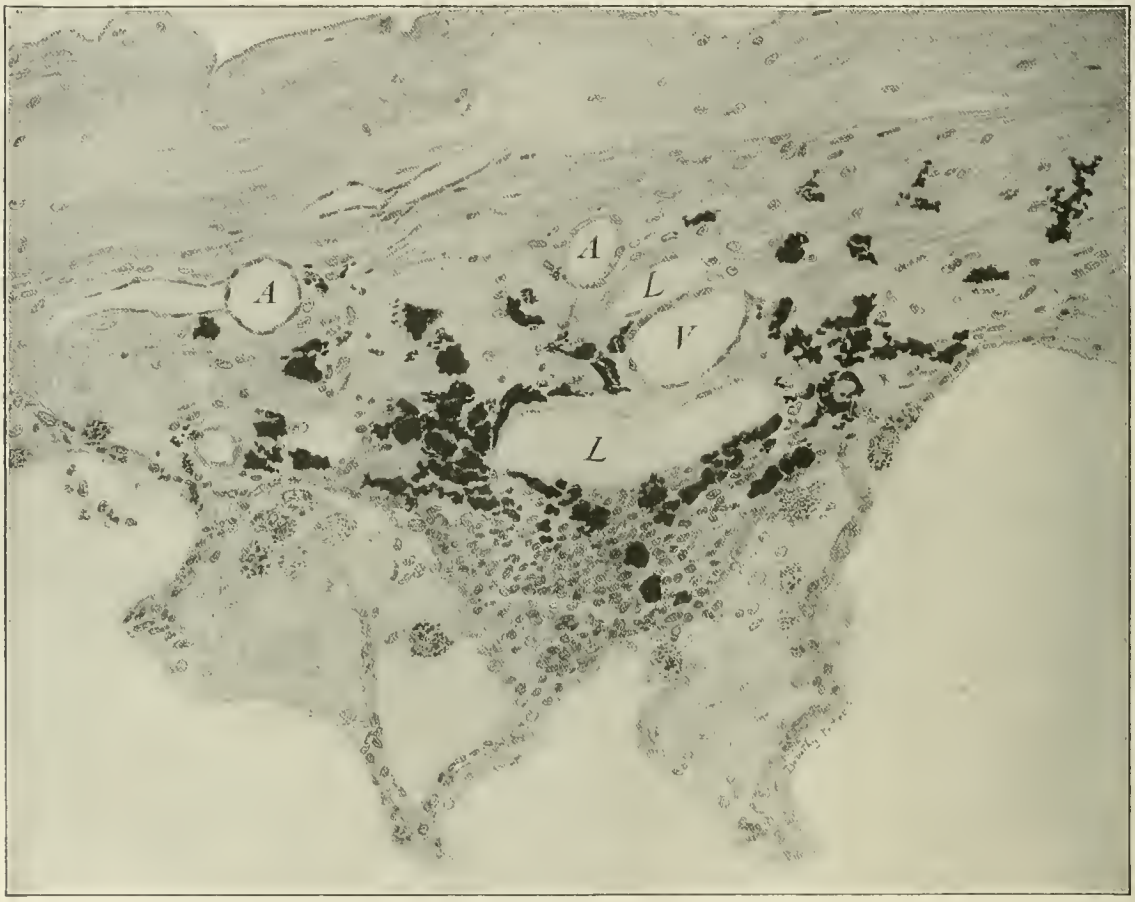

Fig. 3816.—Section of the Pleura of a Man Thirty-eight Years Old. A large amount of pigment is present. *A*, *A*, Sections of the arteria bronchialis; *V*, section of a radicle of the vena pulmonalis; *L*, *L*, lymph vessels. Just beneath the lymph vessels a mass of lymphoid tissue can be seen. Scattered about in the section are numerous phagocytes. × 250. (Miller.)

instance small masses of lymphoid tissue were found situated outside the tunica muscularis between it and the accompanying branch of the arteria pulmonaris.

Lymphoid Tissue in Relation to Blood-vessels.—When lymphoid tissue is present along the course of the finer branches of the arteria pulmonaris it is situated between the artery and the adjoining air spaces rather than between the artery and bronchus, as is the case with bronchial lymphoid tissue. The lymphoid tissue may extend for some distance along the artery, but the sheath-line arrangement described by some authors is not to be considered a normal arrangement. In a section taken through a ductulus alveolaris (Fig. 3813) lymphoid tissue may be seen

described by Lüders in the pleura must not be considered normal structures; they are pathological and must have developed from the presence of irritating substances as, for example, particles of carbon. In this case we find more or less pigmentation of the masses of lymphoid tissue and deposition of pigment along the course of the lymph vessels throughout the lung. In other cases we may have an hyperplasia of the already existing lymphoid tissue as, for example, in leukemia. In these cases absence of pigment is the rule.

A radicle of the vena pulmonalis arising in the pleura is shown in Fig. 3809. There are several of these veins about the periphery of the lobule (Fig.

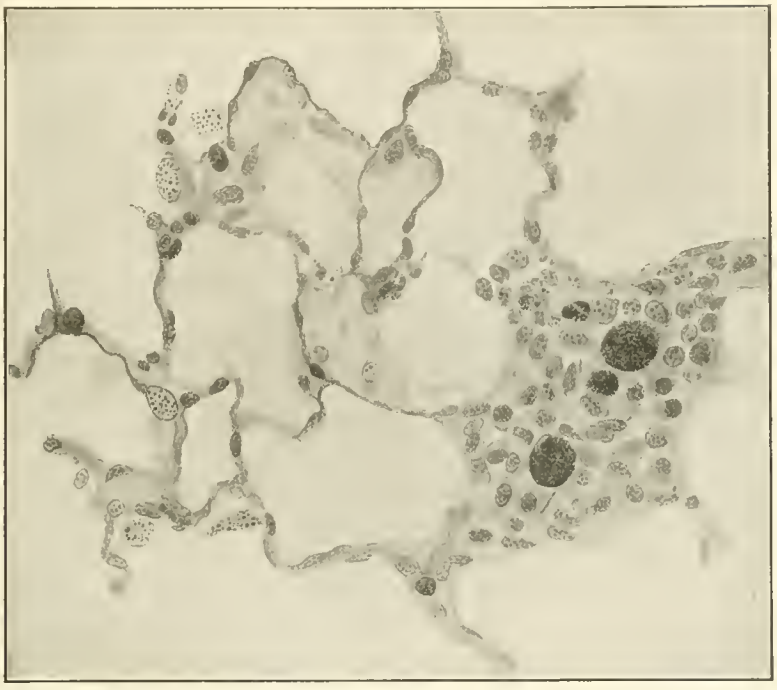

Fig. 3817.—Section of the Lung of a Rat. Phagocytes in various stages of activity can be seen. Some of them are free in the air spaces; others are in close apposition with their walls, while still others are within the mass of lymphoid tissue. Two large macrophages show prominently in the lymphoid tissue. × 500. (Miller.)

3797). At the place where the pleural radicles unite to form a main trunk of the vena pulmonalis there is usually a small mass of lymphoid tissue. In the human lung there are connective-tissue septa, much more highly developed than those about the primary lobules, which separate the secondary lobules from each other. In these septa blood and lymph vessels are associated with each other and where they join the pleural vessels there is always found a mass of lymphoid tissue.

Pigment.—The distribution of pigment within the lung has been referred to in connection with the lymphatics. If a section of the pleura of a child four days old be made (Fig. 3815) it will be found that no pigment is present and the amount of lymphoid tissue is small. In a section of the pleura of a child seven years old the amount of lymphoid tissue has increased and a perceptible quantity of pigment is present. Contrast these sections with one taken through the pleura of a man thirty-eight years old (Fig. 3816). In this section there is a considerable increase in the quantity of pigment present and is especially abundant about the lymph vessel. Scattered aggregations of pigment are also present in the lymphoid tissue. Phagocytes laden with particles of carbon are present in various parts of the section. In this, and the preceding section, the increased amount of lymphoid tissue is to be correlated with the increased amount of pigment.

The investigations of Shingu show that in children under twenty-three days old no pigmentation of the lung is present; from that time on pigment is always present but not always proportional to the age. It is undoubtedly true that the lungs of individuals living in an atmosphere charged with carbon contain a much larger quantity of pigment than those living in an atmosphere comparatively free from carbon, and the investigations of Miller show a corresponding increase in lymphoid tissue which he considers due to the irritation arising from the constant inhalation of irritating substances.

When particles of carbon are inhaled it is only the finer particles that penetrate as far as the alveoli pulmonis; here they are picked up by phagocytes

Fig. 3818.—From a Section of a Bronchus. The ciliated epithelium and the layer of smooth muscle are easily recognized. 1, Section of a gland which opens on the surface of the bronchus. 2, transverse and oblique section of the arteria bronchialis; 3, section of a small ganglion; 4, section of a cartilaginous plate; × 75. (Miller.)

which find their way into the masses of lymphoid tissue and deposit them there (Fig. 3817).

Nerves.—At the present time our knowledge of the nerve distribution within the lung is very deficient. The main trunks which supply the lung

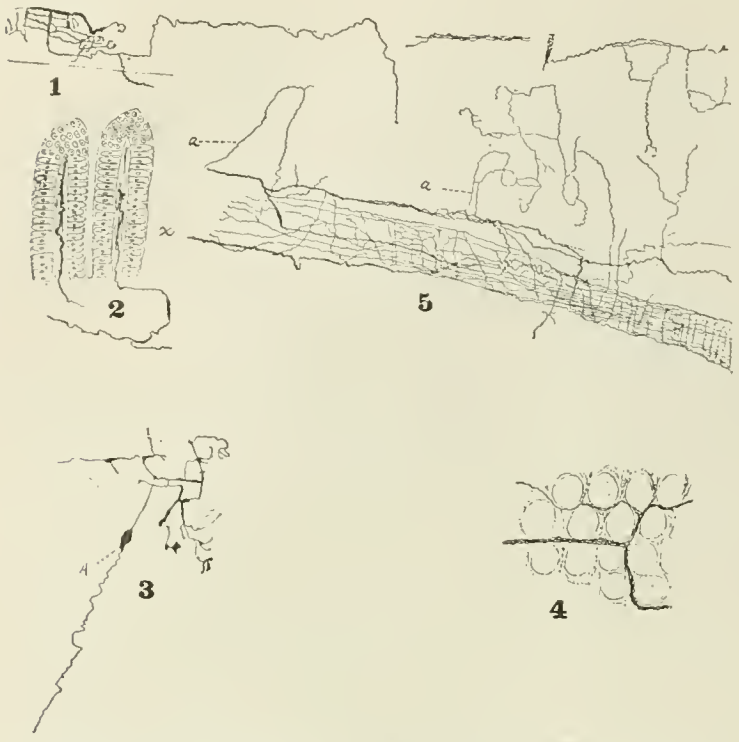

Fig. 3819.—1, Nerve Termination in the Muscular Layer of a Medium-sized Bronchus; the dotted line marks the boundary of the muscular layer; 2, two adjacent rugæ, showing the relation of the nerve fiber to the epithelium; 3, nerve complex within the epithelium of a bronchiole; the letter *A*, marks a small ganglion cell; the dotted line indicates the boundary of the epithelium; 4, nerve bundles and single fibers in the walls of the air spaces; 5, an arteriobronchial plexus: *a*, *a*, fibers passing from the plexus to the walls of a bronchus: the letter *x* indicates the margin of the peribronchial spaces. (Berkley.)

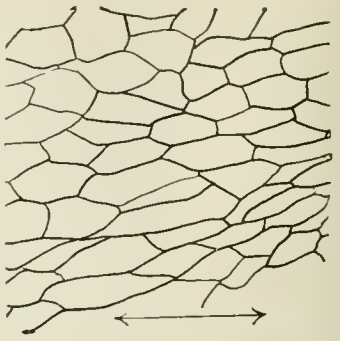

Fig. 3820.—Mesothelium from the Pleura Parietalis (intercostalis) which has been stretched in the direction indicated by the arrow. Note the elongated shape of the cells. × 210. (Miller.)

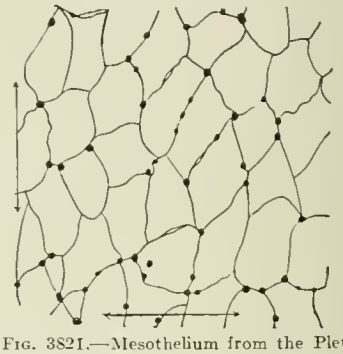

Fig. 3821.—Mesothelium from the Pleura Parietalis (intercostalis) which has been strongly stretched in the directions indicated by the arrows. Note the "stigmata" and the spaces caused by the separation of the cells. × 210. (Miller.)

come from the pneumogastric and sympathetic; these unite at the root of the lung and form the anterior and posterior pulmonary plexuses. The posterior plexus is the larger of the two. From these plexuses branches extend into the lung and are distributed along the bronchi and the pulmonary and

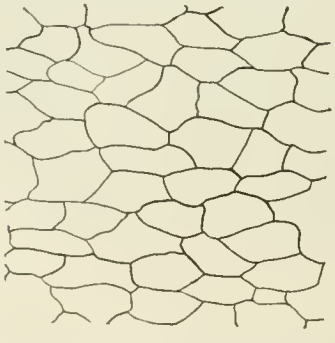

Fig. 3822.—Mesothelium from the Pleura Parietalis (intercostalis) which was fixed *in situ*. Note the regularity of the boundary lines surrounding the cells and the total absence of "stigmata" and openings between the cells. × 210. (Miller.)

bronchial blood-vessels. Along the course of those branches which accompany the bronchi Remak found numerous small ganglia (Fig. 3818). Since the investigations of Remak the only important work on the nervous supply of the mammalian lung has been done by Retzius and Berkley. Retzius found in the lung of a human embryo, fifteen centimeters long, which had been stained by Golgi's method, that he could follow the nerves as far as the last division of the bronchus; distal to that point he does not seem to have found any nerves.

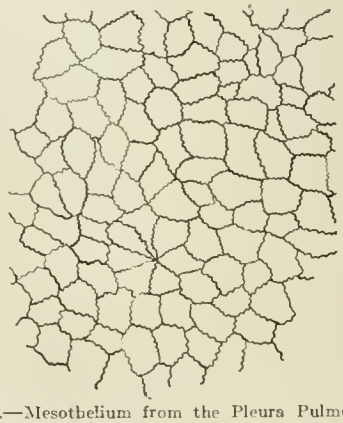

Fig. 3823.—Mesothelium from the Pleura Pulmonalis. Note the total absence of stomata, stigmata, and openings between the cells. The specimen was fixed *in situ*. The center of the rosette of cells, seen near the middle of the illustration, is the place where stomata are said to be always present. × 210. (Miller.)

Berkley also used the silver method in his study (Fig. 3819, 1, 2, 3, 4, 5). His results may be summed up as follows:

The main nerve supply to the lung tissue is derived from the nerves which accompany the bronchial

arteries. Nerve fibers are frequently seen in the septa between the alveoli, in the central portion of the lung as well as near the root of the lung. A direct ending of the nerves in the immediate neighborhood of the epithelium lining the air-sacs was not found. The mucous membrane and muscular tissue of the bronchi are innervated from the nerves following the bronchial artery, and also from the very considerable plexus of nerve fibers found in fibrous layers about the bronchi. In the muscle the nerves end in small, rounded bulbs upon, and not within, the muscle cells. In the larger bronchi nerves could not be followed through the fibrous layer immediately under the epithelium but in the smaller bronchi the nerves could be followed to a well-marked interepithelial arborization. The nerve supply of the pulmonary blood-vessels is not so large as that to the bronchial.

Pleura Pulmonalis.—In other portions of this article attention has been called to the distribution of the blood-vessels, the lymph vessels and the lymphoid tissue in the pleura; there remains for consideration the histological structure. The pleura pulmonalis can, for convenience of description, be divided into four layers: the mesothelium, the submesothelial layer, the elastic layer, and the areolar layer.

The mesothelial layer, as its name implies, consists of mesothelial cells. Since the time of Oedmansson and v. Recklinghausen certain appearances, characterized as preformed openings, found between the cells lining the so-called serous cavities have been designated as stigmata and stomata. As one reviews the literature of the subject it is seen that, while at first the opinion of v. Recklinghausen influenced the earlier investigators to accept these appearances as normal structures, later studies with improved methods have led many to declare that they are not normal structures but artifacts. The author of the present article denied their presence in the pleura pulmonalis in 1896 and his observation has been confirmed by later investigators. The methods of preparation made use of by the earlier and, to a certain extent, by some of the later investigators have been contributive to the production of these artifacts; for example, the rough handling attendant on the removal from the body of the part to be acted on by argentic nitrate, or, what is even greater violence to the tissue, the stretching of the part to be studied over cork, glass or vulcanite rings, or the spreading of the membrane over the edge of a shallow glass dish and pouring over it the solution of argentic nitrate. The strength of the argentic nitrate solution also has its influence; the stronger the solution the greater the number of these artifacts. These statements can be substantiated as follows: If a portion of the wall of the thorax be removed and stretched in one direction slightly, before being acted upon by argentic nitrate, the boundary lines of the mesothelium will remain intact but will show distortion in the direction of the force applied (Fig. 3820); if a second portion be removed and stretched violently in two directions (Fig. 3821) the usual appearance of dots and intercellular spaces will appear when treated with argentic nitrate; if instead of removing the part to be stained the entire process be carried on *in situ* the mesothelium will retain its normal form and the boundary lines will be intact (Fig. 3822). The results obtained when the pleura pulmonalis is thus treated are especially satisfactory (Fig. 3823) though a more delicate subject than the pleura costalis.

The submesothelial layer is formed of white fibrous connective tissue and varies in thickness in the pleura of different animals; in a few instances delicate elastic fibers extend into this layer from the underlying elastic layer. The elastic layer is quite variable in its formation; it sometimes appears as a thin sheet of closely woven elastic fibers sometimes as a dense band of fibers which cross each other at an acute angle; sometimes it appears to be made up of two superimposed layers, a superficial compact layer of coarse fibers and a deeper layer of fine and more closely arranged fibers. There is also a variable amount of white fibrous connective tissue interwoven with the elastic fibers. The areolar layer is also of variable thickness; it is composed of loosely arranged bundles of white fibrous connective tissue and a greater or less number of elastic fibers which anastomose, on the

Fig. 3824.—Elastic Fibers in the Human Pleura. 1, Mesothelium and submesothelial layer; 2, layer of elastic fibers; 3, layer of areolar connective tissue. Note the presence of a few elastic fibers in the submesothelial layer. × 20. (Miller.)

one hand, with the elastic fibers of the lung, on the other hand, with the fibers in the elastic layer of the pleura.

Passing from the general consideration of the pleura pulmonalis to that of the human pleura pulmonalis (Fig. 3824), it will be seen that there is on the outer surface a layer of mesothelium; beneath this is a submesothelial layer made up of bundles of white fibrous connective tissue and fine elastic fibers which are derived from the underlying elastic layer and are, in places, quite abundant. The average thickness of the submesothelial layer is 8.5μ.

The elastic layer varies from 3μ to 7.5μ in thickness and has an average of 5.625μ. The elastic fibers form a compact network with a somewhat oval mesh through which bundles of white fibrous connective tissue pass from the areolar layer to the submesothelial layer. In the pleura of some lungs this layer appears to be made up of a superficial and deep network between which there is a thin layer of white fibrous connective tissue. The elastic fibers of this layer send numerous fibers into the submesothelial layer which at times extend as far as the mesothelium; they also form anastomoses with the elastic fibers of the areolar layer.

The areolar layer averages 60μ in thickness. It is made up of rather coarse bundles of white fibrous connective tissue and scattered elastic fibers which anastomose with the elastic layer and with the elastic fibers of the lung. Lying between the areolar layer and the parenchyma of the lung is another network of elastic fibers, but these must be considered as belonging to the lung rather than to the pleura.

The blood-vessels, lymph vessels, and nerves are situated in the areolar layer. In some sections of the human pleura pulmonalis the author has found small blood-vessels lying within the elastic layer, the only instance where they are so situated that has come to his notice.

William S. Miller.

Bibliography.

For an extended bibliography the reader is referred to the two preceding editions. The following bibliography belongs to the new subject matter included in the above article.

Corning, H. K.: Lehrbuch der topographischen Anatomie. Wiesbaden, 1914.

Flint, J. M.: The Development of the Lungs. Amer. Jour. Anatomy, vol. vi., 1907.

Guillot, N.: Description des vaisseaux particuliers qui naissent dans les poumons tuberculeux. L'Expérience, 1838.

Hutchinson, J.: Article "Thorax" in vol. iv., part ii, of The Cyclopedia of Anatomy and Physiology. London, 1852.

Hyrtl, Joseph: Die Corrosions—Anatomie und ihre Ergebnisse. Wien, 1873.

Krause, C. Fr. Th.: Handbuch der menschlichen Anatomie. Hanover, 1876.

v. Loder, J. C.: Tabulæ anatomicæ. Weimar, 1803.

Lüders, C.: Ueber das Vorkommen von subpleuralen Lymphdrüsen. Kiel, 1892.

Marchand, R.: Les pores des alvéoles pulmonaires. Bibliog. Anatomique, t. xxii., 1912.

Mehnert, E.: Ueber topographischeAltersveränderungen des Atmungsapparates. Jena, 1901.

Merkel, F.: Handbuch der Anatomie des Menschen (von Bardeleben). Jena, 1902.

Miller, W. S.: The Arrangement of the Bronchial Blood-vessels Anatom. Anz., Bd. xxviii., 1906.

Miller, W. S.: The Vascular Supply of the Pleura Pulmonalis. Amer. Jour. Anatomy., vol. vii., 1907.

Miller, W. S.: The Distribution of Lymphoid Tissue in the Lung. Anatom. Record, vol. v., 1911.

Miller, W. S.: The Trachialis Muscle: Its Arrangement at the Carina Tracheæ and Its Probable Influence on the Lodgement of Foreign Bodies in the Right Bronchus and Lung. Anatom. Record, vol. vii., 1913.

Oedmansson, E.: Beitrag zur Lehre von dem Epithel. Virchow's Archiv, Bd. xxviii., 1863.

v. Recklinghausen, F.: Die Lymphgefässe und ihre Beziehung zum Bindegewebe. Berlin, 1862.

Rosenthal, J.: In Hermann's "Handbuch der Physiologie." Leipzig, 1882.

Ruysch, F.: Observatio XV. Observationes anatomicæ. Amsterdam, 1732.

Schäfer, E. A.: Artificial Respiration in Its Physiological Aspects. Journ. Amer. Med. Assoc., vol. li., 1908.

Shingu, S.: Ueber Staubinhalation bei Kindern. Virchow's Archiv, Bd. cc., 1910.

Spalteholz, W.: Handatlas der Anatomie des Menschen. 7te Auf. Leipzig, 1914.

Spitzka, A.: A Note on the True Weight of the Human Lungs. Amer. Journ. Anatomy, vol. iii., 1904.

Sukiennikow, W.: Topographische Anatomie der bronchialen und trachealen Lymphdrüsen. Berlin, 1903.

Walter, R.: Ueber die "Stomata" der serösen Höhlen. Anatom. Hefte, Bd. xlvi., 1913.

Zimmermann, K. W.: Ueber Anastomosen zwischen den Tubuli der serösen Zungendrüsen des Menschen. Anatom. Anz., Bd. xvii., 1900.

Lungs, Abscess of the.—Abscess of the lung probably occurs much more often than it is diagnosed since it not infrequently is a mild process giving but few symptoms and resolving spontaneously. The differentiation between abscess and gangrene may be difficult even at autopsy.

Etiology.—Abscess of the lung is probably always secondary. Lobar pneumonia is a prominent pulmonary infection which may cause abscess. Either macroscopic or microscopic abscesses were found in twenty-eight per cent. of fifty-one autopsies on cases of lobar pneumonia at the Massachusetts General Hospital and in many instances these were doubtless capable of spontaneous absorption. Bronchopneumonia and aspiration pneumonia are also important causes. Abscesses of tuberculous origin are due to the supervention of a mixed infection. Extension of a suppurative process in a neighboring organ may cause abscess formation in the lung. Empyema, subdiaphragmatic abscess, or liver abscess may all rupture into the lung tissue and discharge by way of a bronchus. Or infection may extend from a bronchus to an area of lessened resistance, such as an infarct, and bring about abscess formation.

The location of infected emboli in the lung may determine the development of multiple small abscesses. The most frequent causes of such a condition are ulcerative endocarditis, septic puerperal thrombosis and thrombosis of the sigmoid sinus occurring in middle-ear disease. Abscess may follow penetrating injuries of the lung whether from without or from a foreign body in the bronchus. Echinococcus disease is an infrequent cause as are infections of the lung with fungi or the breaking down of a gumma or a new growth.

Pathology.—The abscesses in pneumonia may be microscopic in size and collected in isolated areas. When larger they are usually round and may involve the greater part of a lobe. They are generally more or less circumscribed and contain pus and often shreds of pulmonary tissue. The pus may or may not be foul. Erosion of a blood-vessel may result in serious hemorrhage. Tuberculous abscess is generally situated near the apex, the other forms may be found anywhere but the most frequent location is the right lower lobe. Metastatic abscesses are small and are often situated beneath the pleura. In older processes organization may take place and with the expectoration of the pus the contraction of the scar tissue may lead to the obliteration of the cavity. When the abscess is near the surface of the lung the pleura is also inflamed and adhesions form between the two layers.

Symptoms.—If in a case of lobar pneumonia there is persistence of the fever, an increase in the cough and in the purulent nature of the sputum and a failure in the resolution of the lung, one is justified in suspecting the presence of an abscess. In a typical case there may be a sudden paroxysm of cough and the expectoration of a large quantity of purulent material which may or may not be foul. After such an attack it may be possible to make out the physical signs of a cavity. The sputum contains a large amount of pus and often a variable amount of blood. Shreds of pulmonary tissue and elastic tissue may be made out on careful examination. Physical signs are often negative. Dulness results both from the abscess and from the surrounding consolidation. After evacuation, the signs of a cavity may be made out. Râles are usually heard over the lesion. If near the surface there may also be the signs of pleurisy with the pain that accompanies that condition.

Complications.—There is always consolidation of the tissue about the lesion. Hemorrhages are frequent but generally small in amount. Infection of the pleura is frequent and an empyema may develop. Cerebral abscess is a rare complication.

Diagnosis.—The history, cough, temperature, the character of the sputum and the physical signs of a cavity are important diagnostic points. Encysted empyema or the encapsulation of pus between the lobes or between the lung and the diaphragm may be confusing. The signs of abscess are those of consolidation while in empyema they will be those of fluid. The history is important and the location of the signs may be suggestive. The diagnosis from bronchiectasis can hardly be made. In tuberculosis the examination of the sputum should make the diagnosis for if the process is sufficiently advanced to cause cavity formation the bacilli should certainly be present. The use of the *x*-ray is very important and may determine the diagnosis. Exploratory puncture should never be done since there is always grave danger of infecting the puncture tract.

Prognosis.—Recovery occasionally occurs with complete obliteration of the abscess cavity. Incomplete recovery is quite commonly seen. Single lesions are more favorable than the multiple ones which are almost always fatal. It is possible that the microscopic variety, of course, may escape detection. Traumatic

cases are favorable while those following a bronchopneumonia are more often fatal.

Treatment.—Medical treatment may be worth trying in individual cases though the results of surgical interference are generally better. It consists in rest, fresh air, and abundant food, narcotics to procure the necessary sleep, and the attempt to favor the evacuation of the cavity by the posture of the patient. Incision and drainage of the abscess offers a better chance of cure. The operation may be performed with the aid of a pressure chamber or by intratracheal insufflation anesthesia. The avoidance of the formation of a pyopneumothorax is very important.

In the preparation of this article, free use has been made of the section on abscess of the lung in "Diseases of the Bronchi, Lungs, and Pleura" by F. T. Lord, New York, 1915. Ralph G. Stillman.

Lungs, Congestion of the.—Congestion of the lungs may be active or passive.

Active congestion (active hyperemia) occurs in the initial stage of all inflammations of the lung or may follow the inhalation of irritating vapors. French writers describe a definite disease (maladie de Woillez) with initial chill, pain in the side, cough, dyspnea, and slight fever which they consider an acute congestion. The patients recover in three or four days. The signs are indefinite, such as impaired resonance, weak vesicular or blowing breathing with crackling râles. There is no way in which such an attack can be differentiated from an abortive pneumonia and it is very probable that these cases are all pneumonias. Leuf reports cases in which, in association with drunkenness, exposure and cold, death occurred suddenly, or within twenty-four hours; post mortem an extreme congestion of the lungs was the only pathological condition found.

Passive Congestion.—*Etiology.*—In this condition there is an excess of venous blood in the lungs due to obstruction to the flow of blood into the heart. Mechanically, this results from the presence of chronic valvular lesions of the heart in which the compensation is broken. This occurs especially in long-standing cases of mitral stenosis with hypertrophy of the right ventricle. It will also occur in myocardial degeneration with decompensation and the development of relative insufficiencies. In the most extreme grade of passive congestion, the lungs are voluminous, russet-brown in color and tear with great resistance. This is the so-called brown induration. On section, the lung shows at first a brownish-red tinge, later the cut surface, exposed to the air, becomes rapidly a vivid red from oxidation of the abundant hemoglobin. Histologically, it is characterized by (*a*) great distention of the alveolar capillaries; (*b*) increase of the connective-tissue elements of the lungs; (*c*) the presence, in the alveolar walls, of many cells containing altered blood pigment; and (*d*) the presence, in the alveoli, of numerous epithelial cells containing blood pigment in all stages of alteration, which cells are also found in great numbers in the sputum.

The *symptoms* are dyspnea and cough. There may not be much expectoration and the sputum may be blood streaked or brownish. Attacks of intense dyspnea, orthopnea, cyanosis and cough may occur and are termed cardiac asthma.

In long-standing passive congestion with marked weakness of the heart, there is a transudation of serum from the blood-vessels into the dependent portions of the lung. This is known as hypostatic congestion. If an infection supervenes, there will be development of consolidation and a hypostatic pneumonia. There is generally more or less edema of the lungs associated with this form of pneumonia which is of the lobular type. Uncomplicated passive congestion gives rise to no physical signs. In the hypostatic form there may be dulness, feeble breath sounds, and numerous crackling râles. With the development of consolidation the signs of pneumonia may be easily noted but not infrequently the patient is so weak that the breath sounds are not heard or the signs of edema obscure the picture.

Treatment.—This consists in the treatment of the primary disease; with its improvement the signs and the symptoms of the congestion disappear. If the symptoms are severe and are secondary to uncompensated valvular affections, venesection with the removal of from twenty to thirty ounces of blood, may reduce the congestion and relieve the right heart.

James Rae Arneill.
Revised by Ralph G. Stillman.

Lungs, Edema of the.—This is a very common condition, in which there is congestion of the pulmonary blood-vessels, water logging of the parenchyma, and effusion of fluid into the air vesicles. It is hard, in many cases, to dissociate the condition from congestion: in fact edema and congestion are frequently combined, for both may be due to the same cause.

Etiology.—Simple acute pulmonary edema occurs more especially in cases of nephritis, cardiac failure, and arteriosclerosis. Occasionally, it has been found associated with severe septic infection and pulmonary embolism.

The most aggravated form, known variously as acute fulminating, acute suffocative, or acute paroxysmal edema, which comes on often without warning and offers a grave menace to life, is associated in many instances with arteriosclerosis, chronic interstitial nephritis, and aortitis. Brouardel could not recall having met with a case apart from renal disease. Allbutt has noted the association with aortitis. I have seen one case myself, of the most intense character, in a young girl the subject of mitral insufficiency, and one, also, in a middle-aged woman, in whom autopsy showed the organs to be perfectly healthy.

We may group cases of pulmonary edema into five classes, more or less well defined from one another.

1. *Agonal.*—This form is undoubtedly the most common, being found practically at every autopsy. It is the expression of a number of factors, a failing heart, general weakness, the recumbent position, sometimes inflammation, sometimes toxemia. One or more lobes, a whole lung, or both lungs, may be affected. Curiously enough, it may be the apices of the lungs that are chiefly involved. It supervenes at or a little before the death agony.

2. *Inflammatory.*—This is usually local. It may be found in the neighborhood of pneumonic patches, tumors, infarcts. Then, it is often termed "collateral edema." Congestion, and then edema, mark the onset of inflammatory processes in the lung.

3. *Congestive.*—The type example of this is found in obstructive valvular diseases of the heart. It is then an indication of failing compensation. A weak heart muscle may also bring it about. Local pressure on a branch of the pulmonary vein, as from a mediastinal growth or aneurysm, may cause it. Respiratory failure, by lessening the propelling action of the thoracic wall, may be a factor. The cases occurring in connection with gross cerebral lesions are possibly of this nature.

4. *Toxic.*—We meet this in cases of Bright's disease. Here, the lungs being excretory organs, they are irritated by the passage through them of toxic materials retained in the system which should have been eliminated by the kidneys. It is difficult, however, in such cases to exclude altogether the inflammatory element. Possibly, those cases occurring in the course of severe anemias, and in cacheetic conditions,

ought to be included here as also postanesthetic cases.

5. *The Acute Fulminating Form.*—This is classified on the basis of its cardinal and most striking clinical features, its etiology being unknown.

Pathogenesis.—In edema of the lungs the cardinal feature is the passage out of the blood plasma from the vessels into the alveolar spaces. We can best understand the process if we recall the various factors that have been proved to be at work in similar conditions elsewhere. Three factors, in particular are of importance, the blood pressure, the capillary walls, and the quality of the blood.

A sudden and temporary increase of blood pressure does not bring about edema. Where, however, the blood pressure is constantly high, as it is, for example, locally at least, in the lung in cases of circulatory obstruction of any kind, the plasma may escape from the normal channels. Here, another element possibly comes in. Owing to the imperfect aëration that results, degeneration occurs in the lining epithelium of the capillaries, so that this membrane becomes more permeable. Degeneration, moreover, is particularly likely to occur in the various toxic states and as a result of infection. The nervous system, also, is not without its part in the process. Vasomotor influences must be invoked in the earlier stages, at least, of inflammation. It is not impossible, indeed, or even unlikely that just as one can have a pure vasomotor edema of the skin and subcutaneous tissues or of the larynx there may also be an analogous condition in the lung, in short, an angioneurosis. This, I venture to suggest may be the explanation of some of those extraordinary, but fortunately rare, cases of acute fulminating edema in which the patient dies or is for a time in grave jeopardy, without any very obvious cause.

Alterations in the blood, by changing its viscosity, or secondarily inducing degenerative processes in the vessel walls, may conduce to edema. We see, for example, edema of the legs in chlorosis and pernicious anemia.

We see, therefore, that a number of contributing factors may be present, one or more of which may be working in any given case. Few cases, indeed, are due to one cause alone.

Considerable experimental work has been done in connection with the subject of edema of the lungs. To W. H. Welch of Baltimore is due the credit of doing the pioneer work on this subject, and his monograph, published in 1878, is still a *locus classicus.* Welch did not think that enfeebled action of the whole heart, or passive hyperemia from obstruction, were competent to explain edema of the lungs. He found he could produce this condition by ligation of the aorta and its branches, and, also, of the pulmonary veins. The degree of obstruction necessary to produce this effect, however, could hardly ever occur in the human subject. Welch was able to confirm the view of Cohnheim and Lichtheim that very great increase in the blood pressure in the aorta may occur with relatively little effect upon the intrapulmonary pressure, and, moreover, that the right ventricle is capable of overcoming enormous obstacles in the pulmonary circulation without material lowering of the aortic pressure. His final conclusion was that the essential feature was to be sought in "a disproportion between the working power of the left ventricle and of the right ventricle of such a character that, the resistance remaining the same, the left heart is unable to expel in a unit of time the same quantity of blood as the right heart."

This disproportionate action of the two halves of the heart with predominance of the right side may, of course, be brought about in several ways. Thus, Grossman found in cases of pulmonary edema due to muscarine poisoning a condition of spasm, and not paralysis, of the left ventricle. Von Strümpell's idea was that there was a sudden failure of the left ventricle. This mechanical theory, propounded by Welch, while operative in the human subject in some cases can hardly be an adequate explanation for all. Disorders of innervation, changes in the capillary endothelium, and qualitative alterations in the blood can by no means be ignored.

The nature of the edema produced experimentally by the injection of adrenalin is not entirely clear. Whether it is the result of increased blood pressure throughout the body of a local toxic action on the vessel walls is a matter of some doubt.

In that form of edema which is not very infrequent following the induction of anesthesia, we may perhaps invoke as an explanation a local action of the drug upon the pulmonary capillaries from two directions, from the outside during the act of inhalation, from the inside during excretion. Thus, an irritative congestion is produced, together with, possibly, an increased permeability of the capillary wall.

Under the congestive form, also, may be classed the edema of the lung with albuminous expectoration that sometimes occurs after thoracentesis. Here, the mechanism is somewhat complicated. A compressed lung is a congested lung. Its parenchyma is often more or less inflamed as well. The vessel walls, also, are damaged and to some extent paretic. You relieve the pressure suddenly and a greater congestion still is the result, a great overplus of blood rushing into vessels that are ill prepared to receive it—so-called congestion "by recoil."

The first stage in the production of pulmonary edema is congestion of capillaries in the alveolar walls; then, outpouring of the plasma of the blood into the alveolar spaces, with a certain amount of swelling and desquamation lining endothelium; finally, extravasation of the blood cells. In consequence of all this, the air sacs are so obstructed that the aëration of the blood is greatly impaired. A condition of asphyxia, more or less complete, results. The heart's action is accelerated; increased strain is thrown upon the right side; cardiac function is impaired and may fail entirely. Congestion initiates the process, heart failure increases the congestion. Thus a species of vicious circle is the result.

Morbid Anatomy.—In pulmonary edema the affected portion of the lung is heavier than normal, congested, and full of fluid. On pressure this fluid, somewhat frothy and of pinkish color, can be made to flow out freely. Except in the inflammatory cases the parenchyma of the lung is not friable. The bronchi are usually filled with similar fluid. In the more chronic cases, the fluid and even the lung tissue itself may present a brownish color, due to altered blood pigment. The fluid, too, is thicker than in the acute cases and somewhat ropy.

Microscopically, the alveolar walls are congested, there is a slight exudation of plasma and red corpuscles and there may be seen an occasional desquamated endothelial cell.

The right side of the heart is overdistended with blood of dark color.

Symptoms and Physical Signs.—The earliest manifestation of pulmonary edema is to be found in the appearance of fine crepitations at the bases of the lungs. These may indicate impending heart failure or herald an inflammatory process. At this stage symptoms may be absent or masked by those of the primary condition. If the edema extends, crackling rales will be heard over a wider area, becoming coarser and more bubbling, often sibilant. Now, cough and slight urgency in breathing may appear. Expectoration, if present, is thin, watery, and slightly tinged with blood. In the more aggravated cases, the patient exhibits manifest evidences of distress: the countenance is pale and dusky, the respirations hurried, the

pulse is small, rapid, and sometimes irregular. A more or less abundant frothy fluid of pinkish color exudes from the mouth or through the nose. Dyspnea may be extreme. In cardiac and renal cases such symptoms are of grave moment and death usually impends.

In the acute fulminating variety, the attack comes on without warning in persons who have been considered to be in good health. The symptoms and physical signs above described are present in exaggerated form. The fluid pours out from the mouth and nose continuously and in extraordinary amounts. In one case of which I have notes at least a pint of blood-stained frothy fluid was expectorated, or otherwise escaped, within an hour when death terminated the attack. The patients often have a sense of impending dissolution. Should they recover, the affection is apt to return. A patient of Lissaman's had seventy-two attacks within two years and a half.

Diagnosis is easy. The occurrence of crackling rales in a cardiac or nephritis case, if an inflammatory process can be excluded, indicates simple edema. In the more aggravated cases the signs of asphyxiation with the abundant outpouring of blood-stained frothy fluid from the nose and mouth, the bubbling or sibilant rales in the chest, are distinctive.

Treatment.—In the milder cases the treatment is that of the primary condition. The terminal edemas of Bright's disease and of cardiac failure can hardly be affected by medication or other treatment, and are practically hopeless.

In acute fulminating edema energetic measures are called for. Often bleeding to the extent of eight or ten ounces will be beneficial. Atropine in large doses, frequently repeated, may be tried. As it takes the break off the heart, it should be associated with digalen, strophanthin, or strychnine. Chloroform inhalations are advocated by some who have had wide experience in this disease, and in many cases seem to have saved the situation. If asphyxiation is marked oxygen inhalations are useful.

Albert George Nicholls.

Lungs, Gangrene of the.—Putrefactive changes in the lung tissue may occur in any condition in which the tissue resistance is lowered. Putrefactive bacteria are always to be found in the air passages and any condition lowering the resistance of the body may act as a predisposing cause, while a local disturbance of some kind prepares the ground for their growth.

Under general predisposing causes come diabetes, alcoholism, nephritis, syphilis, prolonged wasting illness, as typhoid fever, septicemia, bronchopneumonia, and tuberculosis. The last two act as local causes also.

The local causes are acute lobar pneumonia, especially in the patient debilitated by alcoholism, diabetes, etc. Deglutition pneumonia is especially likely to be followed by gangrene, because of the rapid decomposition of the foreign material in the lung. The presence of decomposing material in bronchiectatic or tuberculous cavities acts in the same way. Rupture of cancer of the esophagus into a bronchus, and cavity formation in the lung from carcinoma or sarcoma in this organ, are also causes.

Foreign bodies entering through the air pasasges, or carried into the lung through external wounds, as bullets, fragments of clothing, etc., may be exciting causes, or perforation of the lung by abscess from below the diaphragm.

Disease of the mouth, throat, and larynx as noma, diphtheria, abscess in or about the tonsils and pharynx, carcinoma of these regions, and local paralysis, all act by increasing the liability of foreign material entering the deeper air passages.

One of the most frequent causes of pulmonary gangrene is embolism of branches of the pulmonary artery. This rarely takes place as the result of simple embolism, though secondary infection does occur at times, but if the embolus comes from an infected area this lesion, or abscess, frequently results.

Infected emboli from suppurative phlebitis, appendicitis, liver abscess, otitis media, osteomyelitis, or localized gangrene in other portions of the body are carried to the lung and there give rise to suppurative or gangrenous change in the infarct formed. We may have emboli from the same lesion giving rise to both suppuration and gangrene of the lung in different areas.

Bacteriology.—Both anaerobic and aerobic bacteria are found, the first usually predominating. No one particular organism has been proved to be the one at fault, but in all probability a number of varieties are capable of producing gangrene of the lung. The *Leptothrix pulmonalis* is found in many of the lesions and is thought by Leyden and Jaffe to be of great importance. Hirschler and Terray found various staphylococci, *Micrococcus tetragenus*, *Bacillus pyocyaneus*, and *Micrococcus fœtidus*. Other forms found are the *Bacillus fragilis*, *Bacillus racemosus*, *Monas lens*, Cercomonas, and certain forms of streptococci described by Guillemont. This author lays special stress upon the anaerobes and especially the *Bacillus racemosus*.

Pathological Anatomy.—The lesion in the lung may be diffuse or circumscribed and is often multiple. The diffuse form is usually the result of infection through the air passages while the circumscribed form results usually from embolic infection.

In the circumscribed form the lesion is often multiple and bilateral and the peripheral portion of the base of the lung is most often affected. The gangrenous areas vary in size from a very small point to a hen's egg. Near the periphery they are often wedge shaped and the embolus can be found at the apex. Deeper in the lung tissue they are more rounded in form. The color is at first uniformly black or greenish brown, later softening takes place in the center and a greenish offensive fluid or pulp occupies the cavity thus formed. The walls are composed of a shreddy necrotic tissue and outside of this areas of inflammatory consolidation, edema and congestion shut it off from the rest of the lung.

Under the pleura there are often found collections of offensive gases which raise the pleura up to form blebs; these do not usually communicate with the bronchus. A pleuritic effusion of serofibrinous, purulent, or gangrenous material often occurs. The lung may rupture, giving rise to pneumothorax, or the offensive gases of decomposition may collect in the pleural cavity without the entrance of air.

In the diffuse form, the lesion is much the same as that described, except that the limiting wall is not so marked and the area involved is usually much larger and more irregular in shape. At times an entire lobe is involved. Sometimes the contents of one of these pulmonary cavities is expelled through the bronchus and it is possible for cicatrization to occur under these conditions, but it does not often follow because of the usual tendency of the gangrenous process to spread. An intense bronchitis is usually found, especially in that portion of the bronchial tree leading from the necrotic area.

Microscopically, the contents of a gangrenous cavity are shreds of necrotic tissue showing remnants of elastic and fibrous tissue, many leucocytes, more or less disintegrated, bacteria in enormous numbers, and crystals of leucin, tyrosin, etc.

Under complicating conditions we may find the results of emboli from the thrombosed pulmonary veins carried to the brain, kidney, liver, spleen, and other organs and setting up abscess or gangrene there. Abscess of the brain is comparatively frequent.

Symptoms.—The onset of this condition may be completely concealed by the primary lesion. As an instance, in a pneumonia the patient does not have his crisis, but later, usually about the end of the second week after a severe coughing spell he brings up a quantity of the extremely fetid brownish or greenish sputum which is characteristic of this condition, or in a case of puerperal sepsis, the condition may not be suspected until the putrid material is expelled, or if this fails to occur, it may only be found postmortem.

On the other hand, the onset is sometimes sudden with chills, high temperature, nausea and vomiting and later cough, dyspnea, and sharp pain in the chest. Often the depression is marked and the patient seems extremely ill from the start.

There is nothing characteristic of the disease, however, until the fetid expectoration begins. The characteristic sputum is usually brought up during a severe coughing spell and varies from greenish to brown or black in color. It may be accompanied by hemoptysis. On standing it separates into three layers. The top one is frothy and mucopurulent, the second clear, often with a greenish tint, and the sediment composed of greenish or brownish masses, extremely fetid and sickening in odor. Portions of elastic tissue and other lung debris may be found along with blood and pus cells, mucus, crystals of leucin, tyrosin, and margarin, and microorganisms in large numbers.

Physical Signs.—Before the appearance of the characteristic sputum, the signs are those of bronchopneumonia with sometimes a pleuritic friction rub or if the lesion is small and deep seated, there may be no signs found.

After the expectoration of a large quantity of gangrenous matter, the typical signs of cavity may be found, as amphoric breathing, cavernous voice sounds, etc.

Course.—Usually after the fetid sputum begins to be expelled, the amount is considerable. The patient's condition becomes gradually worse, delirium and prostration being marked, and finally death occurs with the signs of profound sepsis.

If the opening into the cavity is free or if a pneumotomy is done, the patient may gradually recover or after a prolonged illness eventually die of exhaustion.

Diagnosis.—This depends upon the characteristic sputum with its offensive odor. It must be differentiated from the foul sputum sometimes found in bronchiectasis and fetid bronchitis. In bronchiectasis, the signs of cavity are found, but the disease is essentially a chronic one and the sputum while foul is not so bad as in gangrene and does not contain elastic tissue, etc.

In fetid bronchitis there is the history of previous fetid catarrh; the patient usually is not seriously ill and the physical signs are only those of bronchitis.

Treatment.—This is either surgical or medical. If the gangrenous area can be located accurately (the Röntgen ray is of great value in this), and is superficial, it may be drained freely by the surgeon and sometimes with good results. If it is not accessible or is draining with great freedom through the bronchus, medical treatment is indicated.

Medical treatment is directed largely to supporting the patient's strength by food, stimulants, and careful nursing, and to overcoming as far as possible the putrefaction and fetor by disinfectants.

Carbolic acid solutions, guaiacol, creosote, and tar may be used by inhalation and sprays, or guaiacol may be used hypodermically or by inunction. For inhalation, a mask may be worn which is saturated with the drug to be used. Henry Lynde Woodward.

Lungs, Infarcts of the.—The study of pulmonary infarct is virtually the study of thrombosis and embolism of the pulmonary arteries. The pulmonary arteries are mostly terminal vessels and have no anastomosing arterial circulation, or where there are anastomosing vessels they are often insufficient to keep up the nutrition of the lung tissue when the pulmonary branch is shut off. In some cases, however, pulmonary branches may become plugged without causing infarct, either because the capillary anastomosis is rich enough of itself or the bronchial vessels supply enough nutrition. The cause of this plugging is in rare instances thrombosis of the pulmonary artery or some of its branches, but much more commonly it is an embolus or emboli brought to these vessels by the blood stream.

These emboli are most often blood clots but may consist of vegetations from the right heart, of fat, of air or other gases, or of metastatic tumor cells. The embolus may be inert, in which case the infarct is of purely mechanical origin, or it may be infected and give rise to infection of the infarct with resulting pulmonary abscess or gangrene.

Thrombosis of large pulmonary vessels is rare, but may result from compression by a mediastinal tumor or aneurysm, from the cachexia of malignant growths, tuberculosis, malaria, and marasmus in infants. Severe pneumonia, gangrene of the lung, pleurisy, and atheromatous or fatty changes in the vessels themselves are rare causes.

Emboli may result from the breaking up of a thrombus in the pulmonary vessels but much more frequently come from thrombi formed in the right heart or in the veins of the periphery.

Any condition which slows the blood stream in the right heart and gives rise to dilatation of the right ventricle and auricle favors thrombus formation. Mitral disease, especially mitral stenosis is one of the most frequent causes, also chronic myocarditis. Because of the slowness of the stream, fibrin is deposited, especially in the muscular network of the auricle and later fragments are broken off and carried to the lungs. In the rare cases of right sided valvular disease, vegetations from the diseased valves may be broken off and carried in the same manner.

Thrombosis in the peripheral veins is usually due to phlebitis and occurs in typhoid fever and other acute infectious diseases and in the phlegmasia of the puerperium. These clots being rapidly formed are especially likely to become detached, giving rise to embolism.

Phlebitis associated with chronic conditions, cancer, tuberculosis, malaria, gout, diabetes, etc., gives rise to embolism less frequently. At times emboli may arise from phelbitis due to varicosities, especially of the lower extremities, from fractures, from pressure upon the veins, by tumors, etc. Phlebitis in the uterine and ovarian veins in puerperal conditions, in cancer and other tumors of the uterus and ovary, and in the renal veins from renal tumors, offers examples of a deep origin for emboli.

Fat embolism results from crushing fractures of bones, especially spongy bones. Portions of marrow enter the ruptured veins and are carried to the lungs.

Gas emboli may result from the production of gas within the veins by gas-forming microorganisms, but this is very rare. Air may enter any vein with a negative pressure when it is wounded. This is especially likely to occur in the veins of the neck.

Metastatic cells from various tumor masses, especially the malignant forms, may also act as plugs and later develop metastatic growths.

The effect of blocking off the pulmonary vessels varies with the size of the vessel affected. Obliteration of one of the larger branches cuts off an entire lobe, of one of the medium branches an entire lobule, and of the smaller branches portions of a lobule—so called capillary embolism.

The larger emboli are usually inert while the infected or metastatic emboli are usually small and go

deep into the pulmonary system giving rise to the capillary form.

Pathology.—If a large vessel supplying a lobe is plugged, the area supplied by it becomes very anemic and atelectasis of the part occurs. If the patient does not die at once, the part becomes congested and edematous and sometimes a typical hemorrhagic infarct develops which occupies nearly a whole lobe. More often, however, the smaller vessels are affected and the resulting infarcts occupy one or more lobules.

The right lung is most often affected and especially in its base, posterior border, and edges. This is probably due to a stronger and more direct current in the right pulmonary artery (Gerhardt). This is borne out by the fact that when the current is diminished because of collapse or atrophy of the right lung, emboli become more frequent in the left lung. The number of infarcts developed depends upon the number of emboli and varies from one to many.

The typical hemorrhagic infarct is wedge-shaped with its apex at the point of embolism, toward the root of the lung and its base toward the periphery often in relation with the pleura. The base is covered with an inflammatory pleuritic exudate and the wedge-shaped mass can be readily felt in the lung. On section a recent infarct appears purple or black, dry and shining with a smooth or somewhat granular surface. About the infarct is a bright red area of congestion and sometimes considerable edema. The embolus is often found at the apex of the infarct as a more or less whitish mass obstructing the lumen of the vessel.

The explanation of the hemorrhage that takes place into the lung area, from which the pulmonary blood supply is cut off, is still in dispute. Cohnheim's theory that it was due to back flow from the capillaries and veins has been disproved. It has been shown by Kuettner and Litten that infarction may occur with both the artery and vein tied off, but that if the vessels from the aortic system—namely, the bronchial arteries and branches from the diaphragm, mediastinum, pericardium, esophagus, and trachea—are all cut off it does not occur.

In other words, it seems necessary to have some collateral circulation set up before the hemorrhagic extravasation can occur, but if this is too free the embolus is not followed by infarct formation. Infarction occurs most frequently when the lungs are hyperemic and Willgerodt has shown that this hyperemia (stasis) predisposes to infarct formation by preventing the establishment of a free collateral capillary circulation. The collateral flow being too weak to overcome the back pressure from the veins, the capillaries become gradually distended until extravasation occurs and the infarct is the result.

Ranvier and Duguet have shown that there is an interval sometimes as long as two to three days between the embolism and the final formation of the infarct and explain the later process as the result of rupture of the vessel proximal to the embolus, due to inflammatory disintegration of its walls.

At times the circulation in an infarcted area may be reëstablished and absorption gradually occur, but usually a fibrous scar takes the place of the infarct. As has already been mentioned metastatic abscess, gangrene, or tumor mass may result if the embolus contains animate matter.

Symptoms.—Embolism of the larger vessels may cause sudden death or syncope. If death is not immediate, sudden and very severe dyspnea, a rapidly dilating heart with palpitation, pain in the precordium, and marked cyanosis are followed by death in a few minutes, or a few hours at the most.

In some cases the immediate symptoms are less severe, pain in the side and dyspnea followed later by bloody expectoration. Some of these patients recover but more die from recurring attacks of dyspnea and asystole.

In making the diagnosis, the etiology is of the greatest importance; such symptoms occurring in a patient the victim of a phlebitis, or a crushing fracture or following delivery makes the diagnosis clear, while without this sort of history it may be extremely difficult to rule out angina pectoris or acute dilatation of the heart from other causes.

In embolism of the smaller vessels resulting in hemorrhagic infarct, the symptoms are somewhat more definite. Pain in the side coming on suddenly with a chill and later expectoration of bright unchanged blood, bloody mucus, or dark blood are quite characterisite when associated with a weak dilated heart or especially a mitral stenosis of marked degree. Later a small area of dullness may be found at the base of one lung with bronchial breathing or diminished breath sounds. A friction rub may be heard if the infarct is superficial.

In some cases there may be no bloody expectoration and no pain, thus rendering the diagnosis very uncertain, but the development of an acute pleurisy with some of the above etiological factors present, especially acute endocarditis, will warrant the diagnosis (Gerhardt).

In some cases fever may occur but this is not always the case. If the infarct becomes infected then the fever assumes the septic type and the sputum becomes that of pulmonary abscess or gangrene.

The prognosis depends upon the size of the vessel that is plugged. Complete occlusion of large vessels always terminating fatally. When only the smaller vessels are involved the result depends upon the cause of the embolus and upon the prospect of repetition of the lesion.

Treatment is largely preventive. Patients with phlebitis must be kept quiet in bed for from five to six weeks and all movements of the affected parts must be avoided as far as possible. When the embolism has occurred the heart must be supported with digitalis and caffeine, and the dyspnea relieved by oxygen, counterirritation, and cupping, the treatment of the cause being carried out also.

Henry Lynde Woodward.

Lungs, Neoplasms of the.—Primary tumors of the lung have usually been regarded as quite rare. This is, I think, an erroneous notion. About twenty-five cases a year are recorded in the literature. When we consider, however, the difficulties attending the diagnosis of the condition, the fact that autopsies cannot always be obtained, and that doubtless many cases are not reported, it would seem that the condition is more common than has been supposed. Secondary growths in the lung are, of course, frequent enough, these organs being in many cases the site of election for metastatic deposits. Benign growths, being usually of small size, and giving rise to few or no symptoms, are generally only discovered accidentally at autopsy. The tale of these is therefore small. Some idea of the frequency of primary malignant neoplasms of the lung may be obtained by a reference to the postmortem records of some of the large European hospitals. Rolleston and Trevor found only eight cases of primary malignant disease in 3,983 autopsies. In 21,034 sections in Munich there were seventeen cases of primary carcinoma. At Breslau, Pässler found sixteen cases of carcinoma and four of sarcoma in 9,246 autopsies. Reinhard and Wolf reported forty-three cases in 20,116 at Dresden. At the Charité in Berlin, Karrenstein in 10,272 cases found primary malignant growths of the lung in 0.31 per cent. Combining these statistics, primary malignant tumors of the lung occur in 0.18 per cent. of all autopsies. Compared with cancer of other organs, primary cancers of the lung amount to 1.48 per cent.

With regard to the relative frequency of primary carcinoma and sarcoma of the lung it is extremely difficult to reach a correct judgment. It has generally been held that carcinoma is more common than sarcoma. Rolleston and Trevor believe the contrary. Undoubtedly, many of the earlier cases diagnosed as carcinoma were really endothelioma, which being a growth of mesothelial origin, has more in common etiologically with the sarcomas than the carcinomas. If, further, we exclude from the category of primary tumors of the lung, as some seem disposed to do, those cases which originate in the bronchi, there can be little doubt that the sarcomas form the largest proportion of the pulmonary primary new growths. It would seem, however, to be a somewhat difficult matter in many cases to decide from what structure a pulmonary malignant growth has originated, and any classification on this basis must be largely fallacious.

In the matter of sex incidence, according to Pässler, seventy-three per cent. of primary cancers of the lung occur in men. Secondary cancer is usually said to be more common in women, owing to the relative frequency of cancer of the breast and uterus, but West rather doubts this.

Both carcinoma and sarcoma may occur at the extremes of life but in general conform to the rule that carcinoma is more frequent after middle life, and sarcoma before it. According to Swan, carcinoma is most common between the ages of fifty and sixty, and sarcoma between thirty and forty. The earliest case of primary carcinoma of the lung is that reported by M'Aldowie in a child of five and a half years. Baumann and Bainbridge record a case of round-celled sarcoma in a child aged three years and eleven months. At the other end of the scale sarcoma has been met with at sixty-seven, and a number of cases of carcinoma are reported at seventy and upward.

Benign Neoplasms.—The primary benign tumors of the lung afford considerable variety, but are so rare that they are of pathological rather than clinical interest. They can rarely be diagnosed during life, and usually give rise to no symptoms. The forms described are fibroma, lipoma, lipomyoma, myoma, papilloma, osteoma, enchondroma, chondroangioma, lipochondroadenoma, mucous adenoma, and colloid adenoma. Teratomas, dermoids, and others are also reported.

Probably most, if not all, of the tumors described as *fibromas* are not properly to be classed as blastomatous, but are, rather, more or less circumscribed areas of induration resulting from irritation or inflammation. We see these, for example, around deposits of coal pigment or other foreign matter, and in healed tubercles. As such do not possess independent growth they are not true tumors.

Lipomas are very rare. They are found usually beneath the pleura, or between the lobes of the lung. One case of a submucous lipoma growing in the wall of a bronchus has been reported by Rokitansky.

Laboulbène, quoted by H. Chiari, examined a tumor, apparently a lipomyoma, which had developed in the bronchial submucosa.

An example of *myxoma* has been reported by Virchow.

Intrabronchial *papillomas* have been met with by Williams.

Osteomas are distinctly rare. Care must be taken not to confuse with these tumors the calcified areas which are so often found in old tuberculous foci and in the walls of chronic cavities. Metaplasia of fibrous tissue into bone, which is observed not infrequently in healed inflammatory lesions, also should not be regarded as a tumor growth. Virchow met with an irregular spicular mass in the upper lobe of one lung, which he regarded as an osteoma. Rindfleisch has reported a case of multiple osteomas.

Enchondroma is found in the form of small rounded masses as large as a pea or hazelnut, so small and so inert as to give rise to no symptoms. It is usually taught that these originate from the wall of the bronchi, but, as a matter of fact, this association has only exceptionally been made out. They are commonly found near the hilus of the lung, but also in the parenchyma near the surface. As some of them have attained a relatively large size and also involved the lymph nodes at the root of the lung, they are probably to be regarded as cases of chondrosarcoma. Enchondromas of the lung may also be metastatic. The growth is usually encapsulated and lobulated, and composed of hyaline, more rarely elastic, cartilage. Calcification, myxomatous degeneration, and even ossification have been observed. Virchow has described a highly vascular form under the name of enchondroma telangiectodes; Siegert, an analogous tumor as chondroangioma.

Teratomas come in a class by themselves. They are rare in the lung, some six cases only being known according to Latase, mostly dermoids. Albers has recorded a case of a cystic tumor of the lung in which hairs were discharged in the sputum for many years. Zipkin has reported a case of adenorhabdomyoma in a stillborn female child and refers to a similar case of Helbing's. These forms are apt to be associated with some congenital anomaly of the heart.

Malignant Neoplasms.—The malignant tumors of the lung are carcinoma, endothelioma, and sarcoma. The first and last mentioned are usually secondary; the second, most often primary.

Primary malignant disease may on both pathological and clinical grounds, be conveniently considered as affecting three sites, the root of the lung, the main body of it, and the pleura.

Primary *carcinoma* of the root of the lung is usually of small size, unilateral, and characterized by the presence of much connective tissue. Its main effects are secondary, due to the pressure upon, and other interference with the bronchi, blood-vessels, and lymphatics of the lung.

The affected lung is usually smaller than its companion, and when cut into is found to be occupied at the root by a small, hard, whitish mass which extends along the bronchi, becoming thinner and less conspicuous as one approaches the periphery. Extension apparently takes place along the peribronchial lymphatics. The new growth is firm and cuts like fibrous tissue. The contained bronchi are often notably compressed. Where preserved, they are inflamed and may contain pus. Occasionally, the new growth extends through the wall of a bronchus, forming an ulcer or papillary outgrowth on the inner aspect. Microscopically, the tumor is of the scirrhous type.

Carcinoma of the body of the lung is considerably more common than that of the root, and may form a large growth weighing several pounds and occupying the greater portion of the organ. Several forms have been described. In one, one or more large soft somewhat isolated masses are found in the neighborhood of a bronchus which is included in the growth, originating either from the wall of the bronchus or from its associated mucous glands. This form is of the medullary type. Another variety, very rare, takes the form of multiple disseminated nodules of miliary size or somewhat larger, scattered throughout the lung. The massive cancers are slightly more frequent in the right lung than in the left. On the right side the upper lobe is affected twice as often as the lower. On the left side the incidence is reversed.

Primary cancer of the pleura has been described under the terms "columnar-celled carcinoma," cylindrical-celled carcinoma," and "epithelial cancer." Most of these were reported many years ago and doubtless would be classed now as endotheliomas. Inasmuch as there are no glandular or epithelial

elements in the pleural membrane true carcinomas of this membrane cannot exist unless one uses the term "carcinoma" entirely in the histological sense.

These tumors may occur in the form of small flattened discrete patches of whitish color on the pleural surface, or the membrane may be nodular, or, again, uniformly thickened, firm, fibrous, almost suggesting cartilage.

When we come to consider the mode of origin of these pulmonary cancers we enter a somewhat debateable field. Three possibilities may be mentioned. The new growth may arise from the bronchial mucosa, the epithelium of the bronchial mucous glands, or from the alveolar epithelium. The difficulty in deciding from which of these structures the cancer has developed in any given case lies in the fact that the cancer cells do not necessarily remain true to the type from which they sprang. Metaplasia of cells is quite common, and in many of these carcinomata epithelial cells of all varieties may lie side by side. Tumors, for example, that have clearly arisen from the columnar cells of the bronchial mucosa may contain transitional, polyhedral, and squamous cells. In a case described by Siegert the cylindrical cells of the bronchial mucous membrane gave rise to a tumor composed of squamous cells. Conversely, growths which, with hardly a doubt, have arisen from the flattened lining cells of the alveoli have produced tumors composed of columnar cells. The majority of cancers of the lung contain cylindrical cells and are situated in the bronchial walls and this association can hardly be accidental. There can be but little doubt that pulmonary cancers usually originate from the bronchial mucous membrane or from the secreting cells of the bronchial mucous glands. That malignant tumors can originate from the alveolar epithelium is also to be accepted, though such instances are rare. That the alveolar epithelium can proliferate atypically, forming papillary outgrowths into the alveolar spaces may be observed in several chronic processes in the lung such as passive congestion, syphilis, indurative pneumonia, as, also, in the neighborhood of malignant growths. In such cases metaplastic transformation of the squamous cells into cylindrical ones has been noted, and it would seem to be extremely probable that such unstable cells might readily on occasion give rise to malignant growths. Friedländer has reported a case in which the carcinoma developed from the squamous cells overlying a tuberculous scar in the bronchial wall.

Under these circumstances it is not hard to understand that carcinomas of the lung will evidence considerable variability, and that it will often be impossible to determine from what particular structure they have arisen.

The form which arises in the bronchial wall, composed of anastomosing strands of cubical and cylindrical cells, held together by a stroma derived from the peribronchial connective tissue, is the most frequent. Those consisting of masses of polymorphous cells, or of squamous cells with cell-nests and keratinization, are less common.

The stroma in carcinomas of the lung is usually scanty, but in the older tumors and in those originating at the hilus of the organ may reach a considerable amount, in some cases constituting a veritable scirrhus.

As in malignant growths elsewhere degenerative changes are common, mucous and fatty degeneration, liquefaction and necrosis. In cases where the tumor involves a bronchus infection may occur with the production of suppuration or even gangrene. Concretions, calcareous or amylaceous, may be found. In one case ossification in the stroma of a squamous celled cancer has been described (Siegert).

Primary *endothelioma* may originate in two ways, from the subpleural lymphatics or from the deep lymphatics. Many of the tumors involving the pleura or the root of the lung come under this category. Histologically considered, there is in many cases a practical identity of endothelioma and carcinoma, and the difficulty of differentiating these two forms of tumor is very great. In both we may find masses of cells of epithelial type filling up the lymphatic channels, and it is often impossible to say whether such cells constitute an intrusion into the space or are, on the other hand, a derivation from its lining membrane. Which is the explanation in any given case must be largely a matter of opinion.

Sarcoma of the lung is in most cases secondary. Of fifteen cases collected by West, only five were primary. All varieties are reported, round-celled, spindle-celled, mixed-celled, giant-celled, lymphosarcoma, melanoma, chondrosarcoma, and osteosarcoma.

The primary sarcomas are apt to be large, involving a lobe, or even the whole of a lung. In one case the growth extended through the diaphragm into the abdominal cavity.

Metastases from cancers of the lung are met with most frequently in the regional lymph nodes, in the other lung, and in the liver, next in frequency in the pleura, pericardium, and bones. Secondaries, however, may be found in almost every organ of the body.

Secondary malignant growths in the lung are not infrequent. According to Reinhard, they are about fifteen times as common as the primary growths. The original tumor is usually to be found in the breast, pleura, stomach, pancreas, œsophagus, liver, or uterus. In the case of sarcoma the primary growth is generally in bone.

Secondary tumors in the lung are usually multiple and may involve both lungs. They reproduce more or less faithfully the characters of the growth from which they originate. An interesting secondary growth in the lung, though one entirely different from those we have mentioned, as it belongs to the teratoblastomas, is the chorioepithelioma, which, developing in the uterus, gives rise to metastases by preference in this organ.

Secondary new growths may reach the lung in one or other of three ways: by direct extension from neighboring parts: by means of the blood-vessels or lymphatics leading from remote districts: and through the air passages. Thus, the disease may reach the lung by direct extension from the neck, mediastinum, the thoracic walls, or the abdomen. Usually, in such cases the tumor mass is well localized and unilateral. Where the original growth is deeply seated, as in the mediastinum, the pulmonary or pleural manifestations are usually the first to become evident, and it is generally impossible to diagnose whether a primary or a secondary involvement of the lung is at work.

Or, emboli of cancerous cells may reach the lung by way of the blood-vessels from some distant organ. In this case, we find multiple foci of new growth scattered through both lungs of variable size. Miliary carcinosis has been described but is rare.

Again, cancerous material may be carried from some focus in the abdomen, the breast, or neck, by means of the lymphatics, thus reaching the mediastinum or pleura, and thus involve the lung. Cases have been known also to invade the thoracic duct, particles of cancerous tissue in this way being carried into the venous system and eventually into the lung.

Finally, carcinoma of the larynx, trachea, tongue, and pharynx, may invade the lung by the mediation of the air passages.

Secondary sarcomas develop in the lung as the result of embolism, except in the case of mediastinal lymphosarcoma where the invasion appears to be by direct extension. Usually both lungs are involved. Rarely, there may be one metastatic deposit only.

The local effects of tumors of the lung are of some variety. The growth may spread until it has involved

the greater part of the lung, and may then extend to the pleura, mediastinum, the regional lymph nodes, or cause secondaries in more distant parts. If a bronchus be invaded a fungating mass may be formed within its lumen, parts of which may be coughed up. Detached particles may be carried to other portions of the bronchial tree, where they may set up inflammation or secondary growths. In one interesting case (Peacock) a cast of the tube was formed of tumor material which was expectorated.

The first effect of the new growth upon the lung tissue itself is to cause compression. Where large masses are present the intervening parenchyma usually shows emphysema. If a bronchus be compressed or invaded in such a way that air cannot enter it, the corresponding lobules of the lung collapse and become airless and edematous. If the blood-vessels and lymphatics be obstructed in addition we get exudation, partly serous, partly cellular. Under such conditions inflammation may supervene and we may get a form of bronchopneumonia. Such areas may soften in their centers and abscess formation, or even gangrene, may result. If the necrotic material can escape by way of a bronchus a cavity may result. The cavities found in the lung in cases of cancer are rarely due to softening of the new growth itself, but nearly always are to be attributed to the degeneration of inflammatory foci.

Should the new growth reach the pleura, inflammation of that membrane, with exudation, either serous or hemorrhagic, is apt to occur. Adhesions may form by means of which the growth may extend to the chest wall. Empyema has also been reported. One of the rarest events is the production of pneumothorax. This occurred in one case of secondary sarcoma of the lung which I saw in consultation about two years ago. The primary tumor was an angiosarcoma of the testis.

The etiology of malignant growths of the lungs is that of malignant disease in general. Irritation and trauma play a relatively important part. Injury to the chest wall has been noted in some cases. Ancke has pointed out the frequency of carcinoma of the lung among the cobalt workers of the Schneeberg district.

Symptoms.—The symptoms referable to benign growths of the lung are usually trifling, and the condition is unsuspected. Even in the case of the malignant tumors symptoms may for long be in abeyance, and when they do develop none of them is pathognomonic. Sometimes the first evidence that anything is wrong presents itself when some complication, such as pleurisy, pneumonia, abscess, or empyema, sets in. The character and variability of the symptoms is dependent on the number, size, and position of the new growths. The presence of complications, naturally, increases the difficulties of diagnosis, and, indeed, the primary condition may be overlooked.

The history of the case, the bodily wasting and loss of strength, and the cachexia will often suggest the possibility of malignancy. The most frequent symptoms are dyspnea, cough, and pain in the chest.

Dyspnea is an uncertain feature and may not appear until later on. Its occurrence seems to depend largely on the rapidity with which the mischief in the lung develops. Large, slowly growing tumors may cause little or no disturbance of respiration, the lung having time to adapt itself to the altering condition. In the case of rapidly growing tumors and in disseminated carcinosis dyspnea may be a marked feature.

Cough is not often troublesome and is often absent. Its severity depends upon the amount of secretion within the tubes and the difficulty of its elimination. It may be paroxysmal.

Despite the statements in the text-books, there is nothing pathognomonic about the *sputum*. Its characters depend less upon the existence of a malignant growth in the lung than on the presence of associated conditions. Some writers lay stress upon the occurrence of a thin, mucoid, purplish-brown sputum, which has been compared to prune juice. Others have described a reddish gelatinous material like raspberry or red currant jelly. Or, again, it may be nummular, mucopurulent, and of a bright green color. In fact, the sputa found in cases of malignant disease of the lung have their counterpart in abscess of the lung, bronchiectasis, pneumonia, and tuberculosis. Should portions of tumor be coughed up in the expectoration this would, of course, clinch the diagnosis, but this event is rare. Lenhartz regards as of diagnostic significance the occurrence in the sputum of large spherical cells, filled with a multitude of fatty granules, and associated with many epithelial cells which are curiously deformed, having club-like projections. As these cells are inconstant in their incidence the sputum should be examined frequently.

Pain is a variable feature, often absent, but may be severe. Its presence seems to depend on involvement of the pleura, or pressure upon nerve trunks within the chest. It may be neuralgic in character, affecting the side of the thorax and passing down the arm. Sometimes, in cases where pain is absent, there may be a sensation of pressure or constriction within the chest.

The *decubitus* of the patient is often suggestive. He will naturally assume that position which lessens pain and facilitates the breathing. This position varies. Sometimes it will be on one side or the other. Most often he will prefer the dorsal position with the head and shoulders elevated.

In regard to the *physical signs*, two distinct classes of case are to be recognized, according as the involvement of the lung is superficial or deep. In a general way it may be said that the subjective signs are more pronounced in the case of the deep-seated lesions, the physical signs in the superficial ones.

If the tumor be superficial the signs are commonly those of an affection of the pleura, dulness on percussion, and diminution or absence of the breath sounds. There is apt to be pain, but dyspnea and pressure symptoms may be entirely lacking. In the case of large growths or extensive pleural effusions, the affected side of the chest may be distended, and the respiratory movements will be hampered. Occasionally, the physical signs are most marked at the base, and, if at the same time the temperature be elevated, the condition may be confused with empyema. In some instances, as a matter of fact, empyema has been present. A movable line of dulness on posturing is a valuable sign, indicating effusion rather than infiltration.

When the primary tumor is at the hilus of the lung the physical signs are most puzzling. In the earlier stages of the affection they may be absent. The percussion note will not be altered unless there be secondary changes in the peripheral portions of the lung. Should, however, edema or consolidation of these parts occur, the physical signs become those of pleural effusion. The chief symptoms in the case of radical tumors are those of pressure on nerves, vessels, the bronchi, or esophagus. Gradually increasing dyspnea is a feature in this form of carcinoma. As the tumor grows some of the bronchi may be filled up and collapse of the corresponding lobules will follow. The breath sounds are then diminished or completely absent. In advanced cases contraction of the fibrous tissue and collapse of the lung bring about retraction of the chest wall. The arm on the affected side may be swollen and edematous and the veins on the chest may be distended. Other signs are, displacement of the heart, pressure on the esophagus, causing difficulty in swallowing, and pressure on the recurrent laryngeal nerve, leading to alterations in the voice and brassy cough.

Diagnosis.—Much difficulty attends the diagnosis in cases where the tumors are small and disseminated, as in the condition styled carcinosis. Here the signs are those of bronchopneumonia, and if at the same time the temperature be raised the condition is usually mistaken for tuberculosis.

A word or two should be said about the association of tuberculosis and cancer in the lung. Rokitansky thought that the two conditions were incompatible. Experience has proved that this is not so. There is no inherent antagonism between cancer and tuberculosis. Epithelioma of the skin may develop in a patch of lupus, for example, and carcinoma has been known to start in the wall of a tuberculous cavity of the lung. The truth is that the existence of tuberculosis is no protection against carcinoma and *vice versa*. It is this fact which sometimes makes a difficult question still more difficult in the matter of diagnosis.

In persons suffering from malignant disease elsewhere, the occurrence of symptoms or physical signs referable to the thorax will in most cases be correctly interpreted as the result of secondary involvement of the lungs. A double pleurisy, for example, if not tuberculous, would suggest carcinoma.

It is in the cases of primary carcinoma of the lung that the greatest difficulties in diagnosis will arise. The age, the cachexia, the rapid loss of flesh and strength, should be enough to arouse a suspicion of carcinoma, even if the physical signs are not sufficient to locate it. Deeply seated tumors are scarcely susceptible of diagnosis, until at least they have gained much headway. Pressure symptoms will then arise and suggest mediastinal tuberculosis, aneurysm of the aorta, new growths or cysts involving the peribronchial glands and hilus of the lung. Aneurysm of the aorta is so often a manifestation of syphilis that a negative Wassermann test would tend to exclude this possibility. Even in advanced cases the diagnosis will often be little more than a guess.

The difficulties in arriving at a correct conclusion lie in the fact that the symptoms and physical signs of pulmonary malignant disease are similar to those in other and more common diseases. Also, the primary affection is often masked by the complications to which it has given rise. A systematic and repeated search of the sputum will show whether tubercle bacilli are present or not, or if there are any cells which are characteristic of cancer. Puncture of the lung with a rather coarse needle has been suggested in order to withdraw a portion of the lung tissue which may then be examined microscopically. When pleuritic effusion exists one should consider what is the cause of the pleurisy. In cases of tuberculosis and cancer of the pleura the effused fluid is sometimes hemorrhagic though by no means frequently. Diculafoy gives a suggestion as to how these two affections may be differentiated when hemorrhagic pleurisy is detected. The fluid should be centrifuged. If then the supernatant fluid remains pink in color, in short, if there is hemolysis, this indicates cancer. No hemolysis suggests tuberculosis. This observation I have found correct in the case of sarcoma also. Very dark, almost black fluid is in favor of carcinoma. The discovery of the presence of empyema should not be held to negative the existence of carcinoma of the lung, though it is true that the association is rare.

Complications on the side of the lung itself often cause even greater difficulties. Some of these conditions are edema, consolidation, and softening. The signs may all point to effusion into the chest, but thoracic puncture may fail to locate fluid. When the chest is punctured under such circumstances a sense of resistance and solidity in the lung, if encountered, should suggest new growth. Inflammatory or degenerative softening of the lung tissue may lead to the diagnosis of tuberculous cavitation, abscess, or gangrene. In one case, related by West, puncture of the pleural cavity obtained a small quantity of pus. Subsequent investigation showed that this had come from a cavity at the base of the lung. The examination of the sputum, here again, for *B. tuberculosis*, elastic tissue, cancer particles, will be of assistance. The course of the case may give sufficient indication as to what is the real trouble.

Temperature is not a feature of malignant disease of the lung, unless complicated by secondary inflammatory conditions.

Examination of the blood should be made in doubtful cases. Kappis has pointed out the occurrence of a marked grade of eosinophilia in pulmonary carcinoma, and the same thing has been noted in some cases of lymphosarcoma. In one of his cases he found the percentages of leucocytes as follows: in a total leucocyte count of 50,560, the polymorphonuclear cells formed 54.2 per cent., the eosinophiles 38.2 per cent., lymphocytes 5.1 per cent., and transitionals 2.5 per cent. The *x*-rays may be of help in locating tumors of the lung.

Prognosis.—According to Walsh, the average duration of cancer of the lung is 13.2 months. Osler makes it much less, 6.8 months. In the case of secondary growths life is rarely prolonged beyond a few weeks. Secondary sarcoma may be rapid or prolonged. Death may occur in a few weeks or life may be preserved for as much as two, three, or four years.

Treatment.—This, as one can well imagine, is unsatisfactory. Most cases are only diagnosed after the disease is far advanced and beyond remedy. Little can be done except in the way of palliation and in relieving complications. Attacks of pneumonia and pleurisy may be treated on the usual lines. Pain may have to be relieved by the free use of morphia. Any measures should be adopted which will add to the comfort of the patient.

With the introduction of differential air pressure apparatus, and the consequent improvement in lung surgery a new era in the treatment of tumors of the lung has been entered upon. Seydel, who studied this question in the autopsy room found that 9 per cent. of lung cancers and 9 per cent. of pleural cancers were operable. 26.9 per cent. of pulmonary sarcomas were operable and a slightly higher percentage of pleural sarcomas. The actual successes in the way of operation are few, but yet encouraging. Lenhartz removed a carcinoma of the right upper lobe, and the patient lived for at least two years. Garré removed successfully a carcinoma of the pleura. Péan has removed a chondroma and Tuffier an angioma of the lung. Doubtless, with earlier diagnoses and improved methods and increased skill in operating, the record of successes will be considerably improved.

Albert George Nicholls.

Lungs, Physiology of.—See *Respiration*.

Lungs, Pseudotuberculosis of the.—The term "Pseudotuberculosis" is one that possibly needs some defense. Tuberculosis, strictly speaking, is a pathological process characterized by the production of tubercles or granulomas of a special kind. In this wide sense, tuberculosis may be caused by a great variety of microorganisms, and, taking this view of it, the qualification "pseudo" is not required. However, the appellation "tuberculosis" has come to mean by common consent that form of disease produced by the bacillus of Koch, so that all those varieties of tubercle formation due to other causes may with some show of reason be called "pseudotuberculous." In other words, "pseudotuberculosis" is a blanket term, used for convenience, to include those forms of tubercle formation in the lung that simulate the type disease, but are not due to *B. tuberculosis*. The main objection to the term, however, lies in the fact that it groups under the

one heading affections that are etiologically widely different. It, therefore, lacks precision. It is difficult, however, to do away with the term after so many years usage.

Etiology.—A considerable number of microorganisms, both vegetable and animal, are now known to have the power of producing tubercles, macroscopically and microscopically indistinguishable from those produced by *B. tuberculosis*. Certain of these, belonging to the bacteria, both in their morphology and their staining reactions so closely resemble this bacillus, that they are with difficulty to be differentiated from it. In this connection we may mention the smegma bacillus, the butter bacillus of Rabinowitsch, the grass bacillus of Moeller, and the leprosy bacillus, all of which, together with *B. tuberculosis*, are included in what is called the "acid-fast" group. While all the forms mentioned are competent to produce tubercles in experimental animals, none of them, with the exception of *B. leprœ*, seems to do so in man. The smegma bacillus has been found in the sputum in cases of gangrene of the lung, and has given rise to an erroneous diagnosis of tuberculosis. It would seem to be an associated finding rather than the actual cause of the cavitation.

In the lower animals, particularly rats and mice, pseudotuberculosis has been found which was due to an organism closely resembling that of hemorrhagic septicemia (pseudotuberculose zoöléique). In a few instances this is said to have been transmitted to human beings.

Among the higher bacteria found in such cases mention should be made of *Actinomyces bovis* and other forms of streptothrices. Flexner, in 1897, described the case of a man who had the local and constitutional signs of pulmonary tuberculosis, in whom the bacillus of Koch was not found but a streptothrix. To this disease he gave the name Pseudotuberculosis hominis streptothricia. Wolff and Israel, and, later, Norris and Larkin, have described similar cases, also due to a streptothrix, which has been named *Streptothrix israeli*. The saccharomyces, also, may give rise to lesions resembling those of tuberculosis, and it may well be that some of the anomalous cases of phthisis in man are due to organisms of this class.

More authentic are those cases due to moulds, such as *Mucor corymbifer* (Fürbringer, Paltauf) and *Oidium albicans* (Grawitz). More common and, therefore more important, are the forms resulting from infection with the hyphomycetes, notably the aspergilli, the pneumonomycosis aspergillina of Saxer.

Passing on to the animal parasites which can give rise to the lesions of pseudotuberculosis, we may mention the coccidioidal or blastomycetic types, described by Reckford and Gilchrist, and Ophüls and Moffit. Here the lesions in the lung are secondary to an infection of the skin.

Higher still in the scale are certain worms, such as the strongylus, which, with its ova, may give rise to serious trouble in the bronchi and lungs, chiefly in domestic animals.

A very striking affection, usually found in the tiger, cat, dog, and pig, has been met with in India and Africa, the chief symptom of which is hemoptysis. This is due to a trematode worm or fluke, *Paragonimus westermanni*, which gains a lodgment in the bronchi. Stiles, some years ago, collected sixty-six cases in man. The disease has occurred in the United States.

Lastly, lesions resembling those of tuberculosis, may be caused by foreign material in the lung. The most common and insignificant example of this is found in the tubercles resulting from anthracosis. An analogous affection, due to stone or iron dust, is much more serious and may produce a slowly advancing and destructive fibrosis of the lungs.

Morbid Anatomy.—Not much need be said under this heading. The various pathological agents referred to above, like *B. tuberculosis*, can give rise to three types of lesions: an acute abscess formation, the more chronic granuloma, and a chronic indurative fibrosis. The clinical findings will depend upon the nature of the process at work, and are in most respects like those of tuberculosis.

Diagnosis.—In any case which gives the clinical picture of tuberculosis and a persistent search fails to reveal the characteristic bacillus of Koch, one should think of one or other of the diseases classed under the category of pseudotuberculosis. Where the members of the "acid-fast" group of bacilli are at work, confusion with true tuberculosis is likely to occur, unless proper care is taken in the differentiation of the bacilli found in the sputum. In general, it may be said, that while all the members of this group resist decolorization by the action of mineral acids, they react differently with absolute alcohol. *B. tuberculosis* is the most resistant to this agent and will retain its color for half an hour under its action. The other acid-fast bacilli are decolorized in a few minutes, *B. leprœ* the most quickly of all. To avoid errors, the following method should be adopted. Stain the film made from the sputum for five minutes in warm carbol-fuchsin; wash in water; cover with 33.3 per cent. nitric acid for ten seconds; wash in water; wash in several changes of absolute alcohol for three minutes; wash in water; and counterstain in Loeffler's or Kuhne's blue for half a minute. Under this test *B. tuberculosis* is the only one which will appear deeply stained red.

In the absence of any one of the acid-fast bacilli, one should search for streptothrix forms or actinomyces. Here Gram's method will be of value. Actinomycosis may be recognized by the presence of the so-called "sulphur grains" in the sputum. These, under a low power lens, will present the characteristic rosette appearance. Moulds can be recognized by the presence of mycelium and fragmented portions, resembling, but much larger than bacilli. Culture and inoculation experiments will assist in differentiating the various forms.

So far as I know, *Treponema pallidum* has never been recognized in the sputum in pulmonary syphilis, and it certainly is rare in the lung lesions, except in the congenital forms.

Eggs of parasites, and the adult worms themselves, can be recognized under the low power of the microscope.

Only the most interesting and important forms of pseudotuberculosis of the lungs will be described here. Syphilis of the lung, which closely resembles tuberculosis, is dealt with elsewhere.

Paragonimiasis.—This affection is caused by the lung fluke, which gains a lodgment in the bronchi. Infection takes place, supposedly, from drinking-water. The parasites resemble in shape small almonds and attach themselves first to the bronchial mucous membrane. They burrow through the lung in various directions, producing intercommunicating sinuses, some of which may connect freely with the bronchi. The bronchi are much inflamed; cavities are produced, which contain the parasite and its eggs, tissue débris, inflammatory exudate, and hematoidin. Round about the tracks and cavities the lung may be consolidated. Hemoptysis is the most striking symptom. Recovery is the rule.

Actinomycosis.—Actinomycosis is an affection caused by a special fungus, *Actinomyces bovis*. This organism is present in the discharges in the form of small yellowish rounded masses about the size of a pinhead. Under the microscope they present a tangled mycelium with radiating filaments which terminate in clubs. By Gram's method the mycelium stains blue and the filaments can be traced into the clubs which stain pinkish. The general arrangement is that of a rosette.

Actinomycosis is mainly a disease of cattle, but occasionally is met with in man. The organism appears to be present upon grass, hay, or cereals, and gains entrance to the body usually through the mouth, presumably at the site of small abrasions. In man, as in cattle, the commonest site for lesions to develop is about the jaws, the buccal mucous membrane, and the skin. Cases have been known to originate from picking the teeth with a straw, or in one instance a needle.

With regard to the relative frequency of pulmonary actinomycosis we may cite the figures of Rutimeyer, who found twenty-two examples of primary pulmonary or pleural involvement in 105 published cases of the disease.

Incidence.—The disease is most common between the ages of twenty and forty, but may occur at any time of life. The left lung is twice as often involved as the right. The lower lobe of the lung, and especially the lower lobe of the left lung is the site of election for invasion.

The lung may be attacked primarily or secondarily. In the primary form it is presumed that infection has occurred through the air passages. This may in some instances be due to the inhalation of infective material from the buccal cavity. In an interesting case reported by Israel a fragment of tooth was found in an actinomycotic cavity of the lung. Secondary infection may be traceable to direct extension from some neighboring part, as the mediastinum, œsophagus, or liver, or by metastasis through the blood. In the latter event, multiple lesions may be found in other organs. In one of my cases, in which the liver was the primary seat, multiple actinomycotic abscesses were found in the lungs and kidneys. A pyemic form of actinomycosis is recognized in which the infective agents are disseminated by the blood to almost every part of the body. This is said to occur most often in connection with primary actinomycosis of the lungs.

Pathogenesis.—As in the case of tuberculosis, we can recognize miliary, chronic ulcerative, bronchopneumonic, and indurative pulmonary actinomycosis. In the metastatic form multiple acute abscesses are found which closely resemble ordinary pyemic abscesses, but can be recognized by the demonstration of the specific fungus.

The miliary form of infection is a blood infection and may be part and parcel of a generalized systemic dissemination of the disease, or, may be due to the extension of an actinomycotic focus and the discharge of its contents into some branch of the pulmonary artery.

In the bronchopneumonic type the course of events is much the same as in the case of tuberculosis. A bronchitis is first set up, which extends to the neighboring lung parenchyma, causing an accumulation of epithelioid, catarrhal cells, and leucocytes in the alveoli. In time giant cells may appear. Gradually the blood-vessels are obliterated and a form of necrosis sets in, so that the center of the granuloma assumes a yellowish-white color. The longer the case lasts the greater is the extent of the reactive inflammation and the greater the production of connective tissue. When softening occurs cavities may be produced, which contain the specific fungus, pus cells, red blood corpuscles, cell detritus, and fluid. Eventually, the lobe or the greater part of it becomes densely indurated and riddled with cavities and sinuses, resembling the fibrocaseous form of tuberculosis. Round about the older foci may often be seen small subsidiary nodules of more recent development.

In well-advanced cases, as in tuberculosis, the disease process may extend to the pleuræ, pericardium, mediastinum, the heart, or even the peritoneal cavity and contained organs. But actinomycosis, unlike tuberculosis, has a special tendency to attack the chest wall, which may be extensively involved. Pointing abscesses may form which discharge externally through unhealthy looking granulating sinuses. A scanty thin pus escapes which contains the fungus. It is remarkable sometimes how comparatively unobtrusive are the primary lesions in the lung when the secondary disease elsewhere is extremely well marked.

When the serous cavities are involved, there may be a simple serous effusion, or a purulent one, or again, there may be actinomycotic granulomatosis with extensive adhesions. Amyloid degeneration of the various organs has been noted in a few cases, not necessarily those associated with the greatest amount of suppuration.

Clinical History.—The onset is usually insidious and the disease may be unsuspected until the bronchi are involved or a pleurisy supervenes. In the first instance, cough and expectoration excite attention, and in the latter, pain in the side. The pain may be constant, dull and aching, or sharp and lancinating.

Occasionally the disease begins suddenly with a sharp febrile attack, simulating pneumonia, which comes to an end in a few days, only to recur again soon after.

The development of the symptoms is usually slow, and the general health at first is fairly well preserved. Sooner or later, however, the patient gradually loses flesh and strength, the temperature rises, and the pulse is accelerated. In the late stages the fever is of the hectic type. Most cases end fatally in less than eighteen months. The shortest duration recorded is five months, the longest probably three years. The cause of death is usually exhaustion, but may be due in some cases to involvement of some vital organ, like the heart or brain.

Physical Signs.—The sputum is nummular and mucopurulent, and will show the so-called sulphur granules of actinomycosis. Occasionally, there may be an admixture with blood, thus simulating pneumonic sputum.

The objective signs are usually those of pleurisy with effusion. There is dulness at the base of the lung, with diminished vocal fremitus and resonance. In cases of long standing there may be retraction of the affected side. Exceptionally, the voice and breath sounds have been exaggerated, with numerous crackling râles, and evidences of cavitation.

Differential Diagnosis.—Cases of pulmonary actinomycosis bear the greatest resemblance to tuberculosis. The mode of onset, course, and duration are not unlike. As a rule, tuberculosis attacks the apex of the lung: actinomycosis, the base. Occasional exceptions to this rule have occurred. The persistent absence of *B. tuberculosis* is a strong point against tuberculosis. Finding the ray fungus in the sputum or pleural exudate, of course, at once decides the nature of the case. Usually cases of actinomycosis are diagnosed as pleurisy or empyema, less often as indurative pneumonia with bronchiectasis. As a matter of fact, pleurisy or empyema are present very commonly in well-marked cases. The cause is the only matter in doubt. It is a striking fact that actinomycosis gives rise to very little purulent discharge. If then, in the event of evident signs of empyema, an operation be undertaken, and but little discharge be obtained in proportion to the physical signs, one should think of actinomycosis. The same thing holds good in regard to psoas abscess of actinomycotic origin. In one case which came under my observation a large abscess pointed at Poupart's ligament. This was incised and the operating surgeon was surprised to get only a small amount of thin seropus. A persistent sinus formed, in the walls of which the ray fungus was ultimately demonstrated.

Syphilis of the lung may be diagnosed by finding a positive Wassermann reaction, or signs of syphilis elsewhere in the body, together with failure to discover the presence of the actinomyces.

Cases have been mistaken for malignant disease. This latter is rarely associated with hectic fever, however. The previous history of the case, the clinical

course of the disease, and the character of the pleural exudate will serve to differentiate the two conditions.

In hydatid disease, diagnosis may be made if one finds hooklets or bits of membrane in the sputum. In the case of pleural effusion, a clear fluid, poor in albumin, and of low specific gravity speaks for hydatid disease. In doubtful cases the complement fixation test may be tried.

Prognosis.—This is very grave. Practically all cases are fatal. One, that of Netter, was cured by potassium iodide.

Treatment.—The great improvement that follows the use of potassium iodide in cases of actinomycosis of the skin is a strong argument in favor of its employment in the pulmonary affection. It should be pushed to the limit. Where the pleura is involved the disease is usually so extensive that not much is to be expected from treatment. In cases that are attacked surgically, any cavities should be injected with iodoform emulsion and iodoform gauze carried into the sinuses.

Aspergillosis.—This is a granulomatous disease of the lungs due to one of the pathogenic aspergilli, usually the aspergillus fumigatus. The aspergillus niger has been reported to be present in some cases, but there is some doubt as to the accuracy of the observation. The resemblance clinically to tuberculosis is close. Anatomically, the disease is not unlike actinomycosis.

Historical.—The first case of pneumonomycosis was described by Hughes Bennett in 1842. A fungus was found in the sputum and the lung cavities of a person suffering from phthisis. Rayer, about the same time, and, later, Gairdner (1853) described somewhat similar cases in which, in tuberculous subjects, the pleura was invaded by a fungus. Bristowe, in 1854, reported a case, regarded by him as tuberculous, in which there were two communicating cavities in the apex of one lung, on the septum between which was an efflorescence of mycelium. In 1856, Virchow described several cases of aspergillary mycosis of the lungs and bronchi, and subsequently other observers recorded similar cases. All these were regarded as examples of secondary infection.

Dieulafoy, Chantemesse, and Widal, in 1890, described from the clinical standpoint several cases of pulmonary aspergillosis occurring in persons who were fattening pigeons for the Paris market. They advanced the view that the affection was a primary one. Seven years later Renon brought out the most complete monograph that had appeared on the subject, dealing with it from an experimental as well as the clinical side.

Etiology.—Pulmonary aspergillosis is one of the trade diseases, being found in those undertaking the artificial feeding of pigeons and in those who manipulate hair. It is rare outside of Paris. The causal infective agent is the aspergillus fumigatus, spores of which may be intermingled with grains, seeds, or flour. The pigeon feeders fill their mouths with a watery mush of canary and other seeds and transfer this to the birds. Thus, any spores of the fungus may readily pass into the air passages. Hair sorters make use of rye flour to facilitate the separation of the hairs, and the atmosphere of their badly ventilated workshops becomes impregnated with dust which, if it contains the spores, becomes very poisonous. The disease is, naturally, more likely to occur among millers, farm laborers, and those brought closely into contact with grain.

It was at first thought that the specific fungus produced its effects in the lung by mechanical irritation merely, but Bodin and Gautier have proved that *Aspergillus fumigatus* produces a definite toxin. Experimental animals vary in their susceptibility to this substance, and it is a singular fact that pigeons, which are readily infected by the spores, are more resistant to the toxin than are rabbits.

Morbid Anatomy.—So few cases of pulmonary aspergillosis have been studied that our ideas in regard to the lesions produced are somewhat fragmentary. As with tuberculosis, and other forms of pseudotuberculosis, there appear to be both acute and chronic manifestations. We may infer that all forms originate from the bronchi. The bronchi in some cases are thickened, in others, dilated, and about their terminations are small areas of pneumonic consolidation, tending to necrosis and softening. In the dilated bronchi and the cavities the specific fungus can be recognized. The intervening lung structure shows evidences of emphysema, compensatory in character. The pneumonic areas conform to the type of granulomatous inflammation, and in the more chronic forms the aspergilli tend to be arranged somewhat after the fashion of actinomyces. Renon calls this form "abortive" as he considers that here the resisting powers of the tissues is great and that of the microorganism relatively weaker. In the extremely chronic cases an interstitial pneumonia is produced, and the specific fungus may or may not be found in the tissues at autopsy. Cases have been described in which true tuberculosis has been superadded to aspergillary disease, and in two at least, curiously enough, the specific exciting agent of each disease has disappeared.

Symptoms and Physical Signs.—Three main clinical types have been met with, an acute, a chronic, and an emphysematous.

Acute pulmonary aspergillosis has been described by Baccarani, two of whose cases died in seven and nine weeks respectively.

In the chronic form, we have at first signs of bronchitis, with cough, an expectoration of mucopurulent character, sometimes blood stained, and fever. Then, there may be evidences of consolidation at the apex. Pleurisy may complicate the picture. The specific mycelium is found in the expectoration. The course of the disease is slow, and if the fungus be completely expectorated, healing takes place with fibrous induration of the affected portion of the lung.

In the emphysematous form attacks resembling asthma are a feature. There is frequent racking cough, with nocturnal dyspnea. Hemoptysis is uncommon. There is loss of weight and strength, and the disease may run a rapid course.

Mixed forms of the disease also occur, in emphysematous cases signs of consolidation supervening, and in the chronic ones, attacks simulating asthma. It should be noted that the aspergillus may be a secondary invader, the case at first being one of tuberculosis with the bacillus of Koch in the sputum, the aspergillus being subsequently found in the sputum and in the necrotic cavities.

Diagnosis.—This will depend on the discovery of the specific fungus in the sputum. Short of this, there is no way of differentiating the disease from bronchitis and emphysema or from tuberculosis. Where both aspergilli and tubercle bacilli are found, the history of the case will be necessary for one to decide which is the primary infection. When an organism suggesting the aspergillus is detected, it must be differentiated from streptothrix, the streptothrix form of *B. tuberculosis*, and actinomyces. To do this will usually require cultivation and animal inoculation.

Prognosis.—The disease is relatively slow in its progression, tends to spontaneous cure, and never gives rise to disseminated lesions throughout the body. The prognosis, in general, therefore, is more promising than in similar cases of tuberculosis. It is to be remembered, however, that even if the infective process comes to an end, it may leave behind a serious condition, such as chronic induration of the lung, which will lead to dilatation of the heart, and so to a fatal termination. The outlook in the emphysematous form, so far as one may judge from the few recorded cases, is less favorable than in the more chronic cases. Secondary complication with tuberculosis, of course, makes the prognosis still more grave.

Treatment.—There is no specific remedy. Experi-

ments on animals go to show, however, some beneficial effect from iodine preparations and arsenic, so that their employment in man would seem reasonable. It is imperative that the affected person give up his employment, and take up something enabling him to get plenty of fresh air. An out-of-door-life cod-liver oil, tonics, nourishing food, will assist a cure and lessen the danger of infection with tuberculosis. The rest of the treatment is symptomatic. Asthma may be relieved with iodide of potash, tincture of lobelia, stramonium. The bronchitis should be treated with expectorants, creosote, or turpentine, according to the indications. Hemoptysis is to be treated on the same lines as in tuberculosis.

Secondary Pulmonary Aspergillosis.—This occurs where the lung has already been damaged by disease, as in cases of tuberculous cavitation, bronchitis, bronchopneumonia, gangrene, pulmonary infarction, bronchiectasis, and malignant disease. We may infer the secondary nature of the invasion, when we find postmortem the specific aspergilli in some of the lesions and not in others. Most cases appear to be of the nature of terminal infections. It is a curious fact that in gangrene of the lung complicated by aspergillosis there is no fetor.

Pneumonoconiosis.—This is primarily a disease due to dusty occupations. The effect produced depends largely on the character of the dust gaining a lodgment in the lung. The disease is essentially chronic, beginning oftentimes as bronchitis and emphysema and eventually ending in fibrosis. Tuberculosis is often superadded.

Albert George Nicholls.

Lungs, Surgery of.—See *Thorax, Surgery of the.*

Lungs, Syphilis of the.—This subject is one of considerable importance, but it is a curious fact that it has received comparatively scant treatment in the average text-book on Medicine. Undoubted cases are somewhat rare in the literature and this may possibly account for the disease being regarded in general as of little practical moment. One can hardly doubt, however, that were physicians more alive to the possibility of its occurrence, and with our improved methods of diagnosis, the disease would be more frequently recognized than has hitherto been the case.

Historical.—Cases of pulmonary disease regarded as of syphilitic origin have been recorded for 150 years or more. The earlier papers, as will readily be understood, are little more than clinical histories with some speculation. Two main ideas stand out prominently in all this writing: that there is such a thing as a *phthisis e lue venerea*, and that a tuberculous phthisis may have a special character given it by the syphilitic virus. There can be no doubt that, until the improvement in laboratory technique and the advent of Koch's work, tuberculosis and syphilis of the lungs were frequently confused, and most of the cases reported as syphilis were really examples of the former disease.

Depaul, in 1853, was the first to give any account of the morbid anatomy of pulmonary syphilis, which he did in a communication to the Paris Academy, entitled "A Manifestation of Congenital Syphilis, consisting in an Alteration of the Lungs not yet described." Virchow clearly had doubts as to the genuineness of many of the cases reported as syphilis of the lungs, but was inclined to admit as syphilitic certain lesions of the lungs, particularly when associated with luetic manifestations elsewhere in the body. He described the gross appearances of all the forms of pulmonary syphilis recognized to-day, but the finer histological details are lacking. He was the first to describe the "white pneumonia" in infants, though it was Hecker who showed its relationship to congenital syphilis. Virchow also drew attention to the difficulty in differentiating gummas of the lung from other caseous foci, and notes that certain areas in caseous consolidation of the lung may liquefy and become cavitated. This raises at once the question as to the occurrence of syphilitic phthisis. Very little doubt seems to have been entertained in the minds of many clinicians of the time as to the actuality of its existence, owing, no doubt, to the influence of Virchow's teaching as to the non-tuberculous nature of most of the lesions of phthisis. With the discovery of the *B. tuberculosis* and the proof of its causal relationship to pulmonary phthisis, less has been heard on this matter. The first important monographs on syphilis of the lungs with reviews of the literature are those of Carlier (1882) and Hiller (1884). Of Hiller's eighty-four cases with autopsies, only twenty-eight can be regarded as syphilitic. Hiller does not admit the existence of a syphilitic phthisis and thinks that the cavities described in these cases were really bronchiectases.

Careful histological studies in cases of pulmonary syphilis have been made by Stroebe, Councilman, and, lately, Tanaka. All refer to the specific vascular changes, and the last-mentioned observer lays stress, as a differential point, on the presence of elastic fibrils about the blood-vessels and bronchioles. Reuter demonstrated the presence of the *Treponema pallidum* in the white pneumonia of hereditary syphilis. Tanaka, however, in five cases of acquired syphilis involving the lung could not detect this organism in the tissues.

Etiology.—The specific cause of syphilis, of the lungs as elsewhere, is the *Treponema pallidum*. Discovered by Schaudinn in 1905, the specificity of this microorganism has been put on an unassailable basis by the researches of Wassermann, Roux and Metchnikoff, and Noguchi. Considering the wide prevalence of syphilis, it is somewhat singular that the lungs should so frequently escape its ravages, for, with the exception of the congenital "white pneumonia" of infants, lues of these organs is distinctly uncommon. How can we explain this relative immunity of the lungs? This is hard to do, and in the present state of our knowledge our ideas must be largely speculative. The pathogenesis of syphilis is now fairly well understood. There is first the local lesion, the hard chancre, from which the infecting microorganisms find their way by means of the afferent lymphatics to the nearest lymph-nodes, eventually reaching the general blood stream, so that during the secondary period we have to do with an actual spirillemia. In the tertiary period the specific organisms have more or less completely been strained out of the blood and have become localized in the various organs. The syphilitic virus has the striking peculiarity of picking out the blood-vessels for its field of attack. We find therefore lesions such as aortitis, arteriosclerosis, aneurysm, and thrombosis, to be particularly common. The organs most often involved are the liver, brain, and spleen. But wherever the lesions of syphilis are manifested the process appears to begin, without exception, in the blood-vessels. Now, the treponema being carried by the blood stream to all parts of the body, and the lungs being extraordinarily vascular, one would, on the face of it, expect that these organs would at least be as often attacked as would, say, the liver. Contrary to what occurs in the case of tuberculosis, the lesions produced by syphilis in the lungs can rarely be attributed to infection entering by the mucosa of the nose, mouth, or respiratory passages. Syphilitic infection being in the vast majority of cases genital in origin, the involvement of the lungs will usually, therefore, be hematogenic. The fact that syphilitic lesions of the lungs are usually widely disseminated through these organs tends to support this view. It is, of course, possible that in the event of ulceration

of the trachea and bronchi the infective agents may invade the lung directly or by transference along the air passages to adjacent lobules of the lung, but even in this case infection is in its final analysis of hematogenic origin. The researches of Aufrecht, Ribbert, and Baumgarten in regard to the aerogenic transmission of tuberculosis go far to show that an inhalation infection from the upper respiratory passages is next to impossible. Still less can this possibility be entertained in the case of syphilis. Dieulafoy lays special stress upon the fact that in secondary syphilis the lesions in the respiratory system are confined to the air passages, larynx, trachea, and bronchi, while the parenchyma of the lung is without exception involved in the tertiary stage only. Laryngitis and tracheobronchitis are not at all uncommon in secondary syphilis, which has a distinct tendency to attack mucous surfaces. The mucous patches in the mouth are very possibly in a pathogenetic sense akin to the skin eruption, but modified by the conditions of heat and moisture incident to a mucous membrane. With the presence of numberless spirochetes in the buccal secretion, which can readily be demonstrated in these cases, it is practically certain that a similar condition of affairs would subsist in the respiratory tree. That the lung tissue itself is not more often involved is possibly to be explained on the grounds of a local relative immunity of the pulmonary tissue, or, it may be, the syphilitic virus, tending as it does to be disseminated by the blood and lymph streams, cannot readily gain a lodgment in the lung owing to the free circulation and the aid afforded by the respiratory movements. As supporting this last assumption it may be stated that in congenital syphilis of the lung ("white pneumonia" of infants), where in many cases the lung has never been properly expanded, and the circulation is relatively weak, spirochetes have been demonstrated in abundance in the affected lung tissue, while in the pulmonary syphilis of adults the organisms are extremely difficult to find. Both by way of the blood-vessels and by the lymphatic channels, which are in such intimate anatomical relationship with them, the drainage from the lungs is particularly free, so that infective agents are very readily carried off.

Pathogenesis.—I have noted the fact above that the syphilitic virus has a penchant for attacking the blood-vessels, and the lungs are not different from the other organs in this particular. The vascular lesions here, while not so obtrusive as some other features, are, nevertheless, constant and widespread. No matter which form of pulmonary syphilis we study we find the same thing, a mesarteritis of the larger and medium-sized vessels and an obliterating endarteritis and capillaritis of the smaller ones. In the case of the alveolar capillaries the lumen is often so reduced in size that it will not allow the passage of a single corpuscle, while in the advanced stages they may be shrunken, atrophied, or may finally disappear. Councilman, in a careful study of some cases which came under his observation, found a condition of hyaline degeneration of the capillary walls, as also, of the desquamated cells lying in the alveolar spaces. This he considers important. The most obvious feature in the anatomical picture of pulmonary syphilis is the more or less diffused interstitial pneumonitis and fibrosis. As it appears to be practically an absolute rule in pathology that the presence of new-formed fibrous tissue in an inflamed area predicates a previous destruction of tissue, we will probably be not far wrong in concluding that the primary lesion in pulmonary syphilis is the obstruction to the circulation due to the thickening of the blood-vessels and the encroachment upon their lumina. Following upon this, we get atrophy, hyaline and fatty degeneration, loss of tissue, and replacement by fibrous material. In the case of syphilis this fibrous tissue is very dense, with comparatively little round-celled infiltration, tending therefore to contract. We get, then, in cases where the disease is not universal in the organ, a much deformed and contracted lung, the *pulmo lobatus*, recalling the analogous condition in the liver. Between the contracted areas the lung tissue presents marked compensatory emphysema. Traction of the fibrous bands leads also to bronchiectasis and the formation of cavities. The fibrous tissue appears to be specially well developed in the neighborhood of the bronchi and larger vessels. Where the pathogenic process has been most severe we get regular gummas, which may be of all sizes, from a minute microscopic granuloma to a mass the size of a goose egg. A central degeneration, akin to caseation, may be observed in the larger foci. This may soften, giving rise to cavities. Gangrene has even been observed, this due doubtless to secondary invasion by putrefactive microorganisms. Thickening and adhesion of the pleura is common, and there may be effusion into the pleural sac, or even pyopneumothorax.

Morbid Anatomy.—Apart from the frank gumma, found in children and adults, and the diffuse syphiloma ("white pneumonia") of the new-born, both forms that can be fairly readily recognized, syphilitic manifestations in the lungs can be differentiated with difficulty from other cases of granulomatous inflammation, at least so far as gross appearances are concerned. From the strict anatomical point of view three types of disease may be recognized; the gumma, diffuse interstitial pneumonia, and generalized fibrosis. All three forms may, however, on occasion be associated.

Gummas are rare in the lungs of adults, but are somewhat more common in infants and young children. They may be single or multiple: are well defined, and may be surrounded by hyperplastic fibrous tissue or infiltrated lung substance. In appearance they are grayish red or grayish white in color, somewhat translucent, becoming later opaque and caseous. The oldest foci may undergo cavitation. Gummas may vary in size from that of a pea to that of a walnut or even larger. They are most frequently situated near the root of the lung where there is usually a considerable excess of fibrous tissue and the pleura in the neighborhood is also somewhat thickened.

Except that the lesions are localized and the area of necrosis is larger, the microscopical appearances differ in no essential particular from those of the diffuse syphilitic pneumonia. The blood-vessels frequently show thickening of the intima: a few are the seat of an obliterating endarteritis: many of them present one or two layers of elastic fibrils encircling them. The bronchioles are thickened also, owing to marked infiltration of the mucosa with lymphoid cells and concomitant congestion. This, with desquamation of the lining epithelium, leads to more or less complete occlusion of their lumina. The interlobular tissue shows fibrous hyperplasia, with hyaline transformation, and abundant blood-vessels. A few small areas of lymphoid cells may occasionally be seen. The alveolar walls are thickened, owing partly to hyaline change and infiltration with lymphoid cells. The alveolar spaces are greatly encroached upon and practically obliterated by swelling of the walls and the accumulation of cells, lymphoid, endothelial, and blood, within their cavities.

The appearances in the case of the *diffuse interstitial pneumonia* will vary somewhat according to the extent and intensity of the process. But, taking a fairly marked case of subacute or rather chronic duration, we find the following. In one or more lobes, there are multiple areas of consolidation, more or less connected one with the other. On section these are grayish red in color, dry, and smooth, some of them in the centers presenting sharply defined foci of caseation, projecting somewhat above the general surface.

The lung tissue intervening between the solid masses is firm and extremely edematous.

Microscopically, the caseous areas are for the most part very sharply defined, though some of the smaller ones in parts pass gradually into the surrounding tissues. Even in the caseous masses the outlines of the alveoli can often be seen, the alveolar walls being swollen and hyaline. The structure intervening between the caseous masses is fairly dense connective tissue, containing rather numerous spindle-shaped cells. In these parts the lung structure is practically destroyed, only a few thickened alveolar walls remaining. Here and there masses of fibrin can be seen. Around the smaller necroses fibrinous exudation is more marked. Where the induration appears to be less marked, the tissue is loose and edematous rather than fibrous, with very few cells. The alveoli here are small, irregular, and contracted, and lined with cuboidal cells. Many are filled with desquamated endothelial cells.

In those areas that to gross appearance are less affected by the fibrous transformation, the lesions appear to be more acute. In fact, these portions of the lung show the early advancing process. Here, the alveolar walls are more or less atrophied, the alveolar capillaries manifesting hyaline change. The alveolar spaces contain fibrin, proliferated and desquamated endothelial cells, occasionally erythrocytes, with masses of hyaline material. The capillaries, consequently, are thickened, the lumina narrowed, or, in places, even obliterated. The same obliterating process involves the smaller arteries and veins. It is noteworthy that even here fibrous transformation is in evidence, apparently starting from the neighborhood of the bronchi and arteries, and invading the alveolar walls. These walls are therefore thickened and contain numerous small, round cells.

Those portions of the lung outside of the areas of loose connective tissue present similar changes. Here, however, the alveoli are rarely completely destroyed and often may be recognized in small clusters of pale granular epithelial cells, scattered abundantly here and there. The bronchi show striking alterations. Their lumina are narrowed, owing to a fibrous hyperplasia in the mucosa, which either produces a concentric stenosis or a polypoid outgrowth into the cavity. The lining epithelium is usually well preserved but may be desquamated. Leucocytes are conspicuous by their almost complete absence, being found only at the margins of recent gummas and in a few alveoli. The larger bronchi show thickening of the perivascular tissues, degeneration, and metaplasia of the hyaline plaques of cartilage, and a marked round-celled infiltration of the mucous glands. The pallor of the lung is due in large part to anemia, though certain authorities reserve the term "white pneumonia" for those cases in which the color is due rather to an extensive fatty degeneration of the exfoliated alveolar endothelium.

Fibrosis.—Many authors recognize what might be termed a "cirrhotic" condition of the lung due to syphilis. Here bands of fibrous tissue permeate the lung substance in various directions. These bands appear to originate from the hilus or the pleura, and at these parts they may be more dense. E. C. Perry has recorded a case in which a lung was permeated by fine strands of connective tissue, having the appearance of a delicate network, less marked at the apex than elsewhere. The pleura was somewhat thickened and there were fibrous adhesions. The intervening lung substance was emphysematous. Microscopically, the lung was traversed by bands of dense fibrous tissue in which were numerous small areas of round cells, scattered here and there. There was no caseation and no giant cells. The vessels manifested endarteritis.

Symptomatology.—The disease to which pulmonary syphilis bears the most striking resemblance, from the point of view of symptomatology, is tuberculosis. Indeed, by the physical examination of the chest alone, it is not possible to make the differential diagnosis. Yet, it is of the utmost importance to recognize the syphilitic affection when confronted with it, for while the disease is a most serious one, suitable and timely treatment is competent to bring about the most astonishing and gratifying therapeutical results.

Following the analogy with pulmonary tuberculosis, we may recognize three main clinical types: (1) Acute syphiloma, with local or disseminated lesions; (2) chronic syphiloma, simulating chronic ulcerative phthisis; (3) chronic indurative pneumonia.

As occasional complications of the chronic forms, we meet with bronchiectasis and gangrene, it should be noted. While these forms are sufficiently puzzling in themselves, they become much more so when, as may happen pulmonary tuberculosis is combined with pulmonary syphilis.

The acute local syphiloma of the lung is due to the formation of gummas in various parts of the lung, usually, in the middle portion, less often in an apex, more rarely still, in other regions. Such lesions can be recognized by the presence in circumscribed areas of a dull or impaired resonance on percussion, tubular breathing, and subcrepitant râles. Should softening occur with the formation of a cavity, we get, later, the characteristic signs of this condition, cavernous breathing, pectoriloquy, and bronchophony. The expectoration is usually profuse, mucopurulent, and in the late stages nummular. The onset in these cases is fairly sudden, with high fever, severe cough, violent dyspnea, rapid wasting, and profuse perspiration.

Where the lesions are more widespread the clinical picture is that of an acute tuberculous bronchopneumonia. The symptoms are quite as acute and severe as in the local form just described.

Chronic pulmonary syphiloma begins much more insidiously and its progression is slow. At first it resembles closely bronchitis, pulmonary congestion, or bronchopneumonia. While the cough is troublesome, the appetite is good, and the patient does not waste. Fever is practically absent. Later, pain and dyspnea set in, which are worse at night. The appetite fails, wasting comes on and night-sweats occur. Eventually, evidences of cavitation appear, with hectic fever and cachexia. Hemoptysis is rare and usually restricted to fine streaks in the sputum. Rarely, it is profuse.

Chronic interstitial pneumonia of syphilitic origin differs little, if anything, from the chronic fibroses of the lung due to other causes. It may be suspected where the symptoms have been in existence for months or years. Cough, expectoration, possibly slight occasional hemoptyses, of long duration, and but little disturbing the general health of the patient, will cause us to think of the possibility of chronic indurative pneumonia. This possibility becomes a certainty if we find deformity and contraction of one side of the thorax. Paroxysmal discharge of large amounts of expectoration, particularly if it be fetid, will point to bronchiectasis. On percussion, dull areas may be found here and there, with spots of tympany, due to local emphysema or bronchiectatic cavitation. On auscultation, blowing breathing, cavernous breathing, coarse and bubbling râles, with gurgling will be heard. Adhesion of the pleura is common. In the earlier cases pleural effusion may be diagnosed. Dieulafoy is the authority for the statement that local or general bronchiectasis is the most rare of all the forms of pulmonary syphilosis. Bourdieu has collected a few cases of this type.

Syphilitic gangrene may come on with considerable suddenness. After a few days of preliminary malaise, the patient may complain of pain in the side, fever, cough, and expectoration. Physical examination may reveal at some point or other blowing breathing with

coarse moist râles. The expectoration is thin, dark, and horribly offensive. Later, if the patient do not die shortly, signs of cavitation will appear, with wasting and cachexia.

The association of pulmonary syphilis with pulmonary tuberculosis demands brief remark. A syphilitic patient may develop tuberculosis and a tuberculous one syphilis. There can be little doubt that these two diseases can develop quite contentedly side by side, if, indeed, one does not actively assist the other. There is certainly no inherent antagonism. In fact, experience would lead us to conclude that syphilis, w ether hereditary or acquired, actually predisposes to infection with tuberculosis. For tuberculosis of lymphatic glands, bones, joints, and skin are undeniably prevalent in children of a syphilitic stock. This is not surprising when we remember that syphilis is one of the constitutional diseases that produces most of the stunted, weakly, and rachitic individuals, who would naturally fall an easy prey to tuberculosis.

Tuberculosis may make its appearance in those who are in the secondary stage of syphilis, during the time when the roseola and mucous patches are in evidence, but this is distinctly uncommon. In such cases the outlook is grave, for the tuberculosis almost always runs its course in a few months.

Much more often, tuberculosis appears during the tertiary stage. Here the prognosis is not so grave, the tuberculosis tending to assume the chronic fibrous form, somewhat localized, and without fever.

It is to be noted that the association of syphilis and tuberculosis in the same individual does not produce a hybrid disease (scrofulate de vérole of Ricord), but the lesions arise and develop side by side independently and each on its own account. The anatomical proof of this is afforded by a case of Potain's, in which the autopsy revealed disseminated tubercles about an area of white syphilitic pneumonia.

Diagnosis.—As we have seen, the anatomical changes produced in the lung by syphilis bear a striking family resemblance to those produced by tuberculosis, and the similarity in the clinical features of the two diseases is even more pronounced. Differential diagnosis, therefore, requires great care and the exhaustion of all the laboratory means of examination. In a general way, we may say that should a patient who has the hall-marks of pulmonary tuberculosis, present an appearance of well-being out of proportion to the anatomical extent of his lesions, we should entertain the suspicion of the existence of pulmonary syphilis. Severe and disproportionate dyspnea, especially if worse at night, should also arouse suspicion. The localization of the lesions, while by no means absolute, will also aid us somewhat. An area of infiltration or softening about the middle zone of a lung, or at the base, should suggest syphilis. The apex of the lung is relatively less often attacked by syphilis than by tuberculosis. In every case, even where doubts have not entered our minds, we should make a routine examination of all parts of the body. Errors in diagnosis are more often made through sins of omission than through those of commission. The presence of syphilitic lesions elsewhere, roseola, mucous patches, gummas, periostitis, dental defects (including Hutchinson's teeth), diffuse interstitial keratitis, aural lesions, will raise our suspicions almost to the point of certainty. When the lesions of pulmonary tuberculosis have been diagnosed an examination of the sputum should be made in every case. The persistent absence of Koch's bacillus greatly supports the case for pulmonary syphilis, though it should be remembered that its presence does not necessarily exclude syphilis. As we have seen, pulmonary tuberculosis and syphilis may be combined. A strongly positive Wassermann or Noguchi reaction proves the presence of a syphilitic infection, with a few exceptions that are known to most. Scarlatina, yaws, and leprosy may give a positive reaction. The presence of the treponema pallidum in the lung, with the exception of the white pneumonia of hereditary syphilis, has so rarely been demonstrated that a search for this organism in the sputum or in the material removed by puncture of the lung, is likely to be futile. Should we be fortunate enough to meet with a combination of circumstances in which we have a positive Wassermann reaction, a persistent absence of the *B. tuberculosis*, and the coexistence of undeniable syphilitic lesions that we can see, no doubt can exist as to the nature of the case. Less than this will hardly be convincing. The final proof will be in the efficacy of antisyphilitic treatment. If under salvarsan and mercury the lung condition improves, and concomitantly with this the visible lesions of syphilis that are present clear up, the nature of the case is placed beyond question.

Prognosis.—Nowadays, with our improved methods of diagnosis and treatment, it is not likely that we will see the severe and advanced cases of pulmonary syphilis that used to be met with. The prognosis naturally depends on the character and extent of the lesions, an accurate diagnosis, and an efficient specific treatment. In cases where there is much destruction of the lung tissues, while life may be saved, and a sufficient degree of health restored, it would be too much to expect that no lasting effects will result. Shrinkage of the lung and thoracic wall, with permanent dilatation of the bronchi may follow, with all the secondary changes that this involves, chronic bronchitis, emphysema, and enlargement of the heart. Local gummas may be absorbed entirely and leave only small areas of fibrosis, while even a large cavity will shrink and become more or less obliterated in a most surprising way. The cases which give the best results are the acute, subacute, and chronic gummatous pneumonias. Here, restoration to health should be possible within a few weeks. It should not be forgotten in these cases that syphilis is a constitutional disease and after the lesions have apparently cleared we should satisfy ourselves that the disease is eradicated from all parts of the body. Otherwise the ultimate outcome must remain in doubt. The prognosis, then, is only bad in the most inveterate and cachectic cases; ordinarily, it is good.

Treatment.—The treatment is symptomatic and specific. Pain, dyspnea, and expectoration should be treated on general principles, much as one would deal with a case of tuberculosis. Once a diagnosis of actual or probable syphilis is made, vigorous specific treatment should at once be instituted. Inasmuch as pulmonary syphilis is a late lesion and, moreover, one of great gravity, involving danger to life and to the integrity of important organs, the treatment should be intensive and carried as far as possible to the limit. Intravenous injections of salvarsan should be employed at appropriate intervals, with, in between, the exhibition of mercury. Probably, the best method is to use the salvarsan once in three weeks until seven to ten injections have been made in all, mercury being pushed in the intervals to the limit of toleration. Where it is not possible or desirable to use salvarsan for any reason, reliance must be placed on mercury and the iodides. Any of the usual methods of employing mercury may be adopted, but Dieulafoy prefers daily injections of the biniodide. His method is to begin with one-sixteenth of a grain, gradually increasing the dose to half a grain. Fifteen injections form a course. He then gives thirty to seventy-five grains of potassium iodide daily for from ten to fourteen days. At the end of this time the injections with mercury biniodide are repeated. Mercury is more effective than potassium iodide in these cases. The Wassermann test should be applied several times after cure appears to have been attained, say at intervals of three, six, and twelve months, after the cessation of treatment. Only when the reaction

is persistently negative should we consider the patient free from danger. ALBERT GEORGE NICHOLLS.

Lungs, Tuberculosis of the.—PATHOLOGY.—The word "tuberculosis" is derived from the Latin *tuberculum*. The tubercle is a solid round elevation, resembling a pinhead, which may appear in any of the anatomical structure of man or beast. In tuberculosis the formation of the tubercle is due to the bacillus discovered by Robert Koch in 1882, and in all tuberculous lesions the pathological entity is this tubercle. This explains why it is incorrect to use the word "tubercular" instead of "tuberculous" when speaking of the disease due to Koch's bacillus of tuberculosis. "Tubercular" lesions, that is to say, pathological conditions resembling a pinhead elevation, may be found in leprosy, syphilis, and various other skin diseases and they may have nothing whatsoever to do with tuberculosis.

The tubercle of tuberculosis, according to some authorities is an aggregation of epithelioid, according to others an accumulation of giant cells. Concerning the origin of the giant cells there are two definite theories. Koch and Weigert in their writings defend the unicellular theory, assuming that the migratory cells containing the tubercle bacilli undergo nuclear multiplication and are thus transformed into giant cells. Arnold and Metchnikoff consider the giant cells to be of pluricellular derivation. They believe that these cells originate from the confluence of several swollen epithelial cells. For further elucidation of the pathology of this specific tubercle we must refer the reader to the article *Tuberculosis*. The only thing which must be added here in relation to pulmonary tuberculosis is that the tubercle caused by the bacillus of tuberculosis is very prone to undergo caseation which in the majority of cases is probably aided by the association of the microorganisms of tuberculosis with pus-creating bacteria.

ETIOLOGY.—Since Koch's immortal discovery of the origin of tuberculosis we know that the direct etiological factor is the bacillus named after its discoverer. It is a rod-like organism, acid fast, often branching, visible with the aid of proper staining and the high power microscope. (See Article *Bacteria*, vol. i., p. 838.) Although by diligent search the bacillus can usually be found anywhere where there is tuberculosis, it is in the secretion of the tuberculous lung that it is found most abundantly. It has been estimated that the pulmonary invalid who has an open tuberculosis can expectorate as many as seven billion bacilli in twenty-four hours, and it is in the expectoration of the careless or untrained tuberculous individual, who allows his sputum to dry, become pulverized and be inhaled by others as infectious dust, that we must look for in the main for the direct etiological factor in the propagation of tuberculosis.

Besides the infection caused by the inhalation of bacilliferous dust, one must bear in mind the possibility of transmitting tuberculosis through kissing, using the eating utensils without proper cleaning which have been used by tuberculous individuals, using the same handkerchiefs or towels, and lastly the transmission by droplet infection. During the so-called dry cough or when sneezing the tuberculous individual is apt to eject small particles of bacilliferous saliva which might prove a source of infection.

Not to create a phthisiophobia, however, it must be remembered that as a rule it requires a prolonged exposure and a strong predisposition (inherited or acquired) before these minor sources of infection can be productive of tuberculosis. Occasionally tuberculosis of the lungs can be traced to a tuberculous wound infection.

Next in importance to the inhalation method is ingestion. It is now generally conceded that tuberculosis can be contracted by the ingestion of food substances derived from tuberculous animals, particularly from the milk of tuberculous cows. The bovine type of the bacillus of tuberculosis has been found in ten per cent. of all children afflicted with tuberculosis. Whether the reason why the bovine bacillus is so rarely found in adults is because as a rule adults drink less milk than children, or whether tuberculosis in the adult originally of the bovine type has become latent and remained thus for some time during which period a morphological change of the bacillus has taken place, is a matter difficult to decide. Be this as it may, our knowledge of the direct origin of tuberculosis enables us at least to outline a careful and general prophylaxis to protect man and beast from infection by the germ of tuberculosis.

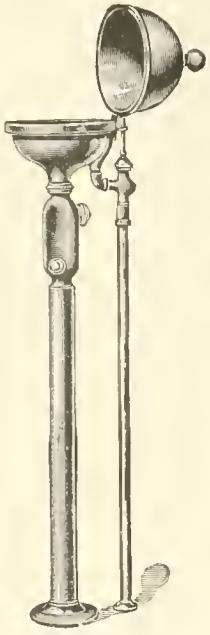

FIG. 3825.—Author's Self-flushing Elevated Spittoon with Cover.

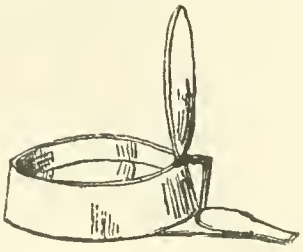

FIG. 3826.—Author's Metal Floor-Cuspidor; cover worked by the foot.

FIG. 3827.—Pasteboard Sputum Purse.

FIG. 3828.—Blue Glass Sputum Cup.

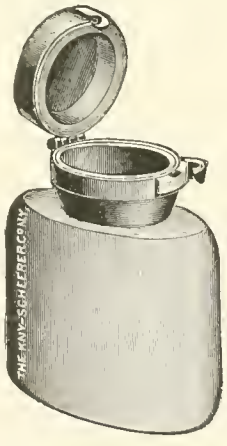

FIG. 3829.—Knopf's Nickel-plated Oval Pocket Flask.

INDIVIDUAL AND GENERAL PROPHYLAXIS.—Though it may be difficult to train children to suppress useless coughing and to cough only when there is secretion rising in the throat, every adult can and should be trained how to cough and when to cough; and all adults and even children over four or five years of age can be taught to expectorate only in a proper receptacle and never to swallow their expectoration.

By proper receptacle is meant any kind of fixed spittoon partially filled with water, elevated or on the ground, but always with cover (Figs. 3825 and 3826); paper, glass, or metal sputum cups (Figs. 3827, 3828, and 3829), or cheap handkerchiefs or cheese cloth cut into squares resembling handkerchiefs. Cheap handkerchiefs and muslin cloths are best disposed of by burning and when paper sputum cups or purses are used, receptacles and contents should be burned together. The sputum collected in fixed spittons and glass or metal sputum flasks should be disinfected and poured into water closets, or it may be destroyed by fire if this is more convenient. To avoid animals or insects getting at the tuberculous sputum, all receptacles for this purpose should be covered. Dogs have been known to have become infected by licking tuberculous sputum, and bacilli still virulent have been found in the excretions of flies and in their dead bodies. No nicked glass or porcelain spittoon should be permitted to be used lest a possible abrasion or wound of the skin result in a tuberculous inoculation. The individual entrusted with cleaning the receptacles should always wash his hands carefully before touching food substances, or, better yet, wear rubber gloves when doing that work.

Although the danger of tuberculous infection from the fecal matter and urine of tuberculous individuals is not so great, the possibility of an infection from these excreta should be borne in mind and the same precautions as for the proper handling and disposal of the sputum should be adhered to.

General prophylaxis must be understood to include rigorous and rigorously enforced bovine laws and antispitting ordinances. All herds of cows should be tuberculin tested and all people employed in dairies, entrusted with the handling of milk, butter, or cheese, should be examined for tuberculosis before receiving licenses. Not only employees in dairies but all those who handle food substances, vegetable dealers, bakers, butchers, etc., should not receive a license without being examined and found free from open tuberculosis, and these examinations should be repeated at stated intervals.

The breast milk of a tuberculous mother has been found to contain tubercle bacilli, and the tuberculous mother is rarely strong enough to nurse the child without endangering her own condition; therefore no tuberculous mother should be allowed to give the breast to her child.

Tuberculosis is not infrequent in swine and has its source usually in the feeding of these animals with dairy products coming from tuberculous cows. Proper measures for the prevention of bovine tuberculosis would probably do away with all tuberculosis in swine. Food remnants left by the tuberculous, particularly in sanatoria, should be subjected to sterilization before being fed to swine. This precautionary measure would avoid the possibility of swine becoming infected with the human type of tuberculosis. Pet animals, such as parrots, canary birds, dogs, cats, and apes are subject to tuberculosis and can be a source of infection; they should never be caressed, especially by children.

The prevention of the spread of tuberculosis from man to man by close contact can be summarized in one sentence. There should be no untrained or uncared-for tuberculous individual, man, woman, or child. The training of the tuberculous individual and those living with him must of course be done by the physician or trained nurse, but at the same time a universal education in schools and colleges, by popular lectures, distribution of popular literature in museums, moving picture shows, etc., must be added as a powerful help in the crusade against tuberculosis as a disease of the masses.

Predisposing Factors to Tuberculosis in Childhood.—Direct bacillary transmission of tuberculosis as a phthisiogenetic factor is well established. Through animal experimentation even the possibility of transmission of the bacillus with the spermatozoon has been demonstrated. Authentic cases of this type of direct transmission in man are, however, extremely rare. The infection of the placenta from a tuberculous mother is more frequent; but even this is only of relative frequency and it may be safely said that a direct bacillary transmission from parent to offspring is rare, or in other words, a specific disposition takes place in only a very small number of cases. It is the physiological strength or weakness of the two parents becoming one through the union of the ovum and the spermatozoon, which gives the child its physical heredity. From tuberculous parents or one tuberculous parent the child is apt to inherit what may be called a physiological poverty. This physiological poverty manifests itself in the growing child particularly in a deficient conformation of the thorax. The child may be flat-chested, or its chest may be cylindrical, but in both instances the upper osseous aperture of the thorax is usually considerably narrowed so as to hinder the proper ventilation of the apices of the lungs. The rest of the child's physique shows anemia with glandular enlargements, flabby skin, and tendency to chronic catarrh of the upper respiratory tract; in short, a condition which some authors have described as scrofulous diathesis, the whole tending to develop into the typical *habitus phthisicus*, so well described by Hippocrates.

This résumé of predisposing factors of tuberculosis in childhood would be incomplete would we fail to consider some of the sociological factors which still exist in spite of our vaunted civilization, such as malnutrition or underfeeding due to poverty or ignorance, and child labor in factory, cannery, or at home. What great predisposing factors to tuberculosis malnutrition and child labor can be, particularly in large families among the poor, has been demonstrated in many cases. In any large family, especially when not well provided for, it is almost invariably one of the latter born children, the fourth, fifth, sixth, etc., who first contracted tuberculosis. This can be explained on physiological as well as on social grounds. At the time of the conception of the earlier born children, the parents were more vigorous and lived in relative affluence, in less congested and consequently better environments. With the increase of the family there is very rarely a corresponding increase of income, hence the entire family live in more congested quarters and on less abundant and less good food. For want of means and to supply the increased demands the mother is perhaps obliged to go to work, and as a result less care is bestowed upon the later born children which are physiologically less well equipped than the earlier born. If later on child labor is added, all the conditions are such as to stunt the physical and moral growth of the child and prepare it for the invasion of the tubercle bacillus.

Treatment of Hereditary Predisposition to Tuberculosis.—As has been shown, the hereditary tendency manifests itself in childhood, and in order to overcome it one may lay down as a guiding maxim: Treat the predisposition to tuberculosis in a child as you would treat tuberculosis itself so that the disease may never develop. In a large percentage of adult cases (over fifty per cent. from the author's observations) a careful anamnesis will trace the disease back to tuberculous manifestations in early childhood. Ritter and Fehling[1] who made similar observations give the percentage as high as 82.5.

To combat this hereditary predisposition, we must first of all remove all possible sources of postnatal tuberculous infection of the human or bovine type. The child of a tuberculous mother should be nursed by a healthy wet-nurse or fed artificially with milk derived from tuberculin-tested cows. The mother and all other members of the family should be in-

structed in general preventive measures, such as refraining from kissing or using the eating utensils for the child which are used by the mother or any one

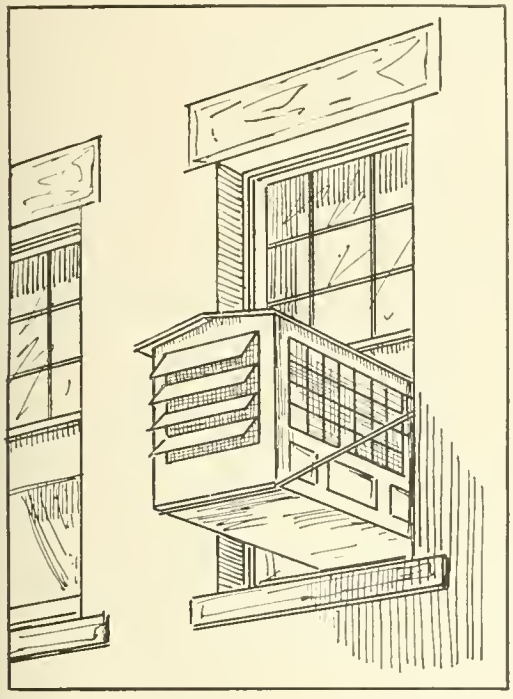

Fig. 3830.—Outdoor Window Crib of Steel in Position.

else without thorough washing. A number of cases have been reported where a postnatal tuberculous infection has resulted from more obscure sources, as, for example, from tuberculous midwives who still maintain that unsanitary habit of sucking the mucus from or blowing air into the mouths of new-born children when there is the slightest sign of asphyxia. Numerous cases of inoculation tuberculosis have been reported in connection with the Jewish rite of circumcision. The direct cause of this was the unsanitary practice of sucking the prepuce in order to stop the hemorrhage when the operating rabbi happened to be tuberculous. Such dangerous practices on part of midwife or rabbi should be condemned. A certificate from a regular physician, based upon careful examination and periodical reexamination, stating the absolute freedom from specific diseases (tuberculosis and syphilis), should be the *sine qua non* before a license to perform the operation of circumcision is granted to a rabbi. Another reliable measure against the possibilty of inoculating the child, when the parents insist upon the orthodox method of circumcision, is the suction through a glass tube, as practised in France and Germany.

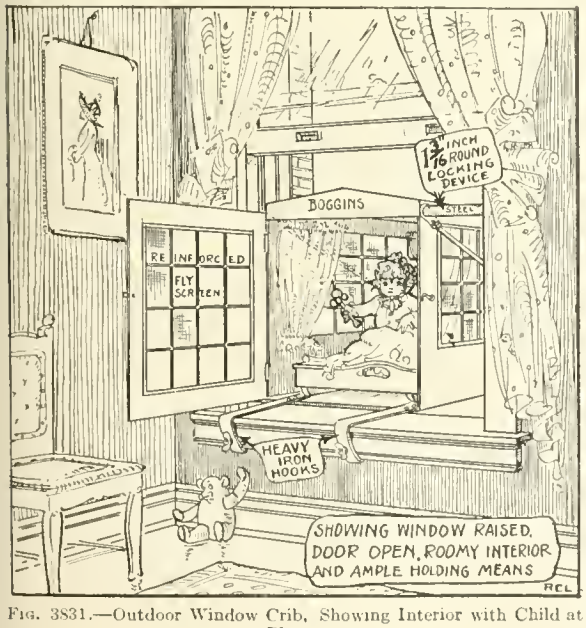

Fig. 3831.—Outdoor Window Crib, Showing Interior with Child at Play.

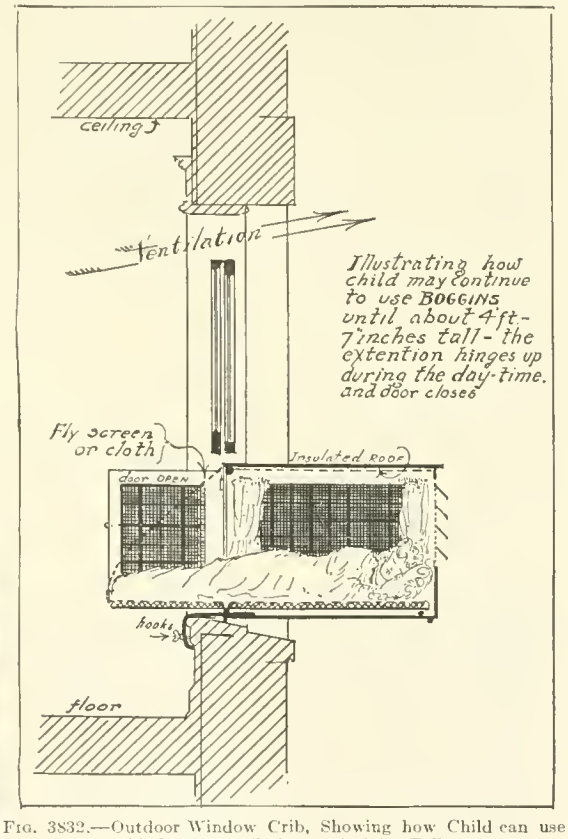

Fig. 3832.—Outdoor Window Crib, Showing how Child can use this Device until about 4 ft. 7 in. Tall.

In the tenement homes of the poor, a tuberculous border whose presence is often necessary to help pay the high rent, has not infrequently been the cause of a postnatal infection. From all this it will be seen that besides careful feeding, the best sanitary environment with plenty of fresh air and, if possible, even outdoor sleeping (Figs. 3830–3835) should be provided for the predisposed child.

As soon as the age and intelligence of the child permits, it should be taught breathing exercises. These should be kept up for many years with a view to enlarging the chest capacity, because the deficient thoracic frame will yield to expansion as long as bones and cartilages are not completely ossified. The illustrations show three exercises which are particularly adapted to open the upper narrow thoracic aperture referred to above. The child's throat should never be encircled by a tight collar and the young growing girl should not wear any restricting gar-

ment or corset. Adenoid vegetations, obstrueting nasal septa or polypi, and enlarged or diseased tonsils must of course be removed if the child should get the full benefit of the breathing exercises. The following are in brief the directions for these exercises:

In front of the open window, or better yet, out of doors, the child is taught to stand straight, body erect and hands at the sides. With the mouth closed he takes a deep inspiration, breathing in all the air possible, and while doing so raises the arms to a horizontal position; he remains thus holding the air inhaled for about three to five seconds (Fig. 3836,1), and while exhaling brings the arms down to the original position. The act of exhalation should be a little more rapid than the act of inhalation. When the first exercise is thoroughly mastered and has been practised for several days, one may begin with the second exercise, which is like the first, except that the upward movement of the arms is continued until the hands meet over the head (Fig. 3836,2). The third respiratory exercise is as follows: Place the hands one above the other in front of the chest, with the fingers bent. The arms and shoulders make a backward movement, the hands moving apart with a motion as though wanting to tear open the chest (the fingers remaining bent), while a deep inhalation is taken. The child holds the breath, counting four by tapping the chest four times with both hands, and at the fifth second starts to exhale, bringing the hands and forearms into the position from which they started. This exercise (Fig. 3836,3) has the advantage that it can be taken in the sitting position, or even when lying on the back.

Fig. 3833.—The Knopf Window Tent in Position with Patient in Bed Looking through Celluloid Window into the Room, but Breathing Outdoor Air only.

Fig. 3834.—The Knopf Window Tent when not in Use.

When it is not practicable to take these exercises, a simpler one can be substituted. The child is taught to raise the shoulders, making a rotary backward movement during the act of inhaling, remaining in this position, holding the breath for a few seconds, and then exhale while moving the shoulders forward and downward, resuming again the normal position. This exercise (Fig. 3836,4) can easily be taken while walking, sitting, or riding.

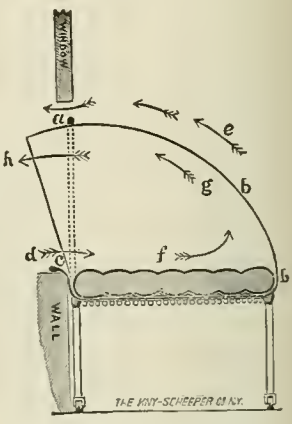

Fig. 3835.—Diagram Showing Ventilation of the Knopf Window Tent.

These exercises should never be taken when tired nor to the extent of getting tired, and all overexertions, physical or mental, should be religiously avoided for the child predisposed to tuberculosis. Plenty of outdoor play and plenty of sleep in pure, fresh and preferably outdoor air will do wonders for the predisposed child and will perhaps be the best security against a development of tuberculosis.

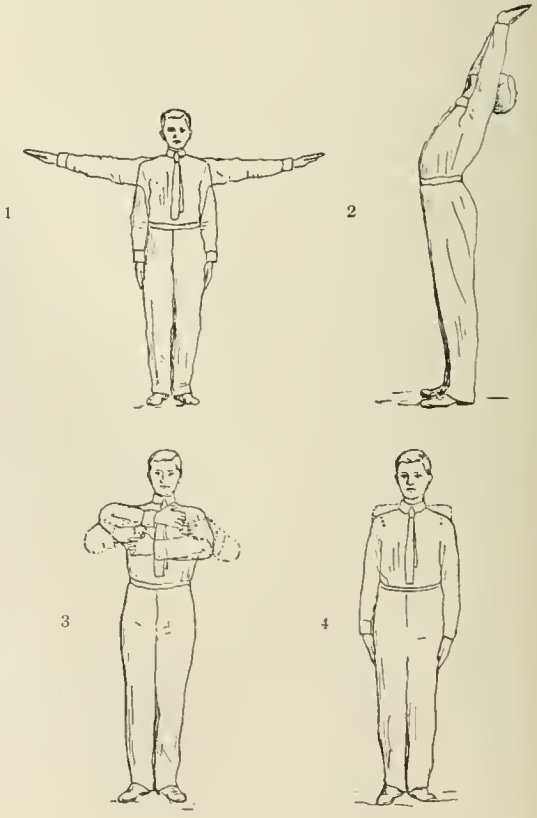

Fig. 3836.—Respiratory Exercises.

There is no question that the removal of the child of tuberculous parentage, particularly when living in the city and in unhygienic environments, will be a most efficacious means of preventing it from becoming a tuberculous invalid. It was this knowledge which inspired Grancher of Paris to stablish his immortal institution known as "L'oeuvre pour la préservation de l'enfance contre la tuberculose," whereby children of poor tuberculous parents living in Paris are boarded in selected homes in the country where they are regularly visited, watched, and from time to time reexamined by physicians especially qualified for the work. The results have been surprisingly good and show what can be done when predisposed children are taken care of at the right time and in the right environments under proper medical supervision.

In this country we have a few preventoria where children with a tuberculous diathesis are received and usually kept until a marked improvement in the physique can be noticed. Educational facilities are always combined with these institutions so that the intellectual development of the child will not be neglected. Another most important means to prevent the predisposed child from developing tuberculosis is the open-air class or open-air school, of which there are now a goodly number in the United States, but not by any means enough. We will hardly combat tuberculosis in childhood with any degree of success unless we make the open-air school the rule, particularly in the lower grades, and the indoor school the exception. Outdoor instruction should be resorted to throughout school life and even in colleges when possible, whenever the subject to be taught and the weather permit it. There are numerous subjects, such as geography, geology, botany, besides recitation and singing, which can be taught out of doors. The indoor classroom should always have the best of ventilation.

As an additional prophylactic measure we must make physical entrance examination and semiannual reexamination of all children and teachers attending public school obligatory. Thus, early tuberculosis will be discovered in the pupil and teacher and the chances of cure will be greatly increased. But concomitant with weeding out the tuberculous pupil and the tuberculous teacher there should be a sufficient number of sanatoria, preventoria, and open-air schools where the tuberculous teacher can teach and the tuberculous child can be taught under the conditions most conducive to recovery.

It goes without saying that good food is as essential to these teachers and pupils as good air, and suitable and nutritious warm luncheons, particularly in winter, should be provided for in all open-air schools.

To prevent or treat the social causes of predisposition to tuberculosis in childhood, such as malnutrition, unsanitary home environments, and child labor, we can suggest here only careful investigation of the home conditions of every undernourished child and the betterment of such by municipal and private philanthropy. Child labor as such should be considered a crime as it is unjust to both the child and the adult laborer. When there are so many idle men and women willing to work but who cannot find employment there surely should be no necessity for the employment of children. It would pay a community in the end to pension the large families of the poor instead of allowing the parents to send children between the ages of eight and fourteen to work in order to help in the support of the family.

Acquired Predisposition.—All debilitating diseases, be they of microbic or other origin, tend to predispose the individual to tuberculosis. The patient recovering from a grippe, pneumonia, pleurisy *a frigori*, typhoid fever, typhus, smallpox, measles, scarlet fever, or other exanthematous diseases, also pericarditis or other heart lesions, nervous affections, even surgical diseases, or a severe traumatic or mental shock, may have left him in a condition below par and thus he has become more susceptible to the invasion of the tubercle bacilli. While pleurisy *a frigori* and streptococcic infections of the respiratory tract may exist, in the vast majority of cases inflammation of the pleura is doubtless due to the bacillus of tuberculosis.

To this list of diseases which predispose the individual to tuberculosis from physiological and also from economic causes, must be added alcoholism, which after all is a disease. In the service at the Riverside Hospital Sanatorium at North Brother Island, where only advanced cases are received, coming from homes located in the most densely crowded and poorest districts of New York, we have been able to establish the following facts in the relation of alcohol to tuberculosis:

The statistics of two years ago show that of 579 male patients, 29 confessed to taking small amounts of alcohol, 256 to taking moderate amounts, and 121 admitted themselves to be excessive drinkers. Of the 147 females, 12 claimed to belong to the first, 23 to the second, and 2 to the last group. The following year, out of 297 males, 9 belonged to the first group, 121 to the second, and 71 to the third. Of the 121 females, 9 to the first, 9 to the second, and none of the women of that year admitted being excessive drinkers. For the male patients this means an average of 68 per cent. who were addicted to the use of alcohol to a more or less large degree.

Bertillon of Paris has shown that tuberculosis is twice as prevalent among the saloon keepers and liquor dealers in general as among other shop keepers. There is no question that the excessive and injudicious use of alcohol predisposes to tuberculosis and that the still popular but very erroneous conception that alcohol is a preventive and curative in tuberculosis has a good deal to do with the prevalence or severity of tuberculosis among the individuals inclined to or already afflicted with the disease.

Aside of the individual heredity or pathologically acquired predisposition there exist numerous other general factors which predispose the adult to tuberculosis. Contrary to the views of some authorities, particularly of the last century, we now find no geographical or climatic predisposition to tuberculosis. Tuberculosis is found everywhere in all lands and all climes. There is of course a difference as to the number of tuberculous individuals in one region of the globe or another, but this depends more upon the density of population than upon the geographical or topographical situation.

As to the frequency of pulmonary tuberculosis as compared with other forms of tuberculosis, from available statistics we have been able to compile the following:

Per 10,000 inhabitants there die from tuberculosis per annum in

Country.	Pulmonary tuberculosis.	Tuberculosis of other organs.
England	12.7	5.5
Scotland	15.5	6.9
Ireland	21.4	6.3
Germany	19.4	2.0
Italy	21.1	5.1
France	25.7	6.4
New York City	18.5	2.6*

As to age, it would seem that pulmonary tuberculosis in the adult is most frequently contracted, or to be more accurate, manifests itself most frequently between the ages of 20 and 25; next in order come the ages from 25 to 35, from 15 to 20, from 35 to 45, from 45 to 55, from 10 to 15, from 55 to 65, under 1 year, from 5 to 10 years, from 65 to 75, and least from 1 to 5

*Because of the incompleteness of the registration areas in the United States, New York only is given as a typical city.

years. In children, tuberculosis of other organs (glands, intestines, mesentery, etc.) is very frequent.

The fact that some large and densely populated cities, relatively speaking, have a smaller mortality from tuberculosis than many towns, can be explained as a rule by the better sanitary conditions in general and the more antituberculosis work in particular, instituted by municipalities. The fact remains nevertheless than wherever there are congestion and bad housing conditions, poverty and consequent underfeeding, there tuberculosis predominates. Concerning congestion as a predisposing cause, the following statistics are striking. Those from Berlin show that of all cases of tuberculosis 42 per cent. occur in families occupying 1 room; 40 per cent. occur in families occupying 2 rooms; 12 per cent. occur in families occupying 3 rooms; 6 per cent. occur in families occupying 4 or more rooms.

Maurice Fishberg investigated the housing conditions of 217 families living in New York, the greatest and wealthiest city of our continent. These families consisted of 1,369 persons of whom 1,129 lived at "home" in 717 rooms and slept in 658 beds. That is about two people to a bed and 1.57 to a room including kitchens. Of 274 tuberculous persons only 112 had separate rooms and only 136 had separate beds. Some consumptive mothers slept on chairs or on the kitchen floor. This state of affairs is usual in all industrial centers of the United States. The conditions of cheap lodging houses are equally striking and deplorable. The Health Department's statistics of New York show that the lodging houses with an accommodation of only 17,500 people furnish in tuberculosis hospitals and clinics combined 1504 cases, or 8.8 per cent. of the total number reported in Manhattan, although the lodging house population is only 0.75 per cent. of the total population. Mr. Charles B. Barnes[2] shows that the lodging house population is eleven times more subject to tuberculosis than the average population.

The percentage of tuberculosis in the majority of our prisons and reformatories is six times as high as among the population outside of prisons.

Concerning poverty as a predisposing cause, the well-known Hamburg statistics still stand as an example. They show that the highest mortality from tuberculosis is in families with a maximum earning of $300 per year, being three times as high as in families whose income is $1,250, and about four times as high as in families earning $6,000 a year. The statistics of Paris, tabulated by Bertillon, are equally striking. He divides the classes into the very rich, rich, very well off, well off, poor, very poor. Among 100,000 inhabitants there died of tuberculosis during a period of five years 907 in the very poor, 641 in the poor, 485 in the well off, 423 in the very well off, 241 in the rich, 159 in the very rich.

The ages of these patients were between forty and fifty-nine, when one should consider them at the height of their financial efficiency.

Tuberculosis cut short the lives of forty per cent. of the men whose widows and orphans were taken care of last year by the New York Society for Improving the Condition of the Poor. The minimum wage of these men was $8 and the maximum wage $18 per week.

It is well known that there are certain occupations which predispose to the pulmonary type of tuberculosis. We have already mentioned the retail liquor dealer who stands at the head of the list in nearly all countries, but in his case the cause of the great morbidity and mortality of tuberculosis should be ascribed to the ingestion of alcohol and not to his work. Men following an occupation involving the constant inhalation of vegetable or mineral dust are certainly rendered more prone to tuberculosis, particularly when their work is indoors. Highest in tuberculosis mortality stand the weavers and tailors, next in order come wood engravers, stone cutters, and workers in metal. The occupation of bookkeepers or indoor clerks predisposes to tuberculosis as much as that of the worker in metal. Miners, farmers, and bricklayers seem to be less predisposed to tuberculosis than others.

As to the frequency of tuberculosis in general the estimates differ, but it is safe to say that in the United States with all its territories, the mortality from tuberculosis is at least 200,000 per annum, and it may be equally safe to say that for every individual dying from tuberculosis there would be found to be at least eight living afflicted with the disease in a recognizable state, were they all carefully examined. That there are not more tuberculous individuals is due to an immunity which may have been inherited or acquired.

Immunity.—The hereditary immunity is difficult to explain, but we know of its existence. Thus, cattle as a rule are immune to the human type of the bacillus and guinea-pigs to the avian type. This hereditary immunity may also be called a race immunity.

The acquired immunity, as its name indicates, we attain during life. The vast majority of civilized mankind has at one time or another suffered from an attack of tuberculosis which has created a state of acquired immunity. Only thus can we explain why all mankind is not tuberculous. Further evidence of this is seen in the fact that where there is less prevalence of tuberculosis, the relative mortality from it is greater than where there is more tuberculosis in the population, that is to say, where there are many infected individuals the relative mortality is low, where there are few, the relative mortality is high. The wild tribes in various portions of the globe and the Indians in our own country are free from tuberculosis so long as they live isolated and do not come in contact with so-called civilization, but when they do become infected their mortality from this disease is unusually high. They have not had time to acquire immunity, and the course of the disease is usually a much more rapid one than in civilized regions. The apes, which most resemble human beings in their anatomical make-up, almost invariably contract tuberculosis when they are removed from their primeval forests and made to come in contact with human beings. Unfortunately, this naturally acquired immunity is not always lasting, or is only partial and therefore in our preventive treatment we try to increase it by the various hygienic, dietetic, and medicinal means. Thus far, we have not been able to create an absolute artificial immunity by heteroinoculation (injection of serum, or vaccine, or other culture products). In our attempts to produce an artificial or specific immunity we must bear in mind that living bacilli are necessary, and as their virulence is never stable, the immunity could of necessity be only transient. In reality, there does not seem to exist any absolute immunity, inherited or acquired, in the human race. We can speak only of a relative or imperfect immunity, which in turn may simply be explained by a heightened resistance to invasion or further spread of tuberculous disease. Besides increasing the resisting powers of the individual not at all or only partially immune, we must of course also seek to combat pulmonary tuberculosis by the earliest possible means of diagnosis so as to be able to treat the disease in its incipiency and by the best hygienic, dietetic, and therapeutic means at our command.

Diagnosis.—The *anamnesis*, a careful record of the family and personal history of the patient to be examined, as well as noting the present condition, is most essential. The following is a reproduction of the history sheet used by the author in private practice:

Date.	No.
Examination of M	Wife of
	Child of
Residence	Referred by
Occupation, formerly	Occupation, now
Age Born in	Married or single
	How many children living?
Social condition	How many children dead?
General Home hygiene	Bedroom Bed Windows

FAMILY HISTORY.

PERSONAL HISTORY.

Diseases of childhood		the 1st, 2d, 3d, etc., child of	
Lung affections		? living:	? dead:
Other severe diseases		Previous health	
Exposure to infection		Best previous weight:	
		When:	
Beginning of present affliction		Supposed exciting cause	
Hemorrhages, when:		Bloody expector, when:	
Night sweats	Chills	Fever	
Pain	Throat affection		
Digestive disturbances and bowels			
		Tea	
Personal habits Alcohol		Drugs	Tobacco
		Coffee	

PRESENT CONDITION.

General appearance	Skin	Height	Pres. weight:
Temperament		Nervous system	
Complexion	Hair	Fingers	Joints
Teeth	Tongue	Pupils	Glands
Heart	Pulse	Temp.	No. of Resp.
Cough	Expectoration		Dyspnea
Appetite	Digestion		Bowels
Sleep	General condition and strength		
Nose and throat	Other organs		
Bact. examination	Urine	Blood	
Form of chest	(see cyrtometric drawing)		
Character of Respiration			
Anterior-post. diameter:	Lateral diameter:		
Expansion, band:	Expans. accord. spirometer:		
Diagnosis, tentative:	Diagnosis, final:		

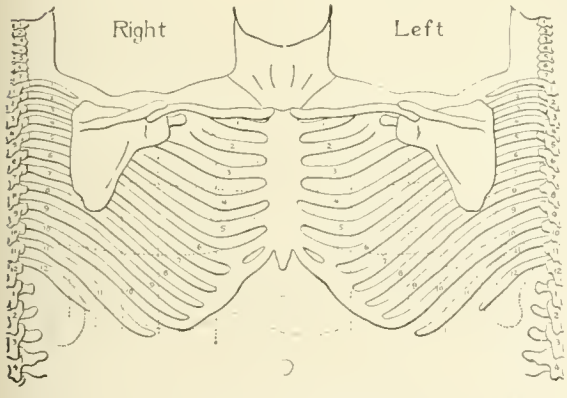

FIG. 3837.—Author's Diagram of Unrolled Chest for Marking Pathological Findings.

From this blank it will be seen that we must never fail to inquire into the economic condition of the patient in order to learn, if possible, the social reason for his having become tuberculous. The best previous weight and height should be ascertained and compared with the present weight, and inquiry should be made as to the length of time it took for loss of weight, if such is present. The relation of weight to height (or corpulence) in the normal individual, according to Papillon and Loomis, is obtained as follows: The weight in pounds divided by the height in feet should be at least twenty-six in normal men and twenty-three in women.

The subjective symptoms and their interpretation in the earlier as well as in the later stages of pulmonary tuberculosis are of great importance. Taking the rectal temperature, while perhaps a little more accurate, need not be resorted to except in unusually obscure cases. There is no distinct temperature curve in tuberculosis. There may be subnormal temperature in the morning, and it may even be normal in the afternoon, remittent or intermittent, and sometimes continuous. In obscure cases it may be wise to take the temperature every two hours. In the majority of patients the rise of temperature begins shortly after the noon hour, attaining its maximum height at about four, and in the early cases becoming normal again at about six. These temperature variations from subnormal in the morning (97.8°) to near 100° at 4 P.M., are significant in early pulmonary tuberculosis. In the latter stages of the disease the afternoon temperature usually rises to 100° and sometimes 102°, often alternating with sensations of colds and typical chills.

Hyperhidrosis is a manifestation of the second and third stages and is particularly distressing and troublesome during the last period of the disease where the mixed infection must be held responsible for this unpleasant phenomenon.

The voice of the patient afflicted with pulmonary tuberculosis is usually weak, with a tendency to become hoarse on exertion or with a change of the weather. Easy tiring after slight exertion, the feeling of weariness and languor without having made any exertion and a change in temperament and disposition, or indifference to work or pleasure is characteristic of a beginning tuberculosis. As the disease progresses the patient often becomes accustomed to this peculiar feeling due to the effect of the toxins secreted in his system, but in many cases the headaches, irritability, insomnia, and loss of appetite continue to be distressing. Dyspnea may and may not be present in the early stages, but manifests itself invariably in the latter stages when it is due to the extension of the envolvement and sometimes to pleuritic effusion. Occasionally we find a severe dyspnea with apparently limited envolvement but the *x*-ray picture shows multiple disseminated areas. Tachycardia is one of the symptoms most frequently found in early cases accompanied by a rapid pulse. There is, however, no distinct pulse in tuberculosis nor can the taking of blood pressure aid us materially in the diagnosis. A small heart is not infrequently found in the tuberculous subject, but this cannot be considered pathognomonic. Cough, although occasionally absent, is after all one of the most constant symptoms in the pulmonary type of tuberculosis. Some patients designate their early cough as clearing the throat. When this early slight cough cannot be explained by a catarrhal condition or some obstruction of the upper respiratory tract it is probably due to the irritation of a tuberculous pleura which so often precedes the more distinct tuberculous envolvement.

In the earlier stage of the disease, cough and expectoration occur more frequently in the morning, and when the patient gets through with his paroxysm and has gotten rid of the secretions accumulated over night, has made so to speak his pulmonary toilet, he will often be relatively free from cough. In the latter stages of the disease, cough and expectoration increase, the former in frequency and severity, the latter in quantity and quality. While sometimes entirely absent, expectoration in the earlier stages is usually scant, full of air, and floats on water. As the disease progresses the sputum assumes a whitish-yellow or greenish color, and in the later stages it becomes purulent, nummular in form, and sinks in water. Sometimes the sputum appears like grains of boiled rice or fragments of cheese. Dark gray sputum indicates cavity formation. The bacteriological examination of the sputum has for its main object the discovery of the presence of the tubercle bacillus, but no one to-day will defer the making of a diagnosis until the appearance of the bacilli in the sputum. When they do appear, in the majority of

instances the case is no longer a very early one. The finding of the bacilli is a strong corroborative evidence of a diagnosis made by physical means. The absence of the bacilli in the sputum does not prove absence of tuberculosis. The number of bacilli found in the sputum is not of diagnostic value. The specimen from an advanced case owing to an excessive bronchorrhea may show only two or three bacilli in the field, and an early favorable case on the road to recovery may eject with one expectoration countless bacilli from a limited focus. (See Prognosis.)

Sanguineous expectoration, or a typical or distinct hemoptysis, are in many cases the objective symptoms which bring the patient to the physician. Slight hemoptysis in early cases is probably due to the weakening of the small blood-vessels by the invasion of the tubercle. The blood from these early hemorrhages is usually bright red, being pulmonary venous blood and thus aerated. In the latter stages of the disease the hemorrhage generally has its origin in the pulmonary arteries. Aneurysms, usually small in size, are formed but their breaking is often productive of serious hemorrhages.

Not all cases of early tuberculosis begin with pulmonary hemorrhages nor are all advanced cases complicated by them. Some authors have attempted to tabulate the frequency of hemorrhage, but no two observers have come to the same conclusion. Some say one-third, some one-half, and some three-fourths of all their cases having had hemoptysis. In young women the gradual diminution and sometimes entire cessation of the menses and the occurrence of a pulmonary hemorrhage at the time when the monthly period should have appeared has sometimes been interpreted as vicarious menstruation. A careful physical examination will quickly explain the true cause of this hemoptysis.

Pain in the chest, particularly between the shoulder blades, or upon pressure in the region of the external upper or lower angle of the scapula, pain on deep breathing or coughing, or in the apical region or upper lobe often attracts the attention of the patient and physical examination reveals either a tuberculous pleurisy or a beginning of pulmonary tuberculosis. Intense and long lasting pains throughout the entire chest are not infrequently distressing symptoms of the latter stages of the disease.

Anorexia so frequently present in the earlier stages of the disease doubtlessly has its origin in the toxemia created by the bacillary secretions. Constipation may alternate with mild attacks of diarrhea. Other complications, such as pneumothorax, pleurisy with effusion, laryngeal tuberculosis, etc., arising at times in the course of pulmonary tuberculosis will be treated under their respective headings.

Physical Examination.—When all questions concerning the subjective symptoms have been answered and all objective observations have been noted, we proceed with our physical examination. The patient should be stripped to the waist. The examination should be made in a warm room and in a comfortable position to both patient and physician. A good way is for examiner and patient to be seated on revolving chairs. The inspection of the patient must include everything from head to foot, including abdomen. Dry, brittle hair is often found in the tuberculous, and one or both pupils may be dilated due to the presence of tubercles along the pneumogastric nerve. The nasal passages should be examined as to their freedom from obstruction; condition of teeth and gums should be observed. Even in the beginning of tuberculosis the mucous membrane of the upper respiratory tract is usually pale. The general aspect is often like that of an anemic individual and slight swelling of the thyroid must be considered as one of the earliest symptoms of a beginning tuberculosis, particularly in young women. It is rarely seen in the latter stages. The condition of the larynx and pharynx should be looked into. The joints, and particularly the fingers, should be examined for hyperplastic conditions due to tuberculosis (clubbed digits and bone tuberculosis). Emaciation is rarely noticed in the earlier stages but always present in the advanced cases. The conformation of the chest is often significant of tuberculous disease. With the aid of a pelvimeter the thoracic anterior and posterior and lateral diameters, and with the aid of the cyrtometer (a leaden band closely applied to the chest) an exact tracing of the chest conformation can easily be obtained and, after its conformation has been studied, filed away with the history sheet. It should be borne in mind that the tuberculous chest may be cylindrical as frequently as flattened. The so-called paralytic thorax is seldom observed in the earlier stages.

The mensuration is of value when one bears in mind that the full circumference of the chest should be at least half of the height of the patient and that anything less means lack of development and a weak constitution. Papillon advises to measure the circumference at the level of the fourth rib at the sternum in front, and at the eighth dorsal spine behind and to take the average of extreme inspiration and expiration. The actual degree of expansion determined by the band is of little diagnostic value since it varies even in perfectly normal healthy individuals from one and one-half to five inches. The same may be said of spirometric measurements. Both band and spirometer are, however, of prognostic value in subsequent examinations. An increase of expansive power concomitant with subsidence of acute symptoms is a favorable sign.

The muscular atrophy too is a sign of the more advanced stage of the disease, so are the thoracic retractions, supra- and infraclavicular depressions, or general thoracic shrinking. Dropping of the acromial end of the clavicle, which normally stands slightly higher than the sternal end, is however often observed in the earlier cases.

The character of the respiration varies with the degree of the invasion. Litten's diaphragmatic sign is usually only observed in the advanced cases and thus is of little value in early diagnosis. The tachycardia already referred to can often be detected by inspection as well as palpation. With the aid of palpation we determine even more accurately than by inspection the character of respiration. Prior to proceeding with palpating for objective fremitus (the fremitus perceived by the examiner) the author recommends the following interesting procedure for elucidating the subjective fremitus, that is to say, the fremitus perceived by the patient. The patient is requested to make a humming sound with the mouth closed, and then he is asked whether he feels his voice vibrating on the left or right side, or where he perceives the vibration most intensely. If there is a sufficient degree of consolidation on either side, the patient will feel the vibrations caused by his voice and indicate where he feels them. The explanation of this phenomenon is the well-known physical law that a solid body transmits the sound waves better than a body containing air. With the aid of the objective fremitus one rarely fails to detect the same localization. If the objective fremitus is but slight or difficult to locate, one may resort to the following procedure, which in the experience of the author has often proved a valuable adjuvant. While the patient pronounces the words twenty-two or ninety-nine or makes similar sounds in a base voice or hums as described, for determining the subjective fremitus, the examiner places the palmar surface of his hand in close juxtaposition with the chest wall of the patient and presses his forehead on the dorsal surface of his hand. Thus, a continuous osseous chain is established and the vibrations transmitted are more delicately perceived by direct communication with the examiner's brain through the frontal bone. In interpreting the value of the objective fremitus let

us bear in mind the following maxim of Lindsay, quoted by Minor in Klebs' "Tuberculosis": "The vibration of the upper right lung being normally much stronger than that of the left, an increase at the right apex must be very pronounced to make certain that it is pathologic, although such an increase at the left apex is suggestive. Slight changes at the left can be assumed when one finds the fremitus over the left apex equal to that over the right. If the fremitus be equal on the two sides and marked, suspect a lesion of the left apex. If it be equal on the two sides and ill marked, suspect the right side."

By gentle and slight palpation of the thoracic walls, preferably with the finger tips, we may detect a great muscular resistance over the infiltrated area; the resistance or spasm is most easily perceived in the supra- and infraclavicular regions. This spastic muscular contraction may be so pronounced as to be visible to the eye, and is according to Pottenger a special sign of fresh active disease. The spastic condition is caused by reflex irritation emanating from the lung and pleura, conveyed by the sympathetic special cord and motor nerves to the muscles.

Percussion is the next most important step. The clavicle can perhaps best be percussed by the immediate method, that is to say, without intervening

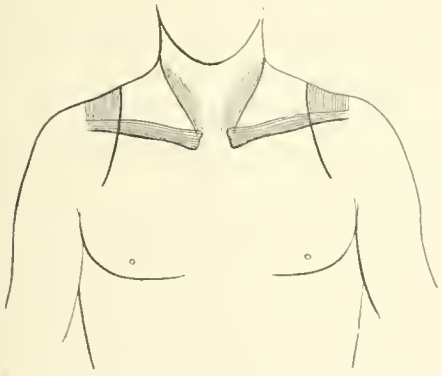

Fig. 3838.—The Clear Space above the Clavicle Shows Kroenig's Areas of Normal Anterior Apical Resonance.

plessimeter, and with the aid of a light percussion hammer. In unilateral invasion of the upper lobes the direct percussion of the clavicle will often determine which side is affected. The percussion note of one side should be compared with the other. They will differ when one side alone is affected but may be identically the same in bilateral lesions. Auscultation must then enlighten us.

All other regions should be percussed with the finger of one hand serving as a plessimeter and one or two fingers of the other hand serving as percussion hammer. The feeling of resistance of underlying tissues can be better perceived thus than with the plessimeter and hammer of rubber or metal. All portions of the thorax should be percussed and the axillary region should never be forgotten. Percussion should be done from above downward, first in front and then in the back. The interscapular region of the back is especially to be examined as deficient resonance here indicates changes in the hilus, which are much more frequently met with in tuberculosis than was formerly thought.

Saddle or apical percussion, that is to say, the mapping out of Kroenig's band of resonance is of value in determining the degree of shrinkage of the apices. The apical percussion should be light and should start at about the middle of a line drawn between the mastoid process and the internal clavicular end, percussing the anterior and posterior portion of the apices. The accompanying illustrations (Figs. 3838 and 3839) of the normal apical resonance, as described by Kroenig, indicate what portion should be percussed in order to determine any shrinking of the apex. Marking and then measuring the space which gives resonance and comparing the two sides will give the desired information.

Percussion of the other portions of the chest should also not be heavy, except when the thoracic muscles are unusually thick. With the aid of percussion giving normal resonance, or dull or flat sounds, we can determine the character of the underlying tissue and the progress of the disease, bearing always in

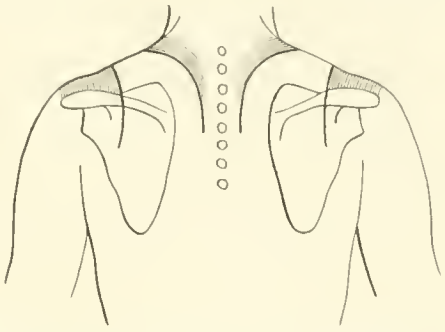

Fig. 3839.—The Clear Space in the Suprascapular Region Indicates Kroenig's Normal Posterior Apical Resonance.

mind the possibility of the existence of enlarged glands, pleural thickenings, etc. A tympanitic note is heard over the cavities, over incomplete pneumonic infiltration, and above large pleuritic effusion. Cracked-pot resonance is characteristic of cavity formation.

One more type of percussion must be mentioned as of value in diagnosis of pulmonary tuberculosis, that is what is known as tidal percussion. The object of this is to discover the vertical excursion of the lung in the complemental pleural space during the act of inhalation and exhalation. Most accurate information can be obtained with this method by carefully

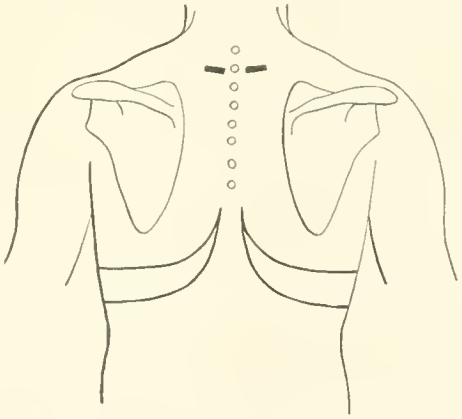

Fig. 3840.—Posterior Tidal Percussion. The two short straight lines indicate the upper boundary of the apex according to Goldscheider's method. The curved lines represent the degree of normal respiratory excursion.

marking the upper boundary of the apex, as indicated by Goldscheider, and then percussing the lower boundary during inspiration and expiration. The tidal percussion in front is not only exceedingly difficult, but not nearly as valuable as the percussion of the back. The accompanying diagram (Fig. 3840) shows the simplicity of the procedure. Even in an early tuberculous invasion the excursion of the lung is generally diminished on the affected side.

Auscultation (immediate or mediate) is the last but perhaps the most important physical means of determining a pathological condition of the lungs. The true diagnostician should resort to both methods. He should use his ear, that is to say, the immediate method whenever feasible and then corroborate it with the stethoscope—the mediate method. Whether the monaural or binaural stethoscope should be used is a matter of training and preferance. The phonendoscope is apt to intensify the breath sounds to an extent that may be misleading and most teachers in physical diagnosis warn against its routine use. The same systematic and comparative method as used in percussion should be resorted to when auscultating. Character of respiration, that is to say, pitch, intensity, duration, quality, and rhythm should be noted. It is well to listen to the auscultatory sounds during normal and exaggerated breathing. One should never fail to listen first for an increased voice fremitus, particularly when the patient is asked to whisper, which means consolidated area.

Next in importance to determine whether there are any pathological changes is that invaluable method pointed out by Grancher of Paris, known as single-phase auscultation, whereby the two phases of the respiratory process are closely observed and compared on the two sides, particularly at the apices, anteriorly and posteriorly.

In early tuberculosis one may perceive diminished respiratory sounds as compared with normal respiration, also the bronchovesicular breathing. The degree of this will depend on the invasion of the large tubes by the tuberculous process resulting in an abnormal conduction of the sounds from these tubes to the surface. Cogwheel respiration, while frequently heard in early tuberculosis, should not be considered as of great value, for it can be perceived in other pathological and sometimes even in normal conditions of the lungs, or in cardiac irregularities.

The most characteristic auscultatory sign in early pulmonary tuberculosis is that which Grancher describes as roughened inspiration due to a narrowing or irregularity of the finer bronchioles. As the process advances, the expiratory sign becomes also perceptibly roughened and prolonged, and when localized in one spot in the apex may be considered of great significance in diagnosis. This phenomenon of a prolonged expiratory murmur is due to a hindrance of the expiratory sound in its passage through a bronchiole studded with tubercles.

Other auscultatory signs may be heard over the apices or other portions of the lung, according to the degree of disintegration of pulmonary tissue. There may be clicking, crackling, groaning, squeaky sounds, crepitant, or subcrepitant, large moist and amphoric (cavernous) râles, typical bronchophony and posttussis suction. The posttussis suction sound is observed immediately after the patient's cough when there is cavity formation. The air being chased out of the cavity during cough, produces a suction sound on its return, accompanied by a click due to the dropping of mucus into the relatively empty cavity. A systolic murmur is frequently heard in tuberculous subjects over the sub-clavian artery on either side. Sometimes the pulsation is so marked as to be perceptible with the eye. Osler thinks that this systolic murmur is probably due to pressure on the vessels by the thickened tuberculous pleura.

The value of the *x*-rays as a means to corroborate a diagnosis of pulmonary tuberculosis is now generally conceded and is of particular value when the disease consists of small foci disseminated throughout the lungs, very often difficult to localize by means of percussion or auscultation. In interpreting an *x*-ray picture of a suspected thorax the possibility of shadows being produced by other conditions—thickened pleura, old pneumonic conditions, etc., must be considered.

Tuberculin reaction will be dealt with at length in a separate article of these volumes. It might, however, be well to mention here that no tuberculin test should be resorted to if subjective and objective signs and symptoms, or sputum examination, have been sufficient to demonstrate an active tuberculosis, and the one who wishes to resort to the tuberculin test should first familiarize himself with the relative value of the tests now used and the precautions which should be exercised to avoid the errors or complications which might arise through injudicious use. I believe the method practised by Dr. Horace J. Howk of the new sanatorium of the Metropolitan Life Insurance Company, near Saratoga Springs, N. Y., is perhaps as safe and reliable a one as we know of up to this time. In the doubtful cases an injection of one milligram of old tuberculin is given in twenty-four hours; if without result on the third day an injection of two milligrams is made, and if this too proves negative, a third and last one of five milligrams is given on the fifth day. If again without result, the patient is declared to be non-tuberculous.

Differential Diagnosis.—A few words must be said on differential diagnosis of pulmonary tuberculosis. There is first the ordinary acute catarrh of apices (the "Spitzen Katarrh" of the German). This catarrh may be due either to streptococcic infection, to the grippe bacillus, or to the milder types of organisms, not as yet known, responsible for simple colds. These acute catarrhs may be accompanied with a temporary more or less pronounced consolidation or collapse of the upper portion of the lungs. The physical signs elucidated by percussion and auscultation may closely resemble those of a tuberculous invasion, and the differential diagnostic points are mainly the acuteness of the onset and the more marked symptoms, such as higher fever and prostration, than is the case with the apical chronic catarrh due to a tuberculous invasion.

The infections due to the influenza bacillus or streptococcus are usually of short duration. Chronic bronchitis with collapse of the upper portions of the lungs, thus simulating tuberculosis, can usually be recognized by the instability of the physical signs and symptoms, the former not remaining localized as in pulmonary tuberculosis. Sometimes there is a collapse of one or both apices with dullness on percussion and diminished respiration, and no fever or other symptoms. The cause is found in the obstruction of the nasal passages, deviated septi, polypi, or adenoid vegetations. The removal of the obstruction will usually clear up the case.

Bronchiectasis may be mistaken for a phthisical condition when the fetor of the breath and expectoration typical of bronchiectasis has developed as a result of the decomposition of the pulmonary secretions. A differential diagnosis can usually be made by bearing in mind that cavitation in pulmonary tuberculosis is more frequently in the upper than in the lower portion of the lung. The reverse is due in bronchiectasis. There may be the same cavernous breathing in bronchiectasis as in pulmonary tuberculosis with cavitation, but in the latter there is found nearly always concomitant with the cavity formation a goodly portion of solidified area which is absent in bronchiectasis. Emaciation, nearly always present in pulmonary tuberculosis, is rarely found and never in the same degree in bronchiectasis. Febrile conditions in the latter disease is also extremely rare. The bacteriological examination of the sputum, the *x*-ray picture and careful tuberculin tests should be resorted to in all doubtful cases. Subcutaneous tuberculin injection for diagnostic purposes should, however, not be resorted to during highly febrile conditions likely to have been caused by the influenza bacillus or streptococcus.

A chronic pneumonia, a chronic asthmatic condition, actinomycosis, and pulmonary syphilis may at times be mistaken for an advanced pulmonary tuber-

culosis. A careful anamnesis, bacteriological examination, Wassermann test, etc., will usually help to clear up any doubt. The possibility of pulmonary tuberculosis and pulmonary syphilis being present in the same individual must, of course, be borne in mind.

Prognosis.—Nothing seems to be more difficult in pulmonary tuberculosis than to arrive at a certain prognosis, by reason of the complexity of the features which have to be considered. There are first the anamnestic data obtained by a careful history taking, including all medical and sociological data; second, the actual conditions found at the time of the examination, in other words, the status presens; thirdly, the response of the patient to treatment; and lastly, those as yet little understood peculiar conditions of hypersensitiveness on the one hand or immunity on the other, both of which conditions might be acquired or inherited.

The prognosis in the male is less good than in the female. While the mortality of children from all types of tuberculosis is very high in the first five years, in the author's experience after that age pulmonary tuberculosis promises a fairly good prognosis.

The age of puberty in both sexes is a dangerous age for tuberculosis, as at this time latent tuberculosis often becomes active. After this period the prognosis is better up to the age of forty than after that age. According to the statistics of the Hanseatic Insurance companies, economic cures (Erwerbsfähigkeit) in pulmonary tuberculosis were obtained at the age of

16 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70
in 79%	75.9%	66.3%	50.6%	47%	33%

The occupation of the patient prior to the development of the disease has a good deal to do with the prognosis. One who has been employed in an outdoor occupation or who has not been exposed to the inhalation of animal or vegetable dusts, offers a better prognosis than the grinders, printers, stone cutters, weavers, bookkeepers, workers in sugar refineries, etc.

A quiet temperament, a strong will to resist temptation and to be obedient to the physician's instructions promise a better prognosis than the highly emotional, easily irritated patient, or one little inclined to obedience.

The individual, one or both of whose parents were tuberculous, who has inherited a physiological poverty and has been much exposed to postnatal infection in early childhood, likewise offers a rather unfavorable prognosis. On the other hand, in a typical scrofulous individual where pulmonary tuberculosis develops at all, the process is slow and relatively benign.

When the conformation of the chest is markedly below the normal standard it must be considered an unfavorable factor. The prognosis is unfavorable in alcoholics.

Pregnancy implanted upon pulmonary tuberculosis makes the prognosis always unfavorable, and the farther advanced the case the greater the danger for mother and child. The nursing of a child by a tuberculous mother will exclude any possible favorable prognosis even if childbirth has not yet seriously impaired the mother's condition. The menstrual period causes a temporary rise of temperature in many tuberculous patients. A decidedly unfavorable sign is the gradual diminution of the menses, and the return to normal quantity and regularity justifies a hopeful outlook.

Dyspnea, according to its intensity, must be considered an unfavorable prognostic symptom. A chronic anemia, and a cyanotic condition of the skin, showing impaired circulation, are of course unfavorable symptoms, but even more so when the condition of the skin reveals an anasarca or edema.

A gain of weight, when concomitant with the improvement of the condition of the lungs is one of the best prognostic signs. Even if the weight remains only stationary for a period of time the prognosis is usually good. A continued normal or nearly normal temperature entitles one to a favorable prognosis. A constant high temperature which does not yield to the usual remedies is indicative either of a serious mixed infection or an intense pure tuberculous invasion. A slight subnormal temperature in the morning is not necessarily a bad prognostic symptom. A constant high pulse and a gradual diminution of the physical strength, even in absence of fever, must always give an unfavorable prognosis. Chills alternating with high fever and hyperhidrosis are indications of mixed infection and the increased toxemia must always be considered an unfavorable sign. Chronic anorexia in this instance is usually another accompanying unfavorable symptom, so are all complications of stomach and intestines which render nutrition and assimilation difficult.

Hemoptysis is the one symptom of pulmonary tuberculosis which, during the earlier stages, does not give any prognostic indication whatsoever. In the author's experience, a goodly number of patients with sanguineous expectoration or moderate hemoptyses at the beginning of their tuberculous invasion made a good recovery, while in others who had never had even a bloody sputum the disease terminated fatally and was of relatively short duration. A very severe initial hemoptysis must of course be considered of grave significance.

Cough with sputum, when on the increase in quantity and purulent, must be considered unfavorable. A strong albumin reaction of the sputum seems indicative of a bad prognosis. On the other hand, the number of bacilli found in one, two, or even a dozen examinations, is not a means of making a definite prognosis. A bronchorrhea, in itself an unfavorable symptom, may be the cause of few bacilli in the specimen examined while a detached almost calcified focus in an individual on the road to recovery being in the sputum examined may reveal the highest of Gaffky's scale as to number of tubercle bacilli found in one specimen.

Of greatest importance in prognosis is a comparison of successive physical examinations with the preceding ones, at intervals of two to four weeks, by which one may judge with reasonable certainty whether the disease is progressing favorably or unfavorably.

The blood pressure does not seem to give any indication of important prognostic value. A constant diazo reaction, on the other hand, is of grave prognostic importance. Weiss of Munich, Heflebower and Metzger and Watson[3] of this country, maintain that the urochromogen reaction, is more accurate and reliable than the diazo reaction these authors have come to the conclusion that in a tuberculous patient when there is a persistent presence of urochromogen reaction in the urine in spite of proper treatment, it probably means a hopeless prognosis. All tuberculous invasions of other organs, such as bones, joints, intestines, peritoneum, or kidneys, make a favorable outcome for the pulmonary lesion virtually impossible.

The subcutaneous tuberculin reaction has, with the majority of clinicians, proved of little prognostic value, and the same may be said of other tuberculin tests.

Of what value in prognosis is our up-to-date knowledge concerning a hypersensitiveness or an immunity to tuberculosis? From clinical observations physicians in the United States have learned to look upon the colored race and our North American Indians as particularly susceptible or hypersensitive to tuberculosis, and when the Negro or Indian is afflicted with the pulmonary type of tuberculosis, the prognosis is, as a rule, a grave one. In the section on Immunity, the author has endeavored to explain what he believes to be the reason why the

black and red races in the United States are so evidently hypersensitive and how the majority of the white races have acquired a certain immunity. Some European observers, like Landouzy of Paris, speak of the red-haired individuals, or Venetian type, as more susceptible to tuberculosis and less responsive to treatment than the ordinary blond or brunette type. In the United States, to which races from all parts of the world migrate, one will find that the Celtic or Irish races present a perhaps greater morbidity, mortality, and less resistance to tuberculosis than the other races, and next to them come the people who have migrated to the United States from Scandinavian countries. In the observations of the author there has not appeared among the French, German, or native American white population of the blond or brunette type any particular susceptibility nor any more than the natural immunity which all civilized people seem to possess. So far as the often quoted immunity of the Hebrew race is concerned our Health Department records and the author's personal experience would show that they contract tuberculosis as readily and perhaps more so than any other race, but when once they have contracted the disease they seem to resist it longer and the prognosis is more favorable.

In view of lack of information and statistical data in general concerning the frequency of tuberculosis in the adult due to the bovine type of the bacillus, we are not yet in the position to say whether this type promises a more favorable or less favorable prognosis in the adult than that of the human type.

Treatment.—Articles on the treatment of tuberculosis usually begin with the consideration of climate for the tuberculous; but climatotherapy is treated of elsewhere (see vol. iii., p. 117), and we will merely quote here from the author's previously published "Maxims for the Selection of Climate in Pulmonary Tuberculosis" the following:

"The ideal climate for the average pulmonary patient in the earlier or more hopeful stages of the disease, is the one where the extremes of temperature are not great, with the purest atmosphere, relative little humidity, much sunshine, and all conditions which permit the patient to live comfortably out of doors the greatest number of days out of the year and the greatest number of hours out of the twenty-four. The vast majority of consumptives are recruited from the laboring classes, and those we must cure in the same or nearly the same climate in which they will have to live and labor after their restoration to health. Results obtained in home sanatoria (located in nearly all sections of the country) would seem to justify this policy."

Solar or heliotherapy, aerotherapy in general, hydrotherapy, and dietetics are described elsewhere in this Handbook. Therefore only a few words regarding them will be said here. Solar or heliotherapy is of value, particularly in cold weather. Whether the sun-bath should consist in exposure to the direct rays of the sun, or merely exposure to the rays when one is clad in light garments which allow the actinic rays to penetrate,must be conditioned by the environments and left to the judgment of the physician. The patient's head should always be in the shade, and fever, hemoptysis, and headache are contraindications to solar therapy. In hot weather the tuberculous patient will, as a rule, feel more comfortable in the shade, the same as any other person.

Hydrotherapy in the form of cold-water applications may be resorted to as a tonic. The temperature should be regulated so as to be sure to produce good reaction. When the patient does not react promptly he should at once return to the warm bed. Very anemic persons and those with advanced tuberculosis would better refrain from all cold-water applications as a tonic. Highly febrile tuberculous patients are often benefited by cold compresses on the head and over the chest.

Concerning aerotherapy, it may be briefly said that the longer the patient can be out of doors with comfort in all kinds of weather, the more will he be benefited. The far advanced and the very anemic, however, should never be exposed to the rigors of cold weather. No matter in what stage of the disease, when the patient suffers from the exposure to cold, this is a contraindication. In winter the patient should never enter a cold bed, it should always be previously warmed. The outdoor sleeper should be appropriately clad and dress and undress in a warm room.

Concerning dietetics in tuberculosis, the essentials may be summarized by saying: feed the patients well with plain, nutritious, easily digested food—meat (red and white, particularly raw or slightly browned scraped beef), vegetables, whole-wheat bread, fish, eggs, and fruit. To give a mixed varied diet at regular mealtimes, with the avoidance of fried food substances, is the best policy. If the patient is much underweight, give an additional egg, preferably raw, immediately after the luncheon and dinner. Avoid feeding between meals and add plenty of salt to the food. The chloride of sodium thus ingested will tend to counteract the demineralization so characteristic of the tuberculous disease.

We must now say a few words on the medicinal, symptomatic, and specific treatment of pulmonary tuberculosis. A general malnutrition may be helped by judicious massage, particularly when the patient is afebrile. We may even resort to occupation therapy in the afebrile state and when the patient's general condition warrants it. Whether or not to go so far as to bring about an autoinoculation by graduated labor is still a question on which authorities differ widely. Great caution as to selection of cases and character of work, and extreme care and watchfulness would certainly seem essential, if we would wish to get results such as claimed by Marcus Patterson[4] of England and his followers.

One of the essential measures to combat cough is to teach a patient to control any inclination to useless coughing, that is to say, only to cough when he feels that he will have to expectorate. Concerning the many medicinal remedies in use to treat the cough of the tuberculous, we should always bear in mind that the less narcotic syrups and other anticough remedies that are ingested, the better for the patient. Hence, we should first try such anticough remedies as can be inhaled or applied locally to the larynx. The following are good prescriptions for this purpose:

℞. Olei eucalypti,
Spirit. chloroformi, ... ℥iiss;
Menthol ..... āā ℥ss.
M. Sig. Inhale five to fifteen drops with aid of inhaler or handkerchief three to four times daily for several minutes at a time.

℞. Creosoti (beechwood),
Spirit. chloroform,
Spirit. rectif. ..... āā ℥iiss.
M. Sig. Inhale ten to fifteen drops with aid of inhaler or handkerchief three to four times daily for several minutes at a time.

℞. Menthol ..... gr. v.
Creosoti ..... gtt. v.
Olei olivæ ..... fl. ℥i.
M. Sig. Warm and inject one dram into larynx daily with the aid of intratracheal syringe or Yankauer applicator.

If cough mixture must be taken one may choose from the following four:

℞. Mist. glycyrrhizæ compos. ..... ℥vi.
Sig. One-half to one tablespoonful every two or three hours.

℞ Heroinæ hydrochlor. . . . . gr. ii.
Acid. sulphuric. dil. . . . . ℥xlv.
Glycerinæ, ... ʒiss.
Aq. laurocerasi.
Syrup. pruni virg. . . . . āā ʒj.
Aquæ destillatæ. . . . . q.s.ad. ʒiv.
M. Sig. One teaspoonful three or four times a day.

℞ Codeinæ. . . . . gr. iii.
Acid. sulphuric. dil. . . . . ℥xlv.
Glycerini. . . . . ʒiss.
Aq. laurocerasi,
Syrup. pruni virg. . . . . āā ʒj.
Aquæ destillatæ. . . . . q.s.ad. ʒiv.
M. Sig. One teaspoonful three or four times a day.

℞ Elixir terpini hydrat. . . . . ʒi.
Glycerini. . . . . ʒiv.
Syrup pruni virgin. . . . . ʒiss.
M. Sig. One teaspoonful every three to five hours.

Whethered recently published a prescription which seems to be particularly efficacious in severer types of cough:

℞ Liquoris morphinæ acetatis. . . . . ℥viii.
Spiritus chloroformi. . . . . ℥iii.
Limonis succi. . . . . ℥xv.
Mucilaginis acaciæ. . . . . q.s.ad. ʒj.
M. et ft. linctus. Sig. One such pastille to be taken when the cough is severe.

For acute pleuritic and other pains in the chest one should likewise try the physical means before administering anodynes. Thus, strapping the chest with zinc oxide adhesive plaster, painting with iodine, or applying dry cups, often suffices to relieve pain. Of course, in some instances hypodermic injections of morphine must be resorted to.

High temperature during the day time and hyperhidrosis at night are the symptoms most difficult to combat medicinally. Absolute rest is the first indication when there is a temperature approaching 100°, and the permanent sojourn in fresh, pure, cool air by day and by night is of equal importance. In sanatoria the construction of rooms which can be artificially cooled would seem of invaluable help in summer when the external temperature is very high. These cold air chambers, wherever they have been installed, have proved of greatest value by eliminating the depressing effect of heat upon the nervous circulatory and respiratory system, thus improving appetite, sleep, and general condition. The installation of electric fans in hot weather in a room of a patient suffering from an advanced pulmonary tuberculosis is also a great help. Partial sponging with lukewarm water should always be resorted to as a help to decrease temperature. The patient perspiring a good deal at night should have at his bedside a glass of milk and a sandwich to take when he awakens weakened and exhausted from excessive sweating.

There is no specific medicinal remedy to counteract fever in tuberculosis. Pyramidon in three-grain doses, twice or three times daily, may help and even quinine in two- or three-grain doses may render service. Against night sweats $\frac{1}{100}$ of a grain of sulphate of atropine or a five-grain powder of agaricin taken at bedtime may be helpful. So also is the administration of fifteen to twenty grains of camphoric acid two or three hours before the usual time of the sweat.

A slight hemoptysis in the early stage of pulmonary tuberculosis is rarely of great consequence, but in the advanced stages it must be considered one of the most serious symptoms. In all stages of pulmonary tuberculosis the treatment of a hemorrhage must be psychical, physical (or mechanical), and medicinal. At the time of examination the patient should already be warned of the possibility of a slight hemorrhage. He should be told that if it occurs he should not be alarmed for it does not lessen the chances for his recovery, that he should go to bed, remain quiet, put an ice bag over his heart, and send for his physician. The same precautionary advice should be given the patient in the more advanced stage of the disease, also to the family and nurse of the patient. After assuring the necessary quiet for the patient it will depend upon the severity of the hemorrhage whether the physician thinks the administration of morphine hypodermically, of emetine hydrochloride (one-fourth to one-half grain), or any of the other newer products such as coagulose, is indicated. In cases where the hemorrhage has assumed a chronic character, the injection of fresh horse serum to increase the coagulability of the blood has rendered good service, bearing of course always in mind a possible anaphylaxis and the wisdom of a trial dose to avoid it. One of the most efficacious means to stop what seems to be an uncontrollable hemorrhage is artificial pneumothorax, providing one is so fortunate as to be able to get into the intrapleural space on the side from which the hemorrhage comes. This is not always easy in view of the usually numerous pleuritic adhesions in the advanced tuberculous case. But in the event of success, the injection of 500 to 700 c.c. of oxygen gas usually suffices to stop the hemorrhage. Oxygen is preferable in these cases because of the stimulating influence it has on the patient's depressed condition after a hemorrhage.

When called to a severe pulmonary hemorrhage the immediate ligation of the upper and lower extremities with the aid of large silk handkerchiefs or similar articles, so as to prevent the influx of blood into the lungs, should be resorted to no matter what subsequent procedures may be indicated.

As another physical means to control a pulmonary hemorrhage strapping has been resorted to. Whether astringent remedies administered by mouth are really effective in pulmonary tuberculosis is still an open question. It is nevertheless prudent for psychological reasons if for no other to give the patient who has had a severe hemorrhage or continued sanguineous expectoration some of the remedies supposed to have a styptic quality. The following prescriptions are good for this purpose:

℞ Stypticin. . . . . gr. ii.
Plumbi acetas. . . . . gr. xviij.
Pulv. digitalis. . . . . gr. ix.
Pulv. opii. . . . . gr. v.
M. Ft. capsulas No. 9. Sig. One every four hours.
℞ Acid. gallici. . . . . ʒii.
Acid. sulph. aromat. . . . . ʒi.
Glycerinæ. . . . . ʒi.
Aquæ. . . . . q.s.ad. ʒvi.
M. Sig. One teaspoonful every hour or two, as needed.

The digestive disturbances, anorexia, constipation, diarrhea (ordinary and tuberculous), and anemia are dealt with at length under their respective headings. The digestive disorders as well as many other serious symptoms, such as high fever, excessive night sweats, prostration from the septicemia—all due to the secretions of the microorganisms, tubercle bacilli and streptococci or staphylococci—will be favorably influenced by diminishing the activity of the respiratory system invaded. One of the best means to do this is artificial pneumothorax whereby the diseased portion of the lung is put at rest by compression and collapse.

Artificial Pneumothorax.—The following are in brief the indications for the operation:

(1) Artificial pneumothorax is indicated first in all such cases of pulmonary tuberculosis as have not improved under ordinary hygienic, dietetic, climatic, and symptomatic treatment. Such cases are, as a rule, moderately or far advanced.

(2) It is indicated also in those earlier cases in which there is no improvement because of mixed infection or lack of recuperating powers, or when for other often inexplicable causes the condition remains stationary or the progress toward improvement is particularly slow.

(3) In all rapidly progressing cases, whether they are treated in institutions or at home, and in whatever climate.

(4) It is indicated for all patients of the moderately or far advanced type, within or outside of institutions, who are discontented, feel that not enough has been done for them, and who are desirous to have artificial pneumothorax tried.

(5) As already referred to, it is indicated in uncontrollable hemorrhage or chronic sanguineous expectoration.

(6) In that group of cases, which King describes as uncomplicated unilateral phthisis, with slow or subacute course, regardless of the degree of lesion, but with such pleuritic adhesion as may be removed by artificial pneumothorax.

(7) In cases of bronchiectasis, not due to foreign bodies or tumors, when climatic, hygienic, and the ordinary symptomatic treatment fails, it is justifiable to try the injection of nitrogen gas, with a view of producing artificial pneumothorax. There are a few cases on record where this means has been successful.

(8) In cases of abscess formation, due to streptococci or other pus infection.

(9) The injection of nitrogen gas into the intrapleural cavity is indicated in cases of pleurisy with effusion when the withdrawal of the liquid becomes necessary. The inflation has here a twofold purpose. First, if the serous fluid has caused a collapse of tuberculous lung tissue the injection of nitrogen gas will maintain the beneficial collapse. Secondly, when the nitrogen is injected slowly while the fluid is withdrawn, it will most likely prevent the unpleasant and sometimes dangerous features which are not infrequently observed after taking away the serous fluid from the intrapleural cavity.

(10) Lastly, Morelli[5] recommends the maintenance of a spontaneous pneumothorax by artificial means and thus accomplishes the immobilization of the lung and the closing of the margins of the pulmonary fistula and a cicatrization. In the event that the communicating opening productive of artificial pneumothorax does not become entirely obliterated, Morelli advises the maintenance of the artificial pneumothorax by subsequent injections of nitrogen.

Bilateral tuberculous involvement, if one lung is more involved than the other, is not a contraindication to the production of artificial pneumothorax. Those who see many tuberculous cases, both in private and hospital practice, will admit that tuberculosis limited to one side is rare in patients who have had the disease for any length of time. Most of the cases operated on in sanatoria and hospitals have had bilateral lesions, and a fair number have shown gratifying results.

Interesting and paradoxical as it may seem, all clinicians doing artificial pneumothorax work have frequently noticed that in spite of the increased activity of the less involved portion of the lung, as a result of compression of the other side, a concomitant improvement has resulted in this non-treated part of the pulmonary lesion. The explanation of this is probably to be found in the diminution of toxins absorbed.

Casts and albuminuria are not necessarily a contraindication, but, of course, one must be guided by the general condition of the patient. When the lesion of the less affected side is a basal one, some authorities consider this a contraindication. In the opinion of Dr. Lapham, this condition is not an absolute contraindication, and the production of artificial pneumothorax is permissible because of the relief which it gives to the patient.

There are, of course, decided contraindications to the production of artificial pneumothorax:

(1) An extensive involvement of both lungs.

(2) When there is so much cavitation in the affected lung that there is danger of the needle entering a cavity.

(3) Dry pleurisy or pleurisy with effusion.

(4) Myocarditis, other serious cardiac complications, or serious renal complications.

(5) Pulmonary tuberculosis complicated by any constitutional disease which in itself is sufficient to inhibit all possible chances of recovery.

(6) When there is an ascites or a distention of the abdominal cavity due to gases in the stomach or intestines, artificial pneumothorax must not be produced until this condition is remedied, otherwise a serious dyspneic condition and heart complications might ensue.

(7) When the patient, in no matter what stage of the disease, is too apprehensive and strongly objects to the performance of the operation, it should not be resorted to.

(8) Finally, artificial pneumothorax is contraindicated in early and favorable cases.

There are a few clinicians who, because of their success in advanced cases, recommend its use in early unilateral lesions. But most authorities up to this date consider an early lesion of pulmonary tuberculosis a contraindication for the performance of artificial pneumothorax. Such early uncomplicated cases, with relatively little involvement, should be treated by the well-tried sanatorium methods in special institutions or at home. Artificial pneumothorax can as yet only be classified as a valuable therapeutic means in a limited number of cases of pulmonary tuberculosis, but it cannot be considered as a successful routine treatment of the disease in all stages.

In producing artificial or therapeutic pneumothorax, all antiseptic precautions, sterilizing of hands, needles, and field of operation, should be rigorously adhered to. While the operation is seemingly slight and is accomplished many times without any accident whatsoever, serious and even fatal accidents have happened. Therefore, the operation should be performed either at the home of the patient or in the hospital, but never in the physician's office.

Furthermore, one should not undertake to treat a patient by compression of the lungs unless he is informed that it will take a long time and probably many inflations before a successful compression is obtained. The patient should also be told that the operation is not always successful.

To avoid accidents from shock, infection, or even temporary discomfort, the patient should be prepared by having his bowels moved. Prior to the inflation a quarter of a grain of morphine should be injected. The skin should be rendered aseptic by tincture of iodine. A local anesthesia of the skin should be produced by ethyl chloride, prior to the insertion of the needle for the injection of novocain, to anesthetize the muscular layers of the thorax.

Before beginning, the apparatus should be tested to see that it is working properly. Since it is not always possible to locate a point free from pleuritic adhesion, several punctures may be necessary before the manometer indicates free oscillation, which means that the needle is in the intrapleural space. Large needles which require a preliminary incision into the skin and thoracic muscles may lead to septic infection, particularly when several incisions become necessary. A finer needle is not likely to do serious damage, even if it does enter the lung. The regions which are apt to be more frequently free from pleuritic adhesions are along the axillary lines. The Kny-Scheerer Company has manufactured a moderately fine needle, which by means of a cap can be easily attached to the rubber hose connecting with the manometer or gas receptacle.

The patient should be placed on his side, with the arms up, so as to widen the intercostal space. The needle is then slowly inserted through the skin and muscular layer in such place where percussion and auscultation has shown a seeming freedom from adhesion. When the needle penetrates the parietal pleura, free from adhesion, a peculiar resistance is felt, which might be likened to the passing of a needle through stretched parchment. When the manometer indicates a negative pressure with free oscillation, the gas is allowed to flow.

As an initial inflation, perhaps not more than 500 c.c. should be injected, except when the injection is made for uncontrollable hemorrhage. To avoid gas embolism, it is advisable to begin with an inflation of 50 to 100 c.c. of oxygen.

As stated above, it is best to inject small quantities of gas at the beginning (about 500 c.c.). This, as a

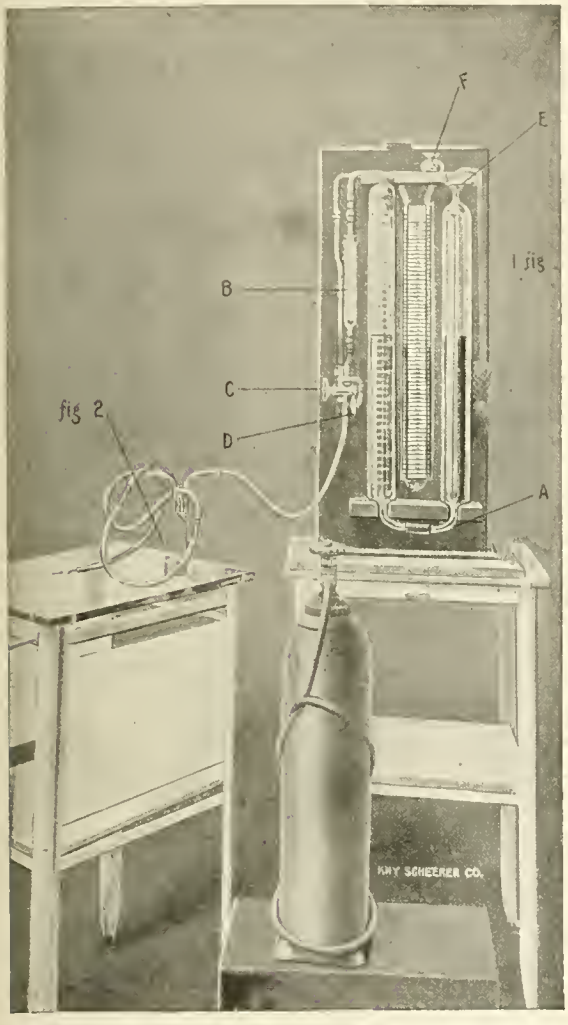

Fig. 3841.—Apparatus for the Production of Artificial Pneumothorax.

rule, suffices to give the desired relief, reduces temperature, and influences cough and expectoration favorably. Robinson and Floyd, however, give as a maximum for the first injection 1,000 c.c., and Bonniger as much as 2,000 c.c. in a strong man and 1,600 c.c. in a woman. Concerning this, King and Mills[6] say: "These larger quantities seem to us unnecessarily heroic, and not altogether devoid of embarrassing sequela if not of danger." In regard to the subsequent injections, the latter say: "Subsequent inflations had best be made at intervals of not more than a few days, until the manometer readings are neutral or slightly positive and the *x*-rays show as complete a lung compression as is possible. After this is accomplished, the intervals between the injections are governed by symptoms, especially the amount and character of the sputum, temperature, etc., and by the *x*-ray. If atmospheric air is used, the intervals will necessarily be shorter than when nitrogen is employed." Atmospheric air should never be used unless it is passed through a filter and rendered sterile.

Sometimes the most careful injection is followed by an immediate surgical emphysema. When the beginning of such a complication arises, the emphysematous area should be encircled by a rubber bandage, which usually suffices to control the condition. Pleuritic effusion may occur later on and should be treated in the usual way. Collapse caused by pleural reflex, intense dyspnea, or hemorrhage, should be treated with injections of morphine, caffein, nitroglycerin, and locally with spirits of ammonia, whiskey, hot-water bags, and ice-bags.

The apparatus (illustrated by Figs. 3841 and 3842) is the original Forlanini apparatus, modified by Saugman, again by Muralt and Nebel, and then upon the author's suggestion made by the Kny-Scheerer

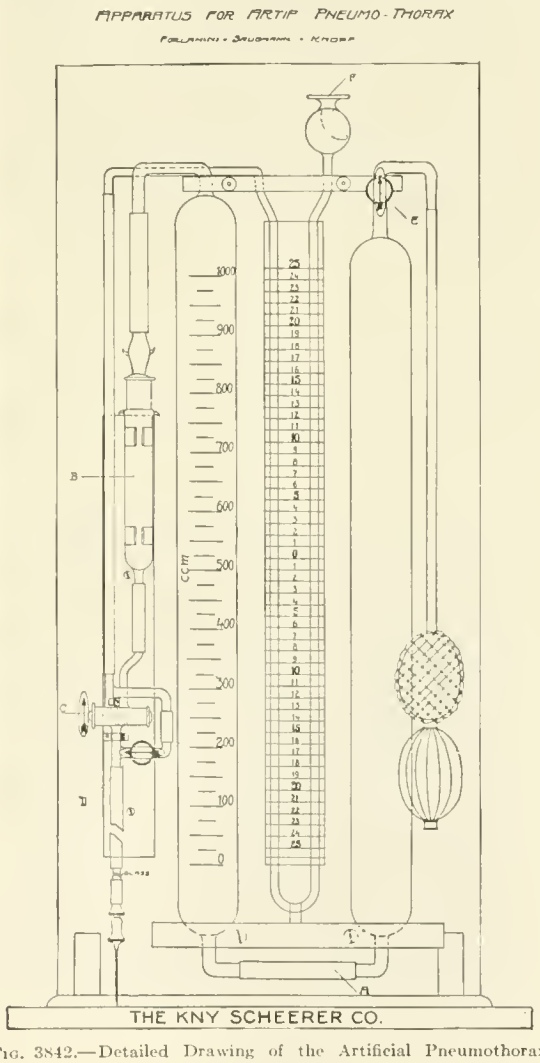

Fig. 3842.—Detailed Drawing of the Artificial Pneumothorax Apparatus.

Company in a little more substantial form, more easily to transport, more clearly graduated, and with glass tubes inserted in the rubber hose connecting the apparatus with the thoracic cavity.

Among the modifications incorporated in this new apparatus, besides the better support of the gas receptacles and stopcocks, is a new manometric scale.

In the older apparatus it consisted of a narrow strip of paper, with no light background, which made the reading of the oscillation exceedingly difficult. The scale in the new apparatus is made of a broad strip of milk glass, which at the same time serves as a background to make the reading indicated by the colored liquid more easy.

The manometric scale is divided into fifty centimeters, twenty-five centimeters above and twenty-four centimeters below zero, indicating respectively negative and positive pressure. To make the reading as easy as possible, every division has a number, and the 5, 10, 15, 20, and 25 are cut in larger and heavier figures. The old apparatus does not indicate all numbers, only 5, 10, 15, etc.

To increase the pressure, the rubber bulb in this apparatus is smaller than in the one heretofore on the market; this is for the purpose of better control when it is desired to use a little more pressure in the flow of nitrogen. The reason for having two intervening glass tubes in the rubber hose connecting the pleural cavity with the apparatus is to enable the operator to see at once if the needle is drawing fluid serum, pus, or blood.

The apparatus consists of two glass tubes, twenty-four and one-half inches high and about two inches in diameter. These two tubes are joined by means of a rubber hose under the base *A*.

The tube at the left is graduated at 1,000 c.c.

The two receptacles are filled with water up to 500 c.c.

The graduated tube to the left hand is filled from the tank with the gas to be introduced into the pleural cavity by the weight of the water in the tube, or by additional pressure, the latter being obtained from a double rubber bulb. The flow of gas into the intrapleural space is slow but steady. The graduated tube is connected with a glass tube containing sterilized gauze *B*, serving as a filter. It has a ground-glass stopper, which can be removed for the renewal of gauze or cotton.

The filter communicates with a two-way diagonal-passage glass stopcock *C*. Stopcock *C*, when turned with the arrow downward, connects the instrument to the gas supply tank (nitrogen or oxygen) by means of a rubber tube. The stopcock, in the same position, serves for the introduction of the gas into the intrapleural cavity.

When stopcock *C* is reversed, that is, with the arrow pointing upward, it is connected to the manometer by a thinner glass tube, mounted between the large glass tubes, thus showing the oscillation when the needle is in the intrapleural cavity.

When the arrow of the by-pass stopcock *D* is pointing horizontally it permits the manometric reading, showing the degree of oscillation while the gas is still flowing provided, of course, that the arrow of stopcock *C* is turned downward.

When filling the instrument with gas, the rubber hose from the tank should be connected to the outlet below stopcock *C*. Stopcock *D* should stand vertically; the arrow on stopcock *C* should point downward; stopcock *E*, on the top of the non-graduated tube, should be turned horizontally to the left. When the flow of gas is no longer desired, stopcock *C* should be turned so that the arrow points upward. If additional pressure is desired, stopcock *E* must be turned with arrow pointing upward.

Funnel *F* connected with the manometer serves for the filling of the manometer tube to zero with an alcoholic solution of methylene blue.

The illustration shows a transportable tank of nitrogen containing twenty-five cubic feet, which is equal to 175 gallons, or 700 liters, under the pressure of 1,800 pounds, per square inch. The same size tank, containing oxygen under similar pressure, can also be procured. While nitrogen may be obtained more cheaply from the air or with the aid of pyrogallic acid, the use of the tank will be found more convenient and simple.

Owing to the high pressure under which nitrogen or oxygen is held in the tank, great care should be exercised that the liquid is not blown out of the glass tube when filling the apparatus. The surest way is to have an intervening rubber bag (Fig. 3843) into which the gas flows first, and from which it can gradually be pressed into the receptacle of the apparatus; but with care the flow of gas from the tank can be regulated so as to avoid accidents. The flow should always be regulated prior to attaching the receptacle to the apparatus.

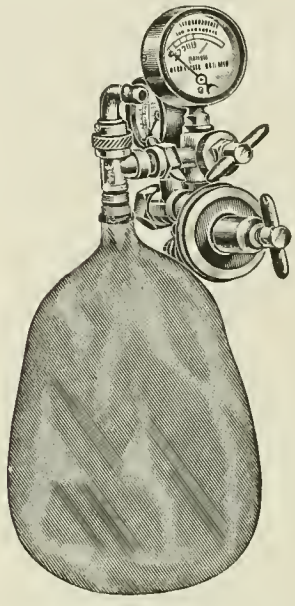

Fig. 3843.—Rubber Bag for Holding the Gas in the Operation for Artificial Pneumothorax.

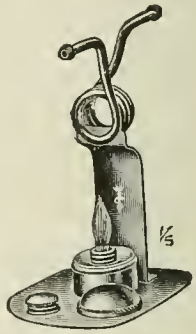

Fig. 3844.—Alcohol Lamp and Coil of Metal Tubing for Heating the Gas in the Operation of Artificial Pneumothorax.

Besides the apparatus, the illustration shows an alcohol lamp with coil of metal tubing (Fig. 3844), a device which will eliminate at least one of the unpleasant features which occasionally attend primary as well as subsequent operations for artificial pneumothorax. The distress which the patient sometimes feels, manifesting itself in anxiety, intense dyspnea, or cardiac pains, is due to the expansion of the nitrogen which has been injected at the temperature of the room. The much higher temperature of the thoracic cavity causes the gas to expand and thus increase considerably in volume. To eliminate the possibility of this accident, the coil of metal tubing is suspended over the alcohol lamp, through which tubing the nitrogen gas is passed before it enters the pleuritic cavity. Pneumonia has been said to have been produced by the inhalation of cold oxygen, hence it is suggested that when oxygen is chosen as the gas to be injected for the production of artificial pneumothorax, it should be passed through a heated coil of metal tubing, after the alcohol flame has been extinguished, to avoid any possible explosion. Robinson and Floyd state that the warming of the nitrogen will materially aid in preventing a "pleural reflex."

The most serious accident which can happen during the operation for artificial pneumothorax is air embolism as a result of the needle entering a vein when the air comes from the long tube connected with the manometer. To minimize the danger of this accident, Sömme[7] suggested a small mercury manometer with a very short, narrow tube, so constructed as to make the entrance of air into the vessel virtually an impossibility. The accompanying picture (Fig. 3845) shows a small manometer which the Kny-Scheerer Company has manufactured for the author. To this manometer can be attached

a Forlanini or Floyd-Robinson needle. The picture explains the working of the apparatus. The little Baldwin guard, which is also illustrated (Fig. 3846), may be attached to the needle and helps to steady the latter during the flow of gas in the intrapleural space. The manometer of the pneumothorax apparatus, indicating with the aid of colored water the oscillations, should be attached to the needle from time to time in order to show the degree of intrathoracic pressure produced by the inflowing gas.

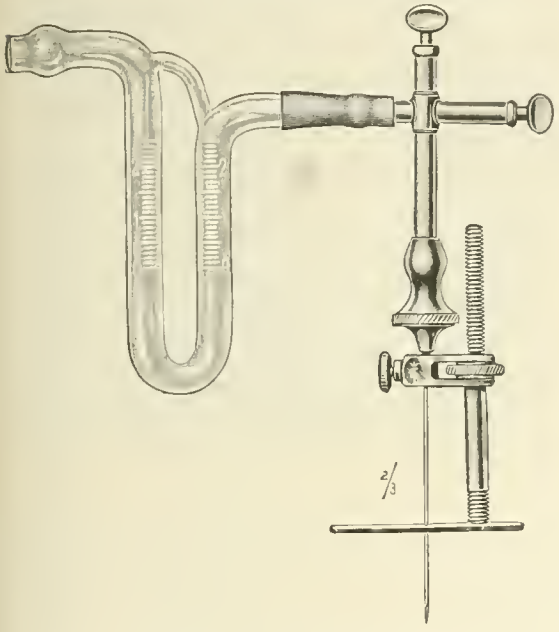

Fig. 3845.—Mercury Manometer to Prevent Entrance of Air in making an Artificial Pneumothorax.

To show what may really be accomplished with the aid of artificial pneumothorax and the difficulties one is apt to encounter, we illustrate the results of six highly interesting cases of pulmonary tuberculosis in which the operation was successfully performed (Figs. 3847–3852). The author is indebted to Professor I. S. Hirsch of the Bellevue Hospital and the Post-Graduate Hospital Röntgen Laboratories, for the photographs of these varied cases. The legends underneath are self-explanatory.

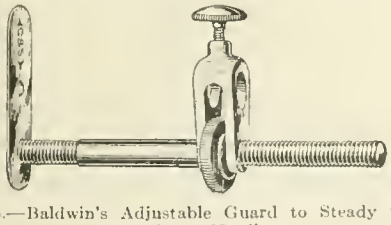

Fig. 3846.—Baldwin's Adjustable Guard to Steady the Pneumothorax Needle.

One is often unsuccessful in producing artificial pneumothorax because of extensive pleuritic adhesions. When such a condition exists collapse of the lung has sometimes been obtained by making use of the methods employed for the obliteration of the pleural cavity in cases of long-standing empyema, namely, extensive rib resection (Estlander's operation), sometimes with modifications along the line of the Schede technique. These operations are accompanied by considerable shock and loss of blood and are not well borne by the enfeebled tuberculous patient; the mortality has been so high as to make the operation unjustifiable in view of the uncertainty of cure, or even of improvement.

As a contribution relating to collapse therapy we must mention the article of Gustav Baer in the *Münchener med. Wochenschrift*, 1913, No. 29, entitled "Ueber extrapleurale Pneumolyse mit sofortiger

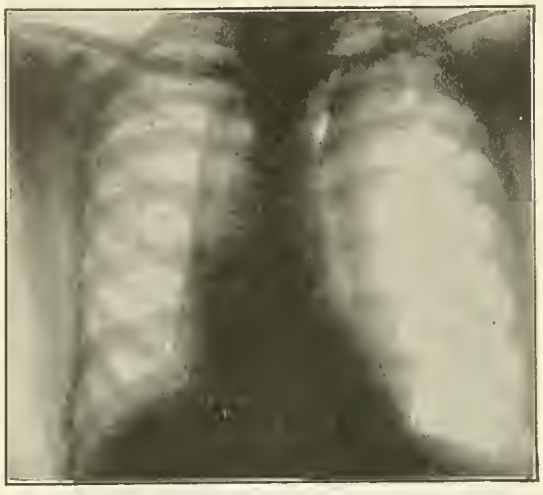

Fig. 3847.—Massive Collapse of Left Lung.

Plombirung bei Lungentuberkulose." The author describes therein a method of occluding the tuberculous cavities by either fat or bismuth paraffin. The first stage of the operation is a resection of the rib, and in order that the operation should be successful there must be a sufficient detachment of the parietal pleura for the purpose of permitting that

Fig. 3848.—Complete Collapse of Left Lung Prevented by Bands of Adhesions.

part of the lung which contains the cavity to collapse. When the cavity is adherent to the parietal pleura, the operation is exceedingly difficult and often impossible. Aside from this, there are limitations to the operation because it is virtually limited to apical lesions only. Baer calls this operation "extra-

pleural pneumolysia" and claims good results in cases which are not suitable for artificial pneumothorax and where other surgical interference is not indicated.

To allow patients with extensive pleural adhesions to receive the benefit of the pneumothorax treatment, Torek[8] has devised the operation which he

Fig. 3849.—Partial Collapse of Right Upper Lobe Only.

calls "Interpleural Pneumolysia." It consists of making a large incision in the sixth or seventh intercostal space under intratracheal insufflation or some other form of differential pressure, finding the line of adhesion between the parietal and visceral pleura, and following this line of cleavage over the entire surface of the affected lung. When this has been completed the lung is left collapsed as far as the

Fig. 3850.—Right Pneumothorax. Collapse of upper lobe (cavity formation); partial collapse of lower lobe.

development of fibrous tissue in the lung itself will allow. The restored pleural cavity is left filled with air, and the pleural cavity and overlying soft parts are closed without drainage. Subsequently nitrogen injections are employed in accordance with the indications which obtain in the ordinary uncomplicated case. Certain modifications in technique may occasionally be necessary, as in the presence of the rupture of a superficial abscess of the lung, and due attention is given to these possibilities by Torek. It should also be stated that many essential points in the technique have necessarily been omitted in this brief résumé of the question for interpleural pneumolysia. One case is reported, and the result seems

Fig. 3851.—Marked Collapse of Right Upper Lobe with Incomplete Collapse of the Cavities; partial collapse of right lower lobe. This demonstrates the fact that the more extensive the lesion is, the more marked is the collapse caused by the injection.

to justify the belief that Torek has made an important contribution to the surgery of pulmonary tuberculosis.

The literature of artificial pneumothorax and lung surgery is already a very vast one, and those desiring

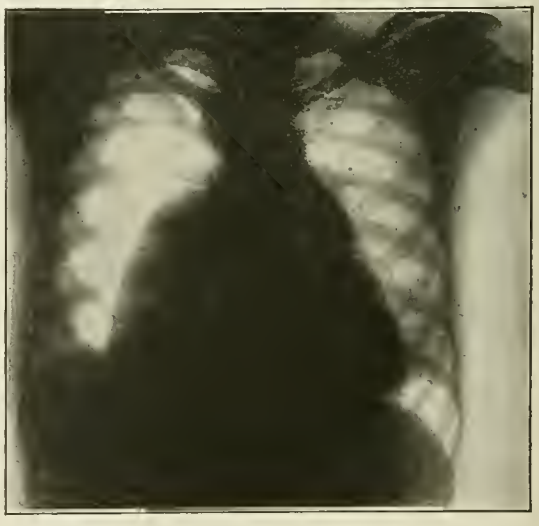

Fig. 3852.—Complete Collapse of Right Lung; it is seen lying as an airless mass at the base of the chest.

to inform themselves on the subject are advised to join the International Artificial Pneumothorax Society, of which Prof. C. Forlanini of Pavia, Italy, is president, Prof. Carpi of Lugano, Switzerland, secretary, and Dr. M. F. Sloan of Towson, Md., secretary for the United States.

Tuberculin.—To combat the many serious symp-

toms of tuberculosis, tuberculin in the various forms and modifications and many other culture products derived from the tubercle bacillus have been tried and recommended since Koch's great discovery and his announcement of the product as a specific in 1890. Since pulmonary tuberculosis is the most frequent type of tuberculous invasion, tuberculin is and has been resorted to most frequently as a therapeutic means in this disease. Volumes have been written on its use, its indications and contraindications, methods of administration and results, and for the many prevailing opinions and choice of preparation we must refer the reader to the special article on *Tuberculin.* Regarding its use in pulmonary tuberculosis we may say that the vast majority of clinicians and phthisiotherapeutists to-day are of the opinion that the tuberculin treatment should never be considered the exclusive treatment of tuberculosis, but that it should always be accompanied by what is generally understood as the sanatorium treatment in special institutions or at home.

Secondly, tuberculin should never be resorted to as a routine treatment and it should no more be considered as a means of absolute cure than any other remedy. There seems to be little difference in the results obtained with the various tuberculin preparations, and the majority of observers agree that it is best to avoid violent reaction, some even claiming that we should avoid even the slightest reaction, and that it is safest to begin with the smallest doses, one hundredth of a milligram, or even less.

Whatever good results have been obtained with tuberculin in institutions or at home must be ascribed to the judicious selection of cases, to the careful administration of the product, and the unusual care exercised in the avoidance of severe reactions. Even the most enthusiastic advocates of tuberculin admit that only under the conditions just enumerated can any good results be obtained.

Lastly, no matter what may be the personal opinion of the physician treating a tuberculous patient, we should not use tuberculin without his consent. We are, however, justified in recommending tuberculin therapy when the usual means have failed to bring about a betterment of conditions, always bearing in mind, however, that in the hands of the inexperienced and careless, the administration of tuberculin can do infinite harm. King of Loomis says: "Tuberculin is a powerful toxic agent and one capable of doing much harm if improperly used. Only those physicians who are willing to devote considerable time to the study of the subject and who have had experience in observing and handling tuberculous patients should attempt its use." This is quite true as also what Shurley says when he calls tuberculin a "double-edged sword," capable of influencing pulmonary tuberculosis favorably in some instances and unfavorably in others. Baldwin, of Saranac Lake, puts it in equally impressive words when he says: "First, tuberculin may work much good in some patients by lessening the sensitiveness to itself; secondly, it may act as a stimulant to healing; or thirdly, it may aggravate the disease."

One of the latest contributions on tuberculin therapy[9] comes from the pen of Dr. Lawrason Brown and his associate, Dr. Edw. N. Packard, Jr., of Saranac Lake, N. Y. The authors give a résumé of the results obtained by the various tuberculin preparations, including that known as the turtle serum of Piorkowski and Friedmann. In the New York hospitals, where the Friedmann treatment was tried, those patients receiving it did not do better than those who did not receive it, and in some of the former owing to violent reactions, the condition seems to have been aggravated. Brown and Packard summarize the subject as follows: "During the past year little advance has been made in the scientific use of tuberculin. It still rests upon an empirical basis. As a rule, only its advocates write about it. What has always puzzled the authors is the fact that, use tuberculin how they will, they can never bring about such happy results as many of its ardent supporters claim. It seems that so far no statistical proof has been adduced to show that tuberculin is much superior to other forms of treatment in many patients; but in a few the results are so striking that those who obtain them are overenthusiastic."

This statement made by an authority like Dr. Lawrason Brown, one who has perhaps had more experience with tuberculin treatment than any other man in the United States, is gratifying to the author of the present article, who held this view for years, because it coincides with his observations and study of cases which had been treated with tuberculin and other culture products. Although we should not abandon the hope of some day finding an absolute specific for tuberculosis, let us in the meantime hold fast to what has proven to be good and whereby the best results have been obtained, namely, the hygienic and dietetic treatment combined with aero-, helio-, and hydrotherapy, under careful medical guidance in institutions, at climatic health resorts, or at home, and let us look upon the various culture products only as valuable adjuvants in certain selected cases.

S. Adolphus Knopf.

References.

1. Brauer, Schroeder, und Blumenfeld; Handbuch der Tuberkulose, 1914.
2. Barnes, Charles B.: Journal of the Outdoor Life, April, 1914.
3. Metzgar and Watsch: Journal of the Am. Med. Association, June 13, 1914.
4. Patterson, Marcus: Autoinoculation in Pulmonary Tuberculosis, London, 1911.
5. Morelli: Gazzetta Medica Italiana, 1911.
6. King and Mills: Am. Journ. of the Med. Sciences, Sept., 1913.
7. Sömme, J.: Zur Verhütung der Luftembolie beim künstlichen Pneumothorax; Tuberculosis, xiii., 6, June, 1914.
8. Torck: Surgery, Gynecol. and Obstet., July, 1914.
9. Brown and Packard: Medical Annual, 1914.

Lupulinum.—Lupulin. "The glandular powder separated from hops," U. S. P. The origin of this substance has been fully described under *Humulus.*

It is bright brownish yellow, becoming yellowish brown, resinous, consisting of minute granules which, as seen under the microscope, are subglobular, or rather hood-shaped, and reticulate; aromatic and bitter.

When lupulin is agitated with water and the mixture allowed to stand, no considerable sediment (sand, etc.) should be deposited. When ignited, lupulin should not leave more than ten per cent. of ash.

It is obtained from the hops by abrasion, and should then be stirred upon the surface of water to remove heavy impurities, with which it is often greatly adulterated. Such adulteration is readily detected by estimating the percentage of ash, for which the above-named ten per cent. is too liberal an allowance.

The differences in composition and action between hops and lupulin are chiefly those of degree. It yields about three per cent. of volatile oil and a proportionately greater amount of the bitter principle, but lacks the tannin. It is given in doses of from five to thirty grains. The Pharmacopœia provides a fluid extract and an oleoresin, the dose of the later being from one to five grains.

Henry H. Rusby.

Lupus Erythematosus.—*Synonyms:* Lupus sebaceus; Lupus erythematodes; Lupus non-exedens; Lupus superficialis; Ulerythema centrifugum; Seborrhœa congestiva; Fr., Lupus erythemateux; Scrofulide érythémateuse; Erythéme centrifuge.

Definition.—Lupus erythematosus is a chronic inflammatory, cellular infiltration, characterized by the

formation of one or more circumscribed, oval or rounded patches, either acutely or moderately inflamed, and covered more or less irregularly, with adherent yellowish-white scales.

Symptoms.—Two clinical varieties of the disease exist, namely, the discoid or circumscribed type, which is the one commonly observed, and the disseminate (lupus erythematosus disseminatus), which is comparatively rare. The circumscribed variety

Fig. 3853.—Lupus Erythematosus. Typical butterfly lesion (Hebra) of the cheeks and nose, with accompanying involvement of the eyebrows and lips. (Fordyce.)

is the common clinical type, and in most of the cases is located on the face; the nose, cheeks, and ear-lobes being favorite sites. The entire nose, with the exception of its lower end, is frequently involved, the disease spreading symmetrically on either side to the cheeks, and gradually widening as it spreads over the malar region; it then closely resembles in configuration the outspread wings of a butterfly. The scalp may be affected by the disease, either simultaneously with or after its appearance on the face. Exceptionally, the scalp may for some years, be the seat of the disease, without its appearance elsewhere. Permanent alopecia results in the diseased areas. In the discoid type there are no constitutional symptoms, and as a rule no local discomfort is complained of. In the disseminate variety, especially when very acute and extensive, there occasionally exists symptoms of general disturbance, and some febrile reaction. The patients complain of a burning sensation, and some itching, which at times may be very considerable. In the circumscribed form, which is the common clinical type, the disease begins as one or several, rather sharply defined lesions, of the size of a pin-head to that of a bean, and slightly elevated. They are of a pinkish to a deep red color, depending on the degree of inflammation, and covered more or less with small slightly adherent, white to whitish-yellow scales. The lesions do not entirely fade on pressure, and grow usually slowly, exceptionally rapidly, by peripheral extension, so that in the course of months or years, they may be from a quarter to several inches in diameter. After attaining a certain size, they are apt to remain stationary, but occasionally again increase in size, after a period of quiescence. The lesions frequently coalesce forming large patches of eruption, which form a characteristic clinical picture. The diseased area is sharply defined, its borders are markedly elevated, and covered more or less with light adherent scales. Its central portion is depressed, is of a lighter red color, and is usually atrophic. Dilated follicular openings, more or less plugged with sebaceous matter, or horny epithelium, can be observed. Occasionally the scaling is very extensive, even projecting into the follicles; but as a rule scaling and infiltration are of a moderate degree. Patches in the scalp are much more infiltrated, the tendency to scar formation is more pronounced, and the resulting alopecia is permanent. In some cases the lesions are very superficial, are scantily covered with branny scales, and have inconspicuous duct openings, but are however sharply defined. In these instances the lesions somewhat resemble a superficial type of seborrhoic eczema. On the other hand, it occasionally happens that the patches are so greatly infiltrated, as to be raised to a considerable degree above the surface of the adjoining healthy skin, and are thickly covered with large adherent scales. Lupus erythematosus disseminatus is much the more dangerous of the two varieties. It is characterized by the formation of small, usually numerous, pin-head to bean-sized lesions, which first appear on the face, and remain there, or spread to the hands, arms, or trunk. Rarely the disease may begin on the body, the face being subsequently involved. The lesions are quite red and hyperemic, and are very slightly scaly and infiltrated. Their centers may or may not be atrophic. Next to the face, the hands are most frequently involved. The subjective symptoms are quite marked, the patients complain of a burning sensation and often an intense itching. Systemic disturbances of an arthritic, gastrointestinal, or febrile type frequently occur. In many cases tuberculosis supervenes, a number of them terminating in death. Two other forms in which lupus erythematosus makes its appearance, are the telangiectatic, which causes a rosy red to deep-purplish color of the skin, with little or no surface changes, and is caused by dilatation of the capillaries; and the lupus pernio type, which is usually located on the ears, fingers, toes, or the flush area of the face. The affected areas are of a purplish-blue color. The condition markedly simulates chilblains. The course of lupus erythematosus is an extremely chronic and persistent one. In very rare instances, the disease spontaneously retrogresses, and disappears, sometimes without leaving a trace, but almost always in such cases, new lesions appear as the older ones fade away. As a rule, the patches are persistent, remaining more or less stationary for indefinite periods. The diseased areas show no tendency to ulcerative or malignant changes.

Etiology.—The disease appears much more frequently in women, the proportion averaging three to one. Of sixty-nine cases observed at the New York Skin and Cancer Hospital, forty-seven were women. It usually makes its appearance in the third decade of

life, but may occur at any age. It is frequently associated with chlorosis and chilblains, and on the hands is scarcely distinguishable from the latter. Any local congestion seems to favor its production. It has occasionally appeared after some preceding inflammatory disorder, such as erysipelas. In some of the cases the disease is the only evidence of ill health, the patient seems entirely well. There can be no question of the material influence exerted by a depressed systemic state, upon an existing lupus erythematosus. The great question, which is unfortunately as yet not satisfactorily answered, is its possible relationship to tuberculosis. There has not been to date, sufficiently clear evidence to definitely settle this question. While tuberculosis either active or latent exists in a large number of the cases, there are still a respectable number, in whom the most careful scrutiny fails to elicit any signs whatever of tuberculosis. The tubercle bacilli have not as yet been found in the lesions. Inoculation of susceptible animals with diseased tissue, has proved unsuccessful; yet however the weight of evidence, leads to the presumption, that lupus erythematosus is the result of the presence in the circulating blood, of a tuberculous or other toxin, at present unknown. Enfeebled circulation, trauma, and irritation, may also prove factors in its causation, and whether the toxins or the local conditions are the exciting factors, is a debatable question. In the present state of our knowledge, we cannot arrive at any definite solution of the problem; but we may deduce however, that the cutaneous lesions are the result of two causes: an internal one, the circulating toxins, which primarily affect the blood-vessels of the part, and a local vasomotor disturbance, superinduced by local irritation (trauma, flushing, eczema seborrhoicum, pernio, etc.).

Pathology.—Lupus erythematosus has been extensively studied, but the histological findings, and the conclusions drawn from these findings, are somewhat at variance. Fordyce and Holder found the capillaries obstructed with packed blood cells, and believe this constitutes the first step in the pathological change. They divide the histopathological process into three factors, round-cell infiltration, degeneration of connective tissue, and secondary atrophy. The chief changes consist in a dense infiltration of small round cells, of the embryonic type. The infiltration varies in extent, but is usually most pronounced along the course of the blood-vessels. It usually appears in the upper half of the corium, and is found only in a slight degree in the deeper parts of the corium and subcutaneous tissue. The blood-vessels are completely obstructed with packed blood cells, and in some cases undergo obliterative endarteritis. The sebaceous glands are primarily hypertrophied, and the seat of hypersecretion. Later they, their ducts, and the sweat-gland ducts, become infiltrated and undergo degeneration, thereby causing the peculiar punctate form of scar which is characteristic of the disease.

Diagnosis.—The discoid type of lupus erythematosus, as a rule, offers no difficulty in diagnosis. It is usually so characteristic, that it is easily recognized. On the face there are only three diseases with which it might be confused, namely: lupus vulgaris, syphilis, and eczema seborrhoicum. Lupus vulgaris begins in early childhood. Nodules or tubercles are always present. There is a marked tendency to ulceration, with resulting tough, hide-bound, scar formation. All of which does not exist in lupus erythematosus. A non-ulcerating tubercular syphiloderm may occasionally grossly resemble it, but the patulous, or plugged gland ducts, and the sharply marginated borders of an erythematous lupus, are wanting. The scales in seborrhoic eczema are of an oily and greasy character, it is usually associated with seborrhea of the scalp, there are no atrophic changes. In the scalp, alopecia areata and folliculitis decalvans can be easily eliminated; the former presents no inflammatory signs, the latter is irregular and jagged in outline, and its follicular origin quite evident. In the disseminate type, when the lesions are located on the fingers, it is occasionally, impossible to differentiate it from pernio, until the advent of the warm season, during which time pernio disappears.

Prognosis.—Lupus erythematosus is a chronic disease of indefinite duration, and very rebellious to treatment. In very few instances it has after an uncertain period, disappeared spontaneously, but this is exceedingly rare; ordinarily the process is either progressive, or stationary, new lesions making their appearance, as the older ones disappear. Some of the cases eventually develop tuberculosis, but as a rule, with the exception of the disseminate type, in which the prognosis is bad, the patient seems well, and suffers little or no inconvenience from the disease, other than mental distress, because of the deformity.

Treatment.—There can be no question of the valuable aid rendered local treatment, by the proper administration of whatever internal remedy seems necessary, after a careful analysis of the patients condition. Whatever tends to increase the facial congestion, should be religiously avoided. Alcohol, hot drinks, excessive coffee or tea-drinking, great exertion, and exposure to wind or sun, are therefore contraindicated. There have been a host of remedies suggested, with a supposed specific effect on lupus erythematosus. Among the most prominent of these is salicin, up to thirty grains, three times daily. It is strongly recommended by Crocker. Iodoform has proved of value. Whitehouse recommends that it be given in the form of one grain keratin coated pills, one pill to be taken after each meal, and slowly increased to nine a day, or to the point of tolerance. Its use should be continued for several months. The best results are attained in the acute hyperemic cases, it exerts little or no influence on chronic plaques of the disease. Hollander administers seven and a half grains of quinine, three times daily, for a week, and in conjunction, paints each diseased area with tincture of iodine, twice daily. After the week is over, a rest from the treatment is taken until the application has peeled off. Hollander claims that the treatment is a specific one. The method has been endorsed by several observers. Hutchinson recommends arsenic, and Unna ichthyol in five to fifteen drop doses. The local treatment depends entirely upon the stage in which the disease presents itself. In the acute hyperemic form, the treatment should consist in the application of bland remedies only, such as calamine and zinc, or magnesia and zinc lotions, according to the following formulas:

℞. Phenolis, ʒss
Pulveris calaminæ preparatæ, ʒij
Zinci oxidi, ʒij
Glycerini, ʒiij
Aquæ calcis, ʒii
Aquæ rosæ, q. s. ad ʒiv
M.

℞. Magnesii carbonatis
Zinci oxidi, aa ʒi
Aquæ rosæ, q.s. ad. ʒiv
M.

They are to be dabbed on with a bit of linen, twice daily. Should they happen to prove too drying, they may be omitted for a night or two, and cold cream used instead. As the acute process subsides, more active applications may be made. Lotio alba is an extremely valuable application at this time, and can be increased in strength from one dram each of zinc sulphat and potassium sulphuret in four ounces of rose water, to six drams of each. It should be ap-

plied not less than twice daily, oftener if possible. As an addition to this treatment Stelwagon paints on liquor potassæ once a week, or every ten days, allowing it to dry on, and then covering it with collodion. In the very superficial erythematous type, I have observed good results from the use of ninety-five per cent. alcohol, applied at very short intervals during the day, the oftener the better. Some of the destructive agents used in lupus erythematosus are: carbon dioxide snow, pyrogallol, trichloracetic acid, arsenical salve pastes, scarification, galvanocauterization, phototherapy, and radiotherapy. Of these agents, carbon dioxide snow is the most important. It is used mostly in the old chronic, thickened, discoid patches, and is applied for from twenty to sixty seconds, according to the degree of infiltration. The pressure should be moderate. It should not be applied to more than two square inches of contiguous surface, although separate patches may be treated at one time. Over bony prominences it should be used with care, so as to avoid too much destruction of tissue. While the Röntgen rays, and Finsen-light have benefited numbers of cases, they are not as valuable in this disease as in lupus vulgaris. Recently the Kronmayer quartz lamp has been extensively used. According to some observers, the results attained are very good, the resulting scar being much less noticeable than after the use of snow. Others claim that the apparatus is of very little if any benefit, and that the disease rapidly recurs in almost every case. There has been a growing tendency to neglect the use of the destructive agents, in favor of milder measures, and it is undoubtedly to the best interests of the patient to do so. PAUL E. BECHET.

Lupus Vulgaris.—*Synonyms:* Lupus exedens; Lupus vorax; Fr., Lupus vulgaire; Lupus tuberculeux; Scrofulide tuberculeuse.

Definition.—A chronic cellular infiltration, caused by the invasion of the integument by the tubercle bacillus, and characterized by the formation of deeply seated, reddish-brown nodules, and infiltrated patches, which either ulcerate or atrophy, leaving scars.

SYMPTOMS.—The face is the most common site for the manifestation of the disease, the nose and cheeks being the parts most frequently affected. It nearly always begins in early childhood, and first makes its appearance as several pin-head to small pea-sized, deeply seated, yellowish to brownish-red macules or tubercles, which are softer in substance than normal tissue. As the disease progresses, and new lesions appear, patches of eruption are formed by the crowding together of these nodules and infiltrated patches. The patch or patches sooner or later tend to break down, with resulting ulceration. The ulcers are rounded or oval in shape, and have soft flat borders of a dark brownish-red color. Their floors are shallow covered with unhealthy red granulations, and bathed in a variable amount of purulent secretion which, drying, leads to more or less crust formation. Later, as the disease progresses peripherally by the formation of new nodules or infiltrations, these ulcers are disposed to heal spontaneously, finally giving place to scar tissue of a densely fibrous character. A fully developed typical patch of lupus vulgaris is usually irregularly shaped, but it may be rounded or ovalish. It consists of deeply seated, characteristic, yellowish to reddish-brown subcutaneous nodules, of a consistency almost as soft as putty. Hutchinson called attention to their close resemblance to pieces of apple jelly imbedded in the skin. This resemblance can be beautifully demonstrated with the use of the diascope. Besides the "apple jelly" nodules, the patch consists of infiltrations of variable extent, and small rounded or ovalish, shallow ulcers, which are at times confluent. Cicatricial formation of a tough keloidal character is also usually present. The outlying area adjoining the borders of the patch may be the site of several isolated infiltrations or nodules. Occasionally the nodules may form heaped-up masses, which with the underlying cellular infiltration and edema, give rise to large fungoid masses (*lupus hypertrophicus*). At times the matured tubercles do not undergo ulceration, but after long periods of time disappear, partly by absorption, partly by exfoliation, leaving an atrophic, cicatricial, pigmented tissue (*lupus exfoliativus*). Separate or grouped patches of lesions may exceptionally be widely distributed

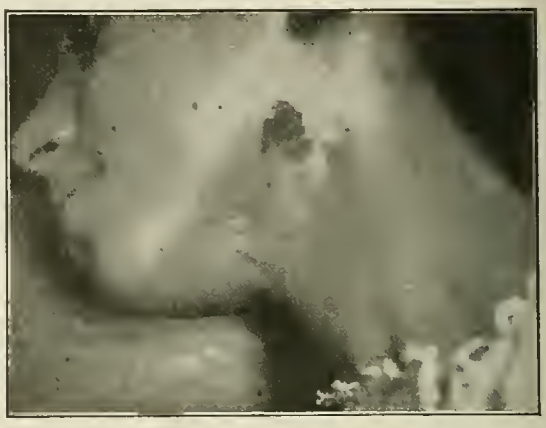

FIG. 3854.—Lupus Vulgaris; superficial type beginning in the scar of a healed tuberculous gland. (Collection of Dr. W. B. Trimble.)

over the body (*lupus disseminatus*). Occasionally the patch consists, at its borders, of a continuous infiltration, which may be irregular or tortuous; this with the usually atrophic or scarred center, makes the patch assume a serpiginous character (*lupus serpiginosus*). The disease in some cases results in serious deformity. When it occurs on the nose, the tissue about this organ, with the exception of cartilage, is destroyed, thereby producing contraction with consequent deformity and narrowing of the nasal orifices. The mouth may also be greatly narrowed, or drawn to one side by cicatricial formation following the presence of the disease in that locality. When it encroaches upon the eye, very severe grades of ectropion may be caused. In the severe cases, the ravages of the disease are at times frightful, the patient looking more like some hideous monster than a human being. While the face is usually the sole seat of the disease, the eruption may be noted elsewhere, either at the same time or subsequently to the face manifestation; exceptionally the eruption may develop on the arms, trunk, or legs alone, the face remaining entirely free. On the trunk it is usually very extensive, forming large areas of superficial serpiginous ulceration, but as a rule the lesions are not as destructive as on other parts of the body. Lupus of the extremities is characterized by the presence of commingled, thickened ridges, tubercles, warty excrescences, ulcers, and callosities. At times the disease produces caries and osseous necrosis, with resulting mutilating effect. Lupus of the mucous membranes may or may not be caused by extension of the lesion from adjoining diseased integument. The lupus tubercle, because of the warmth and moisture, is here transformed into a moist papule or granulating patch, with well-defined borders, and of a dirty, grayish-white color. It may ulcerate, and subsequently cicatrize.

Etiology.—The disease is much more frequently found abroad. Native Americans seem to be more immune, and when affected, present only the localized, milder forms of the affection. It is much more common in females, more than two-thirds of the cases having been observed in women. It usually begins in early childhood, in the majority of cases making its appearance before the age of fifteen. The direct cause of the disease is the tubercle bacillus,

Fig. 3855.—Lupus Vulgaris of Twenty-five Years' Duration (Fordyce.) The destruction of the lobule and cartilage of the auricle is characteristic.

and there can be no question of its contagiousness. Experimental inoculation has been successful, and a number of examples of contagion or accidental inoculation have been reported by different observers. Stelwagon noticed the disease on the faces of several children, who lived with tuberculous individuals, and who were frequently nursed and caressed by them. Winfield reports a case of a tuberculous individual, whose wife and daughter developed lupus. Cases of cutaneous tuberculosis following tattooing, washing of the linen of tuberculous individuals, ritual circumcision, vaccination, and even the piercing of the ear lobe, have been noted. The question of "soil" is of great importance. Poverty, filth, and malnutrition, with a consequent depraved state of health, are predisposing factors which cannot be ignored. The disease is much more frequent among the very poor, living in the midst of dirt and squalor, and its affinity for children may be due to their scratching and picking the face with filthy hands which might have come in contact with tuberculous material, a thing exceedingly liable to happen, particularly if a tuberculous individual be living in the same house or apartment. The disease may also be acquired by indirect inoculation by continuity from deep tuberculous foci.

Pathology.—In lupus the bacilli are found in exceedingly small numbers, in some of the cases, several serial mounts may be examined, without finding a single one. In all other forms of cutaneous tuberculosis they are found in greater abundance. The histopathological changes are brought about by the local action of the tubercle bacillus, and usually begin in the lower portions of the corium, as an accumulation of cells about the capillaries and lymph channels. This cellular new growth soon produces vascular changes, at times leading to complete obliteration. The sebaceous and sweat glands and the hair follicles all suffer alteration, even to total destruction. The epidermal changes are secondary and are not of tuberculous structure. There may be proliferative changes, in which marked downgrowth of the rete into the corium occurs. Hyperkeratosis may be present. Pressure from below may rupture the epidermis, with resulting pyogenic infection and ulceration. Edema and scaling may also occur. The lupus nodule consists of one or several giant cells, surrounded by a number of small round cells, with vesicular nuclei. Interspersed among these are a few multinuclear cells. All of which are enclosed by a zone of connective-tissue cells. No vascular elements exist in the nodule. The giant cells are oval, round, or irregular in shape, and contain as a rule, a homogeneous center, and many peripherally placed nuclei. Upon the epithelial changes produced by lupus vulgaris, epithelioma not infrequently begins. In recent literature, Zweig reports eight cases, and Garibaldi two, in which this complication occurred.

Diagnosis.—The three diseases with which it might be confused are epithelioma, tubercular syphiloderm, and lupus erythematosus. Epithelioma differs from lupus in the following particulars: it occurs late in life; it is usually single; it has an elevated, rounded, pearly border; its base is indurated; the ulceration is deeper, and its course more rapid. There is a history of the wounding of a small wart, mole, pigmented or scaly spot. The lupus nodules are absent. A tubercular syphiloderm in many cases strikingly resembles lupus vulgaris. There are, however, sufficient differences in the symptoms to prevent mistakes. The tubercular syphiloderm appears at a much later age, and its development is more rapid. It is of a darker red color, and shows a marked tendency to crescentic or serpiginous configuration. The ulcerations of syphilis are much deeper, the purulent discharge is more abundant, and the resulting scar tissue is smoother, more delicate, and superficial. On close questioning, a history of the disease may be elicited. The Wassermann reaction is positive. The papules, tubercles, ulceration, and tough fibrous cicatrices of lupus vulgaris, are absent in lupus erythematosus. The patulous, plugged-up gland ducts, superficial atrophy, and firmly adherent yellowish-gray scales of the latter disease, are not found in lupus vulgaris. Lupus vulgaris is very much more deeply seated. The presence of "apple jelly" nodules clinches the diagnosis.

Prognosis.—Lupus vulgaris is a chronic disease, exceedingly rebellious to treatment, and apt in some cases to terminate in death from tuberculosis of the lungs, or other internal organs. Leloir claims that twenty-one per cent. of his lupus patients died of consumption. In children or young adults, when the disease is limited to a few spots, it can as a rule be

readily cured. Even extensive patches of the disease can be eradicated, if one has the cooperation of the patient; but in many instances, repeated recurrences disappoint the patient so greatly, that he refuses any further medical aid.

Treatment.—The mere fact of the presence of a tuberculous process in the skin is to my mind sufficient evidence of some degree of lowered vitality; therefore fresh air, good food, outdoor exercise, and plenty of sunshine are adjuvants, the value of which no one can question. If indicated, any of the alterative tonics may prove of value. Stelwagon finds that cod-liver oil in moderate, long-continued doses, is the most valuable of the internal remedies. It seems to have a material influence in limiting the activity of the disease. Among the host of various remedies recommended from time to time, one might mention thyroid feeding. British dermatologists particularly recommend it, Pringle reporting really remarkable improvement. The results attained by him were gained without producing thyroidism. However, no complete cures have been effected with this remedy.

There has been unfortunately a marked tendency to abandon tuberculin therapy; yet a perusal of the recent literature on the subject, proves that the new tuberculin, T. R., has undoubtedly a favorable influence on lupus vulgaris of the nodular non-ulcerative type; this favorable influence is also exerted on the ulcerative type, if staphylococcus vaccine is simultaneously used. The method, while of proven value, is only an adjuvant, as it has not as yet brought about a cure.

The local treatment is of course the most important, and should have in view the removal of the diseased areas with as little resulting disfigurement as possible. These results are usually attained by surgical, chemical, or other measures. Of these measures the Finsen treatment stands easily at the head, its great therapeutic value, especially in the dry non-ulcerating form of the disease, has been definitely proven not only by Finsen himself, but by Sequeira, Morris, Leredde, Gaston, Stroebel, Lesser, Schmidt, on the Continent, and Hyde and Montgomery in the United States. It is not so effective, and may even fail entirely in cases in which the penetration of the light is prevented by thickened scars, densely infiltrated or hypertrophic areas, or extensive pigmentation or crusting. In these instances pyrogallol, or other applications may be made, so as to bare the diseased areas before applying the light. Of 729 cases treated in Finsen's Lysinstitut in Copenhagen, 40 or 6 per cent. received little or no benefit; 689 or 94 per cent. were either entirely cured or greatly benefited; 56 per cent. were entirely healed, and 17 per cent. had had no recurrences in from two to six years of observation. The cosmetic results are superior to those attained from any of the other methods. The *x*-ray is of great value in the treatment of lupus vulgaris, it removes the lupus nodules, and also greatly reduces and improves the thickened, disfiguring scars which often follow the spontaneous disappearance of the disease. Unfortunately it has to be given to the point of reaction to get its best effects, and not infrequently the resulting irritation causes telangiectatic and other changes, so that on the whole the resulting scars after phototherapy are cosmetically superior to those following radiotherapy.

When the disease is confined to a few small, circumscribed patches, excision, carried well beyond the borders of the disease, and immediately followed by the application of Thiersch grafts, is very successful. Unfortunately the resulting scar is considerable. Among the destructive surgical measures may be mentioned curetting, the use of the dental burr, and linear scarification. In discussing these measures one must not lose sight of the fact that, by making use of them, many new avenues of infection are opened to the tubercle bacilli, to say nothing of the increased possibility of the bacilli being taken up by the vessels and transported to some distant focus, possibly the lung. This disadvantage outweighs in my mind any of the benefits supposed to be derived from their use.

Some of the parasiticides have been successfully used. Salicylic acid, creosote, and pyrogallol, are the most useful. They are best applied in plaster form, in from ten to thirty per cent. strength, depending upon the degree of destruction one wishes to bring about. Galvanocauterization has been recommended. Carbon dioxide snow has a field of usefulness in superficial areas of the disease.

Paul E. Bechet.

von Luschka, Hubert.—Born at Constance, Baden, July 27, 1820. His first occupation was that of an apothecary, and it was not until 1841 that he began to study medicine, first at Freiburg, then for one year at Heidelberg, and finally once more at Freiburg. After practising for a few months at Meersburg, he received his doctor's degree from the University of Freiburg in 1845, the subject of his thesis being "Entwicklungsgeschichte der Formbestandtheile des Eiters und der Granulationen." In 1849 he was made Extraordinary Professor of Anatomy and Prosector at the University of Tübingen, and, after Arnold had gone to Heidelberg in 1852, he was given the full professorship and at the same time made Director of the Anatomical Institute, both of which positions he continued to hold up to the time of his death, which occurred May 1, 1875.

Von Luschka, according to Pagel, was one of the greatest anatomists of the nineteenth century; topographical anatomy being the field in which he particularly excelled. His name is permanently fixed in the history of medical science through the many discoveries which he made (Luschka's bursa or tonsil, cartilage, ligament, etc.). His published writings are characterized by the fact that numerous references to pathological anatomy are scattered throughout his purely anatomical descriptions. The following may be considered some of the more important of his works: "Die Anatomie des Menschen in Rücksicht auf die Bedürfnisse der praktischen Heilkunde bearbeitet," three volumes, Tübingen, 1862–1867; "Die Venen des menschlichen Halses," Vienna, 1862; "Die Muskulatur am Boden des weiblichen Beckens," Vienna, 1861; "Der Schlundkopf des Menschen," Vienna, 1868; "Der Kehlkopf des Menschen," Vienna, 1871; and "Die Lage der Bauchorgane des Menschen," 1873. A. H. B.

Lusk, William Thompson.—Born at Norwich, Conn., May 23, 1838. He studied medicine for three years in Heidelberg and Berlin (1858–1861). Then, upon his return to America, he took service in the United States Volunteer Army, first as a private in the ranks and afterward successively as second lieutenant, first lieutenant, captain, and assistant adjutant-general. In the winter of 1863–1864 he resumed his medical studies and received the degree of M. D. from Bellevue Hospital Medical College in 1864. He subsequently spent a year and a half in study in Edinburgh, Paris, Vienna, and Prague, and in 1865 established himself in practice in New York. For over twenty years he held the position of Professor of Obstetrics, Diseases of Women, Diseases of Infants, and Clinical Midwifery, in Bellevue Hospital Medical College. He was also gynecologist to Bellevue and St. Vincent's Hospitals, and Obstetric Physician to the Emergency Hospital. His death occurred June 12, 1897.

Of his numerous contributions to medical literature it will suffice here to mention his great work en-

titled: "The Science and Art of Midwifery." It was first published in 1882, and the last edition (the fourth) appeared in 1892. It has been translated into French, Italian, Spanish, and Arabic. A. H. B.

Luteins.—In the yolk of the egg and in certain other places in the animal organism as in blood serum, fatty tissues, corpora lutea, etc., yellow or orange-red amorphous coloring matters are found and to them has been given the name luteins, or lipochromes. The luteins are not identical as they show different properties but as a class they are soluble in alcohol, ether, and chloroform. They show a characteristic absorption spectrum with two bands, one of which covers the line *F*, and the other lying between *F* and *G*. They are not identical with bilirubin as they fail to give the characteristic Gmelin test for bilirubin. They are closely related to certain of the pigments, the xanthophyll group, found in the vegetable kingdom. F. P. U.

Luxor.—See *Egypt*.

Lycetol.—Dimethyl piperazine tartrate [$NH(CH_2-CHCH_3)_2NH + H_2C_4H_4O_6$]—is a white, odorless, crystalline powder, readily soluble in water. Like piperazine this salt is said to be a solvent for uric acid, and is used in cases of gouty diathesis. The dose is gr. xv.–xxx. (1–2 grams) dissolved in plenty of water, its lemonade-like taste making of it a pleasant drink.

W. A. Bastedo.
R. J. E. Scott.

Lycopodium.—*Vegetable Sulphur*. "The spores of *Lycopodium clavatum* L. and of other species of *Lycopodium* (fam. *Lycopodiaceæ*)," U. S. P. These plants are evergreen creepers, common throughout the north temperate zone. Their ament-like spikes bear numerous sporangia. These spikes are collected, chiefly in Northern Europe, dried, and threshed. Considerable dirt is inevitable, and this amount is frequently largely increased for purposes of adulteration; hence the necessity for estimating the amount of ash, and for microscopical examination. It occurs as a fine powder, pale yellowish, very mobile, inodorous, tasteless, floating upon water and not wetted by it, but sinking on being boiled with it, and burning quickly when thrown into a flame. Under the microscope the spores are seen to be sphero-tetrahedral, the surfaces marked with reticulated ridges, and the edges beset with short projections.

Lycopodium should be free from pollen, starch, sand, and other impurities, any of which are easily detected by means of the microscope.

When ignited with free access of air, lycopodium should not leave more than five per cent. of ash.

It contains forty-seven per cent. of fixed oil (Flückiger), and has no other important constituent. It is used only as a non-adhesive powder for the protection of moist pills from sticking together, and for dusting upon excoriated places—to protect the surface and to prevent chafing, its action in both cases being wholly mechanical. Henry H. Rusby.

Lymph.—Definition.—Lymph is one of the circulating fluids of the body. It is the all-pervading fluid of the body. It has been said that the higher animals as well as the lower are really aquatic, inasmuch as each cell of a reptile, bird, or mammal lives in a liquid medium—the lymph.

Blood comes into contact with the endothelial cells of the blood circulatory system, and with the cells within the spleen pulp—with these cells and with these alone. But these cells comprise a vanishingly small proportion of the cells of the body. All the rest of the cells—and that is, nearly all of the cells of the body—never come into immediate contact with the blood. They receive their food and their respiratory oxygen through the lymph; while the lymph in turn receives these materials for the sustenance of the cells from the blood.

On the other hand, waste matters, which are constantly forming within active cells, are thrown out of the cells into the lymph and make their way directly or indirectly back into the blood, to be carried to some excretory organ.

The lymph is thus the liquid medium of interchange between the living, active cells of the body (endothelium excepted) and the blood.

The way in which this interchange between blood and lymph, and between lymph and cells, takes place will be discussed under Relation of Lymph to Metabolism.

2. Classification.—The word lymph is frequently used with a somewhat wider meaning than that given in the definition above. In this wider significance lymph includes not only the lymph in the intercellular spaces but also all liquid, not blood, contained within endothelial-lined cavities or circulating within endothelial-lined vessels. This more general definition includes the fluid contents of the pleural, peritoneal, and pericardial cavities.

It includes the chyle together with the contents of all lymphatics and lymph spaces.

The aqueous humor of the eye, the cerebrospinal fluid and the synovial fluid, are closely related to lymph, but differ in certain important properties characteristic of lymph and may not be classed with lymph proper.

Lymph may thus be classified as:

1. *Tissue Lymph*—filling the intercellular spaces throughout the body.

2. *Circulating Lymph*—flowing along the lymph radicles and lymphatics, making its way slowly back to the circulatory system, usually viâ the thoracic duct.

3. *Chyle*—the circulating lymph of the intestinal mucosa and submucosa plus the food-stuffs (mostly fats) absorbed from the lumen of the intestine.

4. *Serous Lymph*—the contents of the serous cavities.

Composition.—Tissue lymph, circulating lymph, and serous lymph have practically the same composition, as follows:

				Per cent.
Lymph,	Water			95.20
	Solids.	Organic,	Proteins. Corpuscles, Serum globulin, Serum albumin,	3.75
			Extractives. Fats, Lecithin, Cholestrin,	0.10
			Sugar, dextrose	0.10
		Inorganic,	Sodium chloride 0.56; Sodium carbonate .24; Other salts .05	0.85
			Chlorides, sulphates, phosphates, and carbonates of Na, K, Ca, and Mg.	
				100.00

The proteins of lymph are contained partly in the corpuscles and partly in solution in the lymph plasma. An important constituent of lymph protein is the fibrinogen—one of the globulins—which is one of the factors in the formation of the clot when lymph escapes from tissues or vessels. All lymph contains fibrinogen; but serous lymph contains no fibrin ferment and will, therefore, not coagulate spontaneously. The serous lymph contains less protein

(about 2.42 per cent.) than tissue or circulating lymph.

The salts of the lymph are the same qualitatively as those of the blood, differing only in their quantitative relations. The proportion of salts of the lymph is less than that of the blood.

Besides the above-enumerated constituents the tissue and circulating lymph contains small and indeterminate quantities of catabolites, chief of which is urea, which is found in amounts approximating 0.016 per cent.

Chyle differs from other forms of lymph in the large admixture of food-stuffs just absorbed from the alimentary canal. Practically all of the fat is absorbed into the lymphatics of the intestinal mucosa and submucosa. It circulates in these in the form of an emulsion. This gives the lymph, otherwise clear and light yellow, the appearance of milk, and called forth from Asellius,[1] the discoverer of the vessels which contain it, the name *lacteals*.

The amount of fat which the chyle contains will vary naturally with the conditions of the observation. If the observation be made upon a dog about two or three hours after a meal rich in fats the lacteals will be found gorged with a chyle as white as milk and very rich in fats. If, however, the observation be made under conditions in which the lymphatics in question are not carrying absorbed fats, the vessels do not differ in appearance from other lymph vessels, and the contained chyle would not differ essentially from circulating lymph in its chemical composition.

Chemical analysis shows the chyle, when drawn from the lacteals after a meal rich in fats, to have the following composition:

				Per cent.
Chyle.	Water			90.67
	Solids.	Organic.	Proteins	2.21
			Extractives, Fat	4.71
			Lecithin	0.54
			Cholesterin	0.85
			Sugar and other organic substances	0.23
		Inorganic:	Salts, similar to those of the lymph	0.79
				100.00

The physical composition of the lymph bears a close resemblance to that of the blood. Like the latter it consists of plasma and corpuscles. The plasma differs in no essential character from blood plasma: straw-colored and clear; alkaline in reaction, through Na_2CO_3 and Na_2HPO_4; coagulable under the same conditions as those which govern the clotting of blood, and as a result of the same factors—fibrinogen, fibrin ferment, and calcium salts; saltish in taste, because of the presence of 0.6 per cent. sodium chloride; specific gravity lower than that of blood plasma because of the smaller proportion of salts.

The lymph corpuscles are simply leucocytes. They are formed mostly in the lymph glands, and are put into circulation first in the lymph, and with the lymph enter the blood circulation through the thoracic duct.

4. The Theory of Lymph Formation.—A brief historic review is necessary to give one an idea of the way in which the present theory of lymph formation developed.

Asellius[1] discovered the lacteals (1622) and thought that they carried absorbed food to the liver for elaboration into blood.

Rudbeck[2] discovered the general lymphatics (1653) and observed that lymph clots like blood and has a salt taste.

Bartholin[3] discovered, independently, the general lymphatics, and believed that lymph formed from blood by filtering through the tissues and that it represented water and salts of the plasma.

Pecquet[4] discovered the connection of the lacteals with the thoracic duct and through this with the venous system (1654).

Monro[5] believed that the lacteals filled by sucking digested food-stuffs from the intestinal canal (1757).

Bichat[6] believed that tissue spaces filled from the blood-vascular system through exhalant arteries ("vasa exhalantia"), that the lymphatics filled from the tissue spaces through open mouths and lacteal vessels by "capillary attraction," and that lymph kept moving through "vital activity" of cells and tissues (1812).

Dutrochet[7] discovered *endosmosis*, and many physiologists believed the riddle of absorption and formation of lymph to be finally solved. The importance of osmosis has been generally recognized by physiologists since that time; but the part which it plays has been variously estimated (1827).

Hunter[8] believed with the older writers that the lacteals filled by suction from the alimentary canal, and that the general lymphatics filled by suction from the tissue spaces. As to the filling of the tissue spaces he recognized the possibility of a filtration through the walls of the blood-vessels (1835).

Johannes Müller[9] did not accept the mechanical theory (capillary attraction, etc.); but, observing that the lacteals did not absorb all solutions from intestines without respect to kind, conceived the idea of "selection," and believed that the formation of chyle was due to the "vital activity" of the living cells of the intestinal wall (1838).

We come now to the last half of the nineteenth century. Over two centuries of speculation guided by an occasional observation had passed since the lymphatics were discovered. Speculation had run the gamut of theories—filtration, capillary attraction, osmosis, vital activity. The physiologists of the period of physical, chemical, and microscopic research were to turn on the searchlight of modern science to solve the problem of lymph formation and movement.

Carl Ludwig[10] approached this problem in his characteristic way. He applied here the methods of the physical laboratory, testing through the mercury manometer the blood pressure, the venous pressure, and the lymph pressure, and, in consequence of his observation of high blood pressure and low lymph and venous pressure, maintained that the lymph resulted from filtration of plasma through the capillary walls. In 1861 Ludwig[11] summed up his theory of lymph formation through filtration and diffusion as follows:

"The blood which is contained in the vessels must always tend to equalize its pressure and its chemical constitution with those of the extravascular fluids, which are only separated from it by the porous blood-vessel walls. If, for example, the quantity of blood in the vessels has increased, the mean blood pressure is also increased, and at once a portion of the blood is driven out into the tissues by a mere process of filtration. The same result is brought about when the constitution of the blood is altered by the absorption of food or by increased excretion by the kidneys, blood, or skin, or when the composition of the tissue fluids is altered in consequence of increased metabolic changes taking place in the tissues. In the latter case the changes brought about in the lymph are effected by processes of diffusion."

Ludwig's theory was generally accepted by physiologists for about four decades. Little work was done during that time. The work done by Tomsa,[12] by Emminghaus and Paschutin,[13] and by Rogowicz[14] all led to results in harmony with the *filtration* theory of lymph formation.

Heidenhain[15] experimented upon the lymph flow from the thoracic duct and concluded that his observations were irreconcilable with the filtration theory, and that "we must assume that the cells forming the walls of the capillaries take an active part in lymph

formation, *i.e.* that the lymph must be looked upon as a *secretion* rather than as a transudation."

During the last decade of the century the whole field was carefully reworked by many skilled observers. A question which had seemed to be settled was again opened by Heidenhain's work, and many new experiments were instituted to determine the parts played by physical and vital forces.

Valuable contributions were made by Cohnstein. Experiments to reproduce the physical relations of the blood and lymph circulations were tried.[16a] A tube of animal membrane, representing the blood-vessels, passed through an outer tube, representing the lymph spaces of tissue. The fluid in these two tubes was subjected to varying pressures with results that led the experimenter to conclude that the pressure within the inner tube (always much greater than that in the outer) was a more important factor than any variations of pressure in the surrounding liquid. On the whole, the author held to the filtration theory rather than to the secretion theory. Cohnstein[16b, c] showed that a considerable but variable time elapses after an intravenous injection of salt or sugar solution before the lymph is affected, and that simultaneous tests of blood and lymph may be misleading.

Researches made by Lazarus-Barlow,[17] by Bainbridge,[18] and by Moussu,[19] all resulted in conclusions favorable to the filtration theory of lymph formation.

In the meantime other experimenters got results which seemed to point to a secretory activity on the part of capillary walls. Hamburger[20] found in a horse under observation that there was an increased flow of lymph from the ductus colli, at the same time that there was decrease of both carotid and jugular blood pressure.

Tscherewkow[21] found no change in the amount of lymph which passed from the thoracic duct after hemorrhage, and concluded therefore that there is difficulty in affirming a direct relation between capillary pressure and lymph formation. Ostowsky[22] made tests of the efferent lymph stream from the testis after intravenous injections of salt, sugar, peptone, etc., and concluded that "lymph flow is practically independent of general blood pressure."

Popoff[23] made experiments on the intravenous injection of dextrose, varying the method of Heidenhain by injecting rapidly (one to two minutes) rather than slowly (thirty minutes), and found that the maximum amount of sugar in the blood was never less than that in the lymph; that the lymph flow from the thoracic duct was increased, but not in proportion to the amount of sugar injected; that the urine is also considerably increased, and that sugar is freely excreted through the urine.

Pugliese[24] investigated the formation of lymph in the fore leg of a dog, and found that venous stasis caused an increased flow of lymph, thus favoring the filtration theory. He found, further, that either active or passive movements of the leg increased the amount of lymph without changing its composition. About this time Asher,[25a, b] associated in a part of his work with Barbèra,[26] made some important contributions to the problem in question, and though he took a middle ground by declaring that "some of the facts discovered can be accounted for upon the physical basis (filtration and osmosis), and some upon the physiological (secretion)," he involved the problem still more by announcing a new factor, viz., *organic activity*. He presented a strong series of facts to show that whenever the activity of an organ is increased, the flow of lymph from that organ is also increased.

Thus during the period of active investigation of the subject of lymph formation a great mass of facts had been established, but the physiological world was still in doubt as to the relative importance of the various possible factors involved in the formation of lymph. The time had come for an analytical mind to take up the subject and bring order out of chaos. This analytical mind was furnished by Dr. E. H. Starling, of London. Starling made an important series of contributions to the literature of this question in 1894 and 1896,[27, 28] and in 1898 he made a masterly review of the whole problem, weighing in a most liberal and impartial manner the various contributions to the solution of the problem of lymph formation.

The early work was subject to criticism in that the experimenters had studied the flow of lymph from the leg and had been obliged to subject the tissues to massage in order to get a flow.

Tigerstedt[30] had first called attention to this difficulty with the early work. Heidenhain recognized the validity of this criticism and devised a new method to avoid it. He studied the flow from the thoracic duct, and assumed that this represented the lymph formation of practically the whole organism. Heidenhain's long investigation was based upon this apparently tenable conclusion, and, as stated above, led to results irreconcilable with the filtration theory.

Starling[29] showed that the flow from the thoracic duct does not represent the general lymph formation. The lymph flow from the anterior limbs, and head and neck, does not enter the thoracic duct, while that of the posterior is so small in amount that it need not be considered; furthermore, the amount which enters from the thorax is so slight that no difference is observed when the cannula is inserted just above the diaphragm instead of near the subclavian vein. It becomes apparent, then, that the flow of lymph from the thoracic duct represents the lymph formation in the abdominal viscera; and these may be further differentiated into two regions: (1) the portal, and (2) the hepatic; or the lacteal and the liver regions.

Starling next demonstrated that the lymph from the liver is most concentrated (*i.e.* contains the largest proportion of solids), that from the portal region is next in its degree of concentration, while that from the limbs, head, and neck is least concentrated. He later showed that this varying degree of concentration consisted principally of a varying proportion of protein, and that the variation of protein depended upon the varying permeability of the capillaries in the three regions; the permeable liver capillaries allowing protein to filter through so easily that it makes six to eight per cent. of the liver lymph; the less permeable capillaries of the portal region permitting only four to six per cent. to filter through; while the least permeable capillaries of the extremities permit only from two to four per cent. of protein to pass.

After a careful examination of Heidenhain's experiments on the flow of lymph from the thoracic duct, Starling concluded that "the lymph production in the organs of the abdomen is directly proportional to the capillary pressure in these organs; and not independent of it as was imagined by Heidenhain."

The next step in the review of the controversy was to determine the influence of hydremic plethora. It was found that this condition may be artificially produced in two ways: first, by injecting intravenously an isotonic solution of sodium chloride (normal saline solution) to the extent of from 300 to 500 c.c.; second, by injecting intravenously a condensed solution of sodium chloride or of dextrose, thus giving to the plasma a high endosmotic attraction for tissue lymph. The blood plasma promptly draws through the capillary wall the tissue lymph, thus draining the tissues and temporarily decreasing lymph flow and increasing intracapillary pressure. The natural reaction to this condition is a much increased filtration of plasma from the overfilled blood system (condition of hydremic plethora) into the lymph spaces of the tissues, and this in turn is followed by an increased flow of lymph along the lymphatic vessels.

That the increased lymph flow is conditioned upon the hydremic plethora and not upon the simple presence of the salt or sugar in the blood was demonstrated by Starling through simply withdrawing an amount of

blood equal to the aqueous solution injected or to the tissue lymph drawn in by osmosis; the result being an increase of the salt (or sugar) without increasing the volume of blood. This procedure resulted in no increase in the flow of lymph, thus proving that it was the condition of hydremic plethora, *i.e.* of increased blood pressure, which caused the increased lymph flow, and not the presence of the increased quantity of salts (or sugar) in the blood.

These soluble, crystalline substances, salt, sugar, potassium chloride, etc., made Heidenhain's second class of lymphagogues. It is apparent that their lymphagogic effect was due to the increased capillary pressure which accompanied their use, and not to any specific stimulation which they exerted upon the secretory activity of the endothelial cells of the capillaries. In harmony with this opinion are the results of Timofejewsky.[31] But the increased blood pressure causes increased filtration; and thus it transpires that the observation which Heidenhain cited to show the untenability of Ludwig's hypothesis only made that hypothesis more secure when rightly interpreted.

Heidenhain's first class of lymphagogues (extracts of leech, mussel, and crayfish) cause a much increased flow of lymph; but Starling showed that they exert this effect through their toxic action upon the endothelial cells of the capillaries, thus making those cells less able to resist the intracapillary pressure, so that, with the latter normal or even decreased, there will be an increased flow of lymph.

Starling has been able to account for many previously unaccountable things and to reconcile the findings of Heidenhain and his associates with the physical theory. It will be remembered that this theory, as formulated by Ludwig in 1861, accounted for lymph formation on the basis of the combined action of filtration and osmosis. No clearer formulation of the present state of our knowledge of this question can be made than that made by Ludwig fifty years ago.

The Relation of Lymph to Metabolism.—This relation was indicated, in general terms, under the definition of lymph. As stated above, the lymph is the medium through which every active cell gets its food and its oxygen; it is also the medium into which every cell throws out the waste matter resulting from its metabolism. When we say that lymph is formed by filtration from the blood and modified by osmosis with the blood, we cover the ground of the initial formation of lymph; we must, however, not forget that the lymph is being continually modified, during the time when it is within the several tissues and organs, by the metabolism peculiar to the respective tissues and organs. The blood plasma which filters into leg muscle, intestinal mucosa, and liver is essentially the same in each case, differing only in the respective proportions of protein, conditioned upon the varying permeability of the capillary walls in these three localities. But the metabolism in these three regions is very different—different not only in respect to what the cells take out of the intercellular lymph, but different also in respect to what the cells throw out into this lymph.

The cells of the muscle will take up fat, dextrose, and protein from the lymph and throw out various midproducts of protein catabolism.

The cells of the intestinal mucosa will make no important drafts upon the lymph; they will, however, absorb great quantities of fat, associated with sodium carbonate (Setchenow[32]), and, according to Colin[33] and to Asher and Barbèra,[34] considerable quantities of protein; and this fat and protein will be poured into the lymph (chyle).

The cells of the liver will absorb from the lymph not only food and oxygen for their sustenance, but also large quantities of material which represents the midproducts of tissue metabolism. The liver is the great central laboratory of the body where urea, uric acid, bilirubin, and biliverdin are made; where dextrose is taken up from the portal system and changed to glycogen in which form it is stored. To accomplish this, great modifications will be made in both the blood and the lymph which traverse the liver. Of the two fluids the lymph is subjected to the more profound change.

It must not be forgotten that wherever blood and lymph are separated by a capillary wall osmotic action proceeds, and there will be a modification of both fluids with a tendency toward equalization. The circulation through the liver not being a rapid one, the diffusion of substances between blood and lymph will be considerable. Urea is thrown out into the lymph by the liver cells, and a small part is diffused into the blood. The rest, according to Wurtz,[35] amounting to about 0.016 per cent. of the lymph, makes its way along the thoracic duct, where it is all poured into the venous system and carried presently to the kidneys for excretion.

The lymph contains various substances whose presence and whose relation to metabolism are not understood. There are glycogen and a diastasic ferment,[36] and there is rennet,[37] besides various other substances in traces.[38, 39]

Ransom[40] found that when the toxin of tetanus was injected into the blood not more than one-third of it ever found its way into the lymph. Similarly when tetanous antitoxin is injected it is retained in the blood to the amount of two-thirds.

The only extensive study ever made as to "The Influence of Diet upon the Chyle," has been reported by Hall,[41] from the Physiological Laboratory of the Northwestern University Medical School. Summing up the results of five four-day diet periods in which quantitative analyses were made of all ingesta and egesta and of the lymph (chyle) collected from the peritoneal cavity of a patient who had suffered from a traumatic chylorrhagia Hall concludes: "The fat content of the chyle varies greatly with the diet; the protein varies moderately, while the sugar varies only slightly. From these facts I believe that we are justified in assuming that not only are the fats absorbed by way of the lacteals, but the proteins also are in part absorbed by way of the lacteals. With equal force it may be said that the sugar is not absorbed by the lacteals, but the trace uniformly found is that which is incident to tissue fluids generally and gets into the thoracic duct from tissue lymph vessels."

The Movement of Lymph.—Frequent mention has been made of the flow of the lymph. Let us now consider what it is that causes the lymph to flow.

Like the veins the lymphatics are thin walled and provided with valves; like the veins the lymphatics are filled from the capillaries by force from the heart, the difference being that the heart forces the blood in a million of capillary streams into the veins, while it forces the plasma of the blood in many hundred million streams through the pores of the capillary wall into the lymphatics.

The initial and principal force which causes the lymph to flow is the *vis a tergo* from the heart, which pushes it on farther and farther from the tissue among whose cells it escaped from the capillary. As it moves forward it is gathered into the lymph radicles; these in turn are tributary to the smaller lymphatics. Once the lymph reaches a lymphatic there is no retreat because the valves block all backward flow.

The heart force alone would be sufficient to cause the lymph to flow throughout its system of vessels and back to the subclavian vein. There are two other forces, however, which are of great importance in assisting this flow. These forces are the negative pressure of the thorax, and the positive pressure exerted upon the blood and lymph vessels by contracting muscles.

Every one is familiar with the influence of negative intrathoracic pressure upon the flow of blood in the veins. Its influence upon the flow of lymph is as important as that upon blood. These fluids are actually pumped into the thorax as water is lifted by a suction pump. Furthermore, the downward movement of the diaphragm makes positive pressure in the abdominal cavity at the same time that it makes negative pressure in the thorax. Thus there is exerted on the lymph in the abdomen both a *vis a tergo* and a *vis a fronte*.

Besides this force exerted by the respiratory movements there is a pressure upon the sides of veins, of lymphatics, and of arteries within contracting muscles. The arteries can by their thicker walls resist this lateral pressure, but the contents of the veins and lymphatics are forced forward—backward movement being made impossible through the closure of the valves.

Hewson[42] believed that lymph was kept moving in the lymphatics by peristaltic movements of the walls of the lymph vessels; but there is no reason to believe that any such movement takes place in any of the higher animals.

The rate of lymph filtration and flow has been investigated by Tschirwinsky.[43] By injecting salicylate of sodium into the blood or lymph stream the time required for it to appear at the upper end of the thoracic duct could be accurately determined. With this method he was able to show: (1) that it required from four to seven minutes to pass from the descending aorta to the thoracic duct; (2) that it required from two minutes ten seconds to three minutes to pass from the femoral artery to the pedal lymphatic; (3) that it required one minute twenty seconds to flow from the pedal lymphatic to the thoracic duct; (4) that it required from thirty seconds to one minute to filter through the tissues.

The flow of lymph seems to be without direct nervous control, though Spallitta and Consiglio,[44] by inducing high pressure in the thoracic duct, observed an increase of blood pressure, and slower, stronger heart beat, which suggested a reflex response to change in the lymph pressure. This points to the probable presence of afferent nerves from the larger lymphatics to the cardiac centers in the medulla.

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REFERENCES.

1. Asellius: De lactibus siva lacteis venis, Basel, 1628. (Cited by Schefer, Text-book of Physiol., p. 286.)
2. Rudbeck: Nova exercitatio anatomica, 1653. (Cited by Schäfer, Text-book of Physiol., p. 286.)
3. Bartholin: Vasa lymphatica nuper in animantibus inventa, Hafniæ, 1653. (Cited by Schäfer, Text-book of Physiol., p. 286.)
4. Pecquet: Experimenta nova anatomica, Paris, 1654. (Cited by Schäfer, Text-book of Physiol., p. 286.)
5. Monro: De venis lymphaticis valvulosis, 1757. (Cited by Schäfer, Text-book of Physiol., p. 287.)
6. Bichat: Anatomie générale, 1812. (Cited by Schäfer, Text-book of Physiol., p. 287.)
7. Dutrochet: Agent immédiat du mouvement vital. (Ann. de Chim., Paris, 1827, t. xxxv., p. 393.)
8. Hunter: Works, vol. iv., p. 299, London, 1835. (Cited by Schäfer, Text-book of Physiol., i., p. 287.)
9. Johannes Müller: Elements of Physiol., Baly's Trans., 1838, vol. i., p. 248.
10. Ludwig and Noll: Zeitsch. f. rat. Med., 1850, Bd. ix., S. 52.
11. Ludwig: Lehrbuch der Physiologie, 1861, Aufl. 2, Bd. ii., S. 562.
12. Tomsa: Sitzungsb. d. k. Akad. d. Wissensch., Wien, 1862, Bd. xlvi., S. 185.
13. Emminghaus and Paschutin: Arb. a. d. Physiol. Inst. zu Leipzig, 1873.
14. Rogowicz: Arch. f. d. ges. Physiol., Bonn, 1885, Bd. xxxvi., S. 252.
15. Heidenhain: Arch. f. d. ges. Physiol., Bonn, 1891, Bd. xlix., S. 209.
16a. Cohnstein: Pflüg. Arch. f. d. ges. Physiol., lix., S. 350,1895
16b. Cohnstein: Pflüg. Arch. f. d. ges. Physiol., lix., S. 508,1895.
16c. Cohnstein: Pflüg. Arch. f. d. ges. Physiol., lxii., S. 58, 1896.
17. Lazarus-Barlow: Jour. Physiol., xix., 5–6, p. 418, 1896.
18. Bainbridge: Jour. Physiol., xxiv., p. 16, 1900.
19a. Moussu: Comp. rend. Soc. de Biol., 1700, pp. 235, 286, 363, and 541.
19b. Moussu: Jour. de l'An., xxxvii., p. 365 et p. 550, 1901.
20. Hamburger: Du Bois-Reymond's Arch., Nos. 3–4, S. 364, 1895.
21. Tscherewkow: Pflüg. Arch., lxii., S. 304, 1896.
22. Ostowsky: Centralbl. f. Physiol., Bd. ix., S. 697, 1895.
23. Popoff: Centralbl. f. Physiol., lx., S. 53, 1895.
24. Pugliese: Pflüg. Arch., lxxii., S. 603, 1898.
25.a Asher: Centralbl. f. Physiol., xii., 486, 1898.
25.b Asher: Zeitsch. f. Biol., xxxvii., 2, S. 261, 1898.
26. Asher and Barbèra: Zeitsch. f. Biol., xxxvi., 2, S. 154, 1898.
27. Bayliss and Starling: Jour. of Physiology, vol. xvi., p. 159, 1894.
28a. Starling: Jour. of Physiology, vol. xvi., p. 244, 1894.
28b. Starling: Jour. of Physiology, vol. xvii., p. 30, 1895.
28c. Starling: Jour. of Physiology, vol. xix., p. 312, 1896.
28d. Starling: Jour. of Physiology, xix., 4, p. 312, 1896.
29. Starling: The Production and Absorption of Lymph, chapter in vol. i., pp. 285–311. Text-book of Physiol., ed. by Schäfer, London, 1898.
30. Tigerstedt: Mitth. a. d. Physiol. Inst. zu Stockholm, 1886.
31. Timofejewsky: Zeitsch. f. Biol., xxxviii., 4, S. 618.
32. Setchenow: Physiol. russe, i., 37, p. 85.
33. Colin: Traité de Physiol. Comparée, 3d ed., t. ii., p. 182, 1888.
34. Asher and Barbèra: Centralbl. für Physiol., Bd. xi., p. 403.
35. Wurtz: Quoted by Schäfer, Text-book of Physiol., vol. i., p. 182.
36. Dastre: C. R. Soc. de Biol., p. 242, 30 Mars, 1895.
37. Floresco: Fourth Internat. Physiol. Congress, Cambridge, Eng. Centralbl. f. Physiol., xii., H. 95.
38. Archard et Boeper: C. R. Soc. de Biol., liii., 22, p. 645.
39. Bayloc: C. R. Soc. de Biol., liii., 18, p. 519.
40. Ransom: Zeitsch. f. physiol. Chem., xxix., 1900, S. 349, u. S. 553.
41. Hall, Winfield S.: Jour. American Medical Assoc., 1910 vol. lv, pp. 388–393.
42. Hewson: Proc. of Syd. Soc., London, 1846.
43. Tschirwinsky: Centralbl. f. Physiol., Bd. ix., p. 49.
44. Spallitta et Consiglio: Arch. Ital. de Biol., xxxv., 2, p. 217.

Lymph Nodes, Diseases of the. *Anatomy.*—The lymph nodes are flattened elliptical bodies interposed in the course of the lymph vessels. The lymph must therefore pass through one or more nodes before reaching the lymph ducts. They occur singly and in groups. In size, the nodes vary from that of a millet seed to that of a bean. They are covered by a fibrous capsule from which trabeculæ are directed inward, forming numerous compartments, which are filled by lymphoid tissue (lymphocytes.) Between the trabeculæ and the lymphoid tissue there is a system of freely communicating channels, the *lymph sinuses*. The lymph, reaching the node through the afferent vessels, passes along the lymph sinuses and escapes by way of the afferent vessels, which begin in a depression, or hilum, in the gland, opposite the point of entrance of the afferent vessels. The lymph nodes have a liberal blood supply, the vessels entering at the hilum, and dividing into minute branches which follow the trabeculæ.

The chief nerve supply is from the sympathetic, both medullated and non-medullated fibers, being present.

There are three principal groups of lymph nodes: those which ramify in the subcutaneous cellular tissue, those which accompany the great vessels, and those in association with the viscera. The nodes are in some instances solitary, but more frequently arranged in groups. The more important groups, from the surgical view point, are in close proximity to the great blood-vessels. The nodes are surrounded by loose connective tissue, and in the case of the extremities they are found chiefly at the flexures of the joints.

Physiology.—The lymph nodes, in common with other lymphoid structures of the body, produce lymphocytes, which constitute twenty-two to twenty-five per cent. of the white blood corpuscles, under normal conditions.

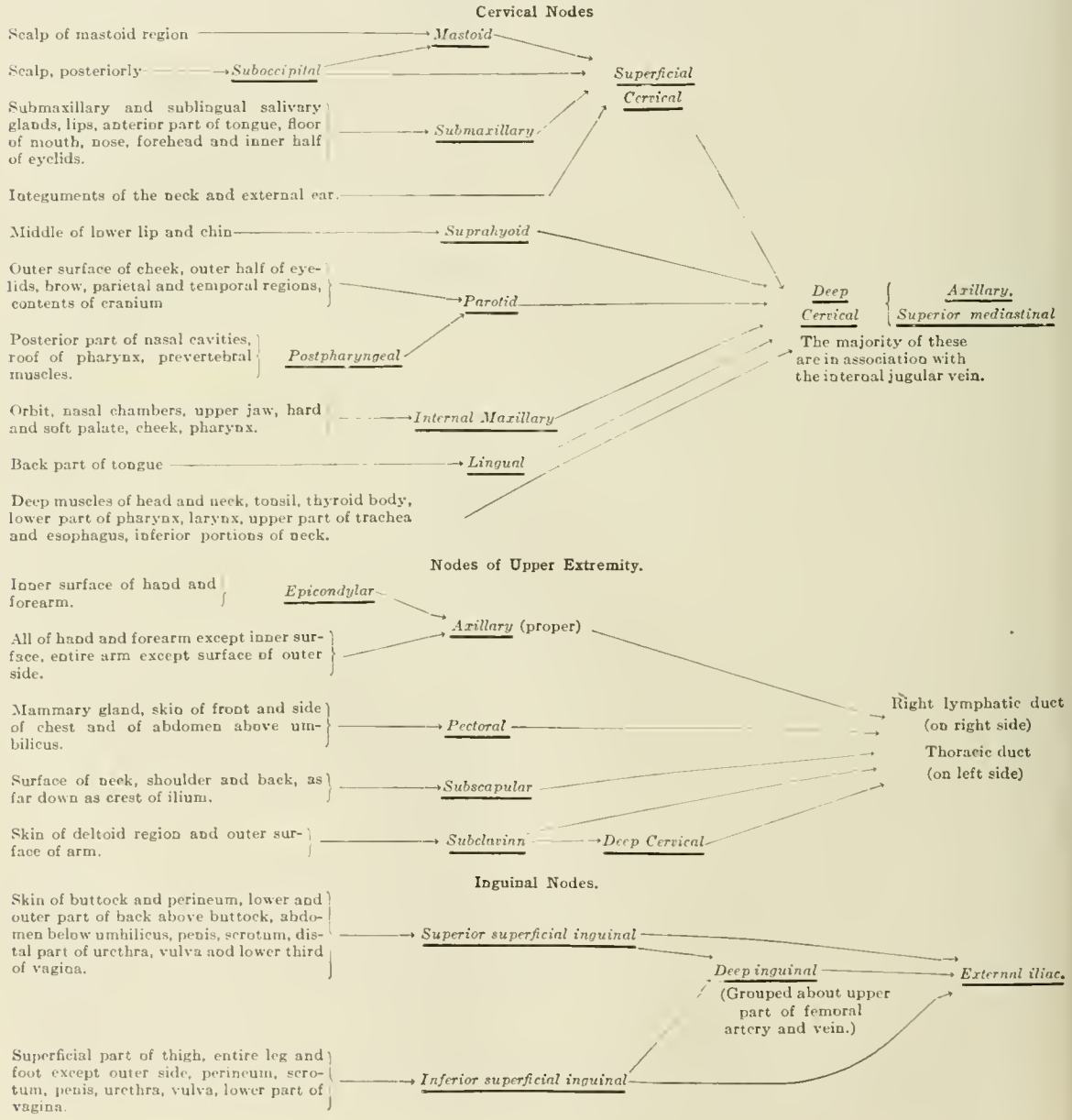
The nodes also act as filters, removing from the lymph current extraneous matters which may have gained access to the system, such as particles of carbon, and especially microorganisms. The foreign matter may reach the node through the blood stream or through the lymph current, where it is apt to be taken up by the endothelial leucocytes.

The diseases of the lymph nodes are therefore the result of mechanical irritation, or the result of infection either local or general.

In order to from an intelligent idea of the sources from which any diseased lymph gland has received its poison, it is necessary to recall the areas in which originate the lymphatic vessels emptying into this gland. As above mentioned, there is a set of lymphatics in the subcutaneous tissue, and another in association with the great blood-vessels. The former is called the superficial set, and the latter the deep set. The number of lymph nodes in the body is estimated at from 500 to 700. The chief groups of superficial lymph nodes, and the sources from which their lymph supply comes, are shown in the diagram.

Pathology.—Lymph nodes respond to the presence of foreign matter in accordance with the nature of the substance. Pigments, such as carbon particles, cause a discoloration and an increase in the fibrous elements. The various toxic agents may cause only a hyperplasia of the cellular elements, or there may be exudation, inflammation, and even hemorrhages and necrosis depending upon the virulence of the irritant. The nodes sometimes become greatly enlarged from the accumulation of microorganisms and other products. In other cases there is a marked periglandular inflammation and extensive necrosis, forming abscesses.

Diagram Showing the Chief Groups of External Lymph Nodes, and the Sources from which their Lymph Supply Comes. (The Names of the Nodes are Printed in Italics.)



Lymphadenitis.—Inflammation of the lymph nodes occurs as the result of irritation, especially from bacteria or their toxins. The infection reaches the nodes by way of the lymph stream, as a rule; through the blood current occasionally. (The adenopathy in the second stage of syphilis remote from the primary lesion is probably the result of the latter.)

The lymph vessels may also be inflamed (lymphangitis) or they may not show any change.

Patients frequently explain the enlargement of the lymph nodes, especially those of the groin (bubo) as having followed a "strain." It is not generally accepted that an ordinary traumatism is sufficient of itself to produce the adenitis; the injury may act as a predisposing cause, but the presence of a bacterial poison is assumed to be necessary to give rise to the symptoms.

The process may be acute, subacute, or chronic, depending chiefly upon the type of the infecting organism. In the more acute forms the node enlarges, the capsule is greatly distended, there is marked congestion, which imparts a deeper red color to the node; and softening or suppuration frequently occurs. The tissues surrounding the nodes are usually involved (periadenitis), being manifested by a diffuse redness.

Certain microorganisms, like the staphylococcus, tend early to pus formation. Others with feeble pyogenic properties cause suppuration only after the process has existed for some time. The tubercle bacillus does not produce pus, in the strict interpretation of the term, but a molecular necrosis (caseation) which may later result in liquefaction, occurs in the advanced stages. Infection of lymph nodes with the *Treponema pallidum* does not cause suppuration, but nodes so involved, or the seat of a tuberculous process, may be attacked by a pyogenic organism when the usual signs of an acute inflammatory process will become apparent, followed by pus formation.

The subacute type results from the presence of mild and evanescent infection. The gland changes are relatively slight, and resolution frequently follows when the source of the poison is eliminated. The enlarged cervical nodes that frequently accompany mild forms of sore throat may be mentioned as an illustration of this form.

Chronic lymphadenitis results from a very mild but continued absorption of bacterial poison. The infecting organism may be one that is but slightly irritating to the tissues, and with little if any tendency to pus formation; or the virus may be so attenuated that but little reaction results. These chronic enlargements are seen chiefly in the cervical region and are due to such lesions as chronic tonsillitis, adenoids, nasopharyngeal catarrh, diseased teeth and gums, middle-ear inflammation, eczema of the scalp, etc. The changes in the nodes in these cases are chiefly hyperplastic. The architecture of the node is retained, but a marked hyperplasia of the endothelial cells and the fibrous stroma occurs.

The majority of these enlargements, especially in children and adolescents, are tuberculous, either as a primary infection from one of the sources mentioned, or secondary to a chronic adenitis, due to some other germ.

Occasionally a case that has presented the characters of a chronic lymphadenitis for months, suddenly takes on the symptoms of the acute form, due to the fresh absorption of pyogenic organisms.

The enlargement of lymph nodes due to malignant disease (sarcoma and carcinoma) presents the characters of chronic lymphadenitis. (The former is primary and the latter secondary.)

Symptoms.—Inflammation of the lymph nodes causes enlargement which in superficial locations is easily palpable and frequently visible. In the acute cases the swelling is rapid, large, and attended with pain, redness and tenderness, and also with fever and the other signs of septic absorption. The nodes are apt to be fused together in one mass. Softening may occur in a very few days.

In chronic lymphangitis the enlargement of the nodes is the chief symptom. There is but little, if any, pain, redness is absent, there is moderate tenderness; the nodes remain discreet for the most part, and there is very little constitutional disturbance.

Diagnosis.—The diagnosis of the acute form is usually easy. One must bear in mind that an aneurysm has been mistaken for an acute abscess, and incised with fatal results.

The chronic type requires a differentiation of tubercle, syphilis, malignancy, and Hodgkin's disease.

Treatment.—In all forms the first indication is to find and treat properly the source of the infection so that further absorption may be prevented. If the process is not too far advanced resolution may then follow.

In acute cases the second indication is to place the parts at rest and to elevate them when possible. These measures tend to diminish the excessive congestion and hence to relieve the pain and swelling, and to limit the process.

It is not probable that external applications influence the course of these cases to any great extent, but custom and the demands of the patient frequently compel one to apply some local treatment. Cold may be applied by means of an ice-bag, or heat in the form of a hot water bag or a poultice, according to the experience of the patient. In some cases cold is grateful, and in other cases heat gives the most relief. Diluted lead water and laudanum or solution of magnesium sulphate may be used to saturate gauze which may be laid on the affected part.

The general indications suggested by the presence of high fever, are to be met. The swelling should be frequently examined for evidences of the presence of pus, which if present should be evacuated without delay. In superficial suppuration a small skin incision should be made. If the collection is deep it should usually be reached by blunt dissection, as advised by Hilton. In either case suitable drainage must be provided. The periodic application of suction cups is rather popular at this time.

It is usually inadvisable to attempt the removal of nodes the seat of acute suppuration, unless, as occasionally happens, they are found lying loose in the abscess cavity.

In the chronic forms, after attention to the cause, the local treatment would depend upon the diagnosis. Applications of iodine or similar counterirritants, may be employed, pending a diagnosis in doubtful cases.

Scrofula.—A certain type of anemia in poorly nourished children, characterized by a marked tendency to chronic inflammatory processes, such as conjunctivitis, keratitis, eczema, catarrh of the nasopharynx, and of the alimentary tract, resulting in chronic enlargement of the lymph nodes, especially the cervical nodes, have in the past been classed as scrofulous (from *scrofa*, a hog; suggested apparently by the thick neck seen in some of these cases.) It has been a common practice to refer to the enlarged glands in these cases as *scrofulous glands*. The writer does not believe in the existence of a disease, or even of a "tendency," "predisposition," or "diathesis," which may properly be designated "scrofula." The term is mentioned here because it is still employed—although with rapidly decreasing frequency—in medical text-books and current medical literature. That condition of lymph nodes which was formerly called "scrofula" and is to-day, to some extent, so designated, should be spoken of as "tubercle." While surgical writers with great unanimity ascribe the majority of cases of chronic enlargement of lymph glands to the presence of the tubercle bacillus, some few still hold to a distinct type of the affection for which they retain the

term scrofulous. In these cases, the tubercle bacilli may not be demonstrable in the enlarged nodes. This view is highly objectionable because it tends to obscure the pathology of the disease, to divert the attention of the profession from the real cause, and hence to make the treatment empirical and impotent. It is not claimed that such glands are invariably tuberculous, but that the majority are, and that the rest are due to some other infection. Some writers are in the habit of using the terms "scrofula" and "tubercle" synonymously but this should be abandoned. Nor is there any more justification for believing in a "vice of constitution" which should be called scrofulous. It may be asserted with great positiveness that the local affection of the lymphatic nodes which has been known as scrofula is a primary infection usually with the bacillus of tuberculosis, and not the secondary effect of a constitutional disease. It cannot be denied that tuberculous glands are frequently, although by no means always, found in individuals who are anemic and otherwise ill-conditioned. This relation is to be explained upon the ground that such subjects not only suffer from catarrhal and other affections that offer a ready means by which germs may gain an entrance into the system, but also possess phagocytes which, like the tissues and glands generally, are not up to the normal standard of vigor, and consequently are unable to resist effectually the invasion.

Neither the profession nor the patient will benefit by calling such a condition scrofula. The underlying causes are probably not the same in all cases. As suggestions, it may be said that affections of the mucous surfaces expose the individual to infection, inasmuch as bacteria more readily penetrate an inflamed or ulcerated membrane, while at the same time the resistance is less effectual on account of the depressing effect which such conditions have upon the system. Some people appear to have defective blood-making organs, and hence to have impoverished blood and feeble resistance. Others have imperfect digestion and assimilation, etc. (See the section on treatment of tuberculous lymph nodes.)

Tuberculosis.—This is by far the most important disease of lymph nodes, as it outranks in frequency all other affections combined. Under this title are included all of the glandular conditions heretofore called scrofulous. No region is exempt; every portion of the lymphatic tract is perhaps equally susceptible, but certain groups of glands are affected much more frequently than others because of their greater exposure to infections.

Frequency.—Observers have asserted that tuberculous lymph nodes exist somewhere in the body in one-third or even a larger proportion, of all autopsies. The majority of instances are in the bronchial, mesenteric, and retroperitoneal nodes, which, as a rule, cannot be recognized during life. Of the surgical (external) forms, the cervical nodes outnumber all others in frequency, the submaxillary, carotid and supraclavicular being involved, in frequency, in the order named. The axillary nodes stand next, and the inguinal last.

Age.—The affection is most common in the first decade of life. From this time on, the proportion of cases gradually diminishes. No age, however, is exempt.

Sex.—There is no marked disproportion of frequency in the two sexes.

Race.—The negro, as met with in this country, probably exhibits the highest degree of susceptibility to tuberculosis. The Irish immigrants seem to be more frequently affected than those who are acclimated.

Etiology.—The bacillus tuberculosis is the cause of the affection. The bacilli find their way into the tissues through abrasions of the skin or mucous membranes and are then taken up by the lymph current and carried along until arrested by the first lymph gland. It must also be admitted that the bacilli may be deposited in the nodes by the blood current, but this mode of infection is probably infrequent. The reason for the more frequent involvement of the lymph nodes of the neck is that these drain such an extensive area of exposed surfaces, all of which are subject to pathological conditions which permit the tubercle bacillus to penetrate the tissues.

The more important of these conditions are: eczema of the scalp, fissures of the lips, carious teeth, ulcers of the tongue and buccal surface, various affections of the tonsils, nasopharyngeal catarrh, adenoids, and suppuration of the middle ear. Of these the tonsils are probably the portal through which the bacilli enter the system in the majority of cases. The frequency of tuberculosis of the tonsils has but recently been recognized, and its importance as a means of infecting the individual appreciated.

Tuberculous disease of the nodes of the axilla and groin, the two other groups of surgical interest, occur as a result of infection passing through lesions of the upper and lower extremity respectively. Examples of the affection in these situations are rare because of the fact that the surfaces drained by these glands are—the hands excepted—well protected and not predisposed to the conditions which favor the entrance of the bacillus. Moreover, the great sources of the infection are the air, the food, and milk. If the mucous membranes of the respiratory and alimentary tracts are normal, the presence of the bacilli probably does no harm; but if abrasions exist, or even if the surface is merely inflamed, they are able to penetrate its layers, from which they are taken up, and carried along, by the lymph current. A chronic catarrh probably so reduces the normal resistance of the epithelium as to invite infection.

An important question, still unsettled, is as to whether the tuberculous infection of the glands is always the primary condition, or whether the glands are first the seat of inflammation, the result of the presence of some other microorganism, and the tuberculous process is engrafted upon this. It is probable, however, that the disease begins in both of these ways, and, further, that a gland primarily the seat of tuberculosis frequently becomes the seat of a secondary infection. Certain it is that some of the cases appear to be examples of pure tuberculous disease, while others show a mixed or multiple infection.

The means by which other bacteria reach the lymph glands is similar to that described in speaking of tuberculous infection, namely, through lesions of the surface of the body, thence through the lymphatic vessels.

Symptoms.—The invariable result of infection of a lymph gland is enlargement; hence a gland which under normal conditions cannot be felt becomes, when diseased, palpable and frequently visible. In the purely tuberculous type the increase in size is commonly the only evidence of the disease, until softening occurs in the later stages. If the infection be due to one of the pyogenic germs, either as a primary affection or superadded to a tuberculous node, there will be, in addition to swelling, local pain, tenderness and redness of the surface over the gland. In some cases these symptoms come on with great rapidity and marked severity, due either to the virulence of the infecting material, the dose received, or the weak resistance of the individual, or perhaps to a combination of two or all of these factors. In illustration, it may be said that a tuberculous adenitis runs a chronic course and gives rise to but mild symptoms. Adenitis due to the staphylococcus gives rise to moderately acute symptoms, while in streptococcus infection the manifestations are frequently so severe as to justify the term virulent. There is every grade of severity between these extremes. It must also be borne in mind that glands which have been enlarged for some time, but

have remained quiescent, may, as the result of a fresh infection, suddenly take on acute symptoms.

A single group of glands are usually affected, especially in the early stages. Occasionally there are multiple foci of disease; particularly is this true in the neck, where it is sometimes bilateral. In the late stages the affection extends from group to group until it seems that all of the lymphatic glands on both sides of the neck are involved. In very rare instances the whole lymphatic system has been involved.

Constitutional symptoms are usually present in proportion to the severity of the local manifestations. In the tuberculous form there may be but a slight elevation of temperature, while the suppurative cases exhibit a marked pyrexia, accompanied by the usual symptoms of fever-malaise, anorexia, headache, coated tongue, etc.; in other words, the condition is that of a septic infection.

Course.—The course of a tuberculous gland tends to destruction by liquefaction. The degenerative process may be very slow, extending over a period of months or years. The glands sometimes remain quiescent for long periods, only to take on renewed activity sooner or later. In some cases there are several attacks of acute symptoms, followed by recession before breaking down finally occurs.

Liquefaction is invariably followed, soon or late, by spontaneous evacuation through the skin, or other route, unless the abscess be evacuated by incision. A sinus remains which persists until all of the remaining tuberculous material is discharged, which is usually a long time.

When a number of glands are involved in the same group they may coalesce and discharge through a single tract, leaving but a single sinus; or there may be as many sinuses as there are diseased glands.

Cases which have a secondary infection superadded run a much more rapid course.

Finally, in rare instances, the breaking down of the gland is followed by absorption of the fluid and spontaneous cure results by caseation and calcification.

Diagnosis.—The presence of enlarged lymph glands, without apparent cause, running a subacute or chronic course, especially if situated in the neck, is presumptive evidence of tuberculous adenitis. A tuberculous family history or tuberculous surroundings add strength to this view. The presence of any of the lesions mentioned under etiology would be the clue to the portal through which the infection occurred.

The conditions from which this must be distinguished are:

1. Simple adenitis, if such a term may be employed, but more properly an adenitis in which the dose of poison has been relatively small, and the gland has been able to dispose of it successfully; this form tends to undergo resolution.

2. A pyogenic adenitis. In this affection which may be of the same type as the foregoing, but the symptoms are all more severe, the poison is present in larger dose; the tendency of the inflammation is toward early suppuration.

3. Syphilitic glandular enlargement will be recognized by the general and symmetrical distribution of the affected glands, especially the posteervical and the inguinal, by the painless character of the affection, by the presence of other signs, and by the history.

4. Carcinomatous glands, secondary to epithelial cancers of the lips, tongue, etc., must be suspected if such a lesion exists or has been previously removed; hence the importance of inquiry in every case at middle age or later.

5. Glanders and other specific infections not already mentioned will be readily recognized by the presence of the primary focus of disease.

6. Bubonic plague need only be mentioned to put the surgeon on guard if the disease happens to exist in the particular locality, or if the individual has come from an infected district.

7. Lymphosarcoma may be indistinguishable from tuberculous disease of the gland in the early stages. In the later course of the case the malignant character will usually become manifest. If in doubt it is proper to remove a gland for microscopic diagnosis.

8. Hodgkin's disease in the beginning presents no distinctive symptoms. It is rare before puberty; three-fourths of the cases occur in men; and the deep chain of cervical glands is apt to be the first affected. Later, the glandular enlargement becomes general, and other signs of the constitutional nature of the condition appear. The glands may be hard or soft to the touch. They very rarely suppurate.

Tuberculous lymph nodes vary in size in accordance with the stage of the disease. When the process is not far advanced, and the node but slightly enlarged, the macroscopic appearances present nothing characteristic. Later the node will be larger, and the cut section will show a general hyperplasia with here and there small whitish, opaque foci, areas of beginning degeneration. As the disease advances, the multiplication of cells gradually interferes with the blood circulation, and softening of the gland occurs followed by absorption of the more fluid part (caseation). The appearance is then very characteristic.

The presence of the tubercle bacilli in the node causes a proliferation of the endothelial cells and the connective tissue cells of the reticulum. The node is usually not equally involved in all parts, but areas of more advanced change are seen here and there, showing some degree of degeneration on the margins of which both large and small giant cells may be observed. In the more acute cases tubercle bacilli may be found in large numbers, especially in the giant cells and in the areas of necrosis. In the more chronic forms the most apparent change is the hyperplasia. The more acute the process the more extensive will be the tendency to caseation, which sooner or later involves the capsule, which may rupture and discharge its contents externally or into adjacent structures. In such cases there is more or less periglandular inflammation and fusion of the tissues into one mass. Rarely, lime salts may be deposited in the caseous node which thus becomes calcified.

Treatment.—The treatment of tuberculous lymph nodes may be described under the following heads: (1) The prevention of further infection; (2) surgical treatment; (3) rest of the part affected; (4) local applications; (5) constitutional treatment; (6) specific treatment; (7) *x*-ray treatment.

The Prevention of Further Infection.—Before discussing the treatment of tuberculous glands something should be said on the subject of prophylaxis. In speaking of the etiology, it was stated that the disease was caused by the absorption of tubercle bacilli from some part of the surface of the body. As the majority of examples of the affection occur in the cervical glands, it will be proper to speak particularly of these. Begin by making a careful examination of every region that might furnish the infection—lesions of the scalp or face, carious teeth, ulcers of the lips, tongue or cheeks, and particularly disease of the tonsils, nasopharyngeal catarrh, adenoids, and middle-ear disease. Nothing could be more irrational than to dose the patient with cod-liver oil, iron, etc., and to paint the skin with iodine while he is daily absorbing more germs. Even the effect of sea air and sunshine will prove futile under such circumstances. Therefore first treat the local infection atrium, in order to stop further absorption. To this end, have all carious teeth properly filled or extracted, remove adenoids, treat a nasopharyngeal catarrh, and, above all, restore the tonsils to a healthy condition, or excise them if need be, and then take up the treatment of enlarged glands.

Surgical Treatment.—This is mentioned second, not because it must invariably follow the former, but because too frequently it is postponed far too long. Conservative physicians naturally hesitate to recom-

mend operative removal of the affected nodes while there is a prospect that the process may undergo resolution by natural processes. The problem is further complicated by the fact that in the early stages it may be impossible to feel sure that the disease is tuberculous. The writer believes tuberculous nodes should be removed early, first, because the disease tends to spread from node to node, and from group to group, until a local and curable trouble may become general and incurable; and second, if breaking down or suppuration occurs, with the attending periadenitis the operation will necessarily be much more extensive, leaving larger scars than an early operation, while if these abscesses are permitted to discharge spontaneously, the sinuses are apt to persist indefinitely and the resulting deformity may be very prominent. In addition there is a possibility that the bacilli may be carried onward and infect other parts. As a working rule it may be stated that whenever a gland or group of glands is enlarging rapidly, or when the local signs of inflammation indicate that pus is either present or forming, operation should not be longer delayed. In the absence of these acute symptoms one may safely wait for as long a time as two months, during which the other methods of treatment may be given a thorough trial. If at the end of this time there is no improvement, the removal of the affected gland should be advised. During the time mentioned, any increase in the local symptoms would be an indication for operation without further delay. On the other hand, the simpler forms of infection which have a tendency to undergo resolution would have disappeared. Manifestations that remain after this length of time are apt to be due to tubercle, sarcoma, or Hodgkin's disease.

It is impossible to distinguish in the early stages between these three conditions, but it is equally proper to remove the affected glands in either case, for then a definite diagnosis can be made by a microscopical examination.

In operating for the removal of enlarged glands of the neck the incision should be made sufficiently free to give proper access to the tumor, and at the same time it should be so placed as to produce the least deformity. The usual principles governing surgical operations apply to the solid forms of these tumors. As the majority of these operations will be for tuberculous glands, it should be emphasized that satisfactory results will only follow thorough removal. Before the glands have broken down this will be a task of comparative ease. After abscesses have formed, however, the dissection is much more tedious, and the chance of obtaining a radical cure is much diminished. In neglected cases and those in which early breaking down has occurred, it has been a common practice to incise the fluctuating swelling and treat it as an ordinary abscess. It will be found in many of these cases that the pus comes from a suppurating gland beneath the deep fascia, and that the discharge has worked its way through the latter and has appeared beneath the skin. With this knowledge, it is our duty in these cases, after incising the abscess, to explore carefully in all directions for any evidence of a track leading to a deeper focus of suppuration. If such be found, it must be followed up and treated in the usual way. The deep glands of the neck lie in close apposition to the great blood-vessels, and when the seat of disease they are particularly prone to involve the internal jugular vein. In all operations, the important anatomical structures which lie in apposition with the glands must be kept in mind and avoided if possible. If the internal jugular vein is distinctly involved, a ligature may be applied on either side of the part affected and the section removed. In order to get better access, if the disease is extensive, the sternomastoid muscle may be divided and sutured again after the mass has been removed. In the absence of pus these wounds may be closed without drainage, but when suppuration is present suitable drainage must be provided.

Rest of the Part Affected.—After appropriate attention to the primary focus, the next principle in the treatment of inflammatory affections is to secure rest of all the structures involved. The more acute the inflammation the more imperative this rule becomes. This course is just as necessary in treating inflammation of lymph nodes as it is in treating inflammation of other structures. For the purpose of keeping the structures of the neck at rest, in cases of cervical adenitis, a kind of "stock" may be worn. This is made of pasteboard and should be cut to fit the particular individual. The two ends meet at the back of the neck. The lower edge should rest on the clavicles, the upper margin is high at the sides, and cut out for the chin just sufficiently to permit the head to maintain a normal position. It need not be high at the back. Having carefully fitted the pasteboard to the neck, and being assured that it is of proper dimensions, the surgeon should have it lightly padded and covered with either white or black silk as preferred, and provided at the back with tapes for tying it in position. It should be worn during the night as well as during the day. If properly made it prevents rotation of the head as well as flexion and extension. In addition to affording rest to the inflamed part it serves to maintain an even temperature of the surface, which is doubtless a factor of definite value. Appropriate means for placing the important structures at rest in adenitis occurring in other parts of the body will readily suggest themselves.

Local Applications.—This is perhaps the least important part of this subject. It is probable that many of the local applications in common use are quite inert, while the most efficient have but a feeble influence. Of all the remedies employed the compounds of iodine seem to have best stood the test of time. A very efficient form of exhibiting this remedy is the ointment of the iodide of lead or of iodide of cadmium, or the compound iodine ointment, all of which are official in the Pharmacopœia. The ointment may be well rubbed into the affected region twice daily, covered with lint and waxed paper, and, if the neck is involved, the stock applied. The tincture of iodine is less efficient than the ointment, but may be applied every second or third day in some of the mildest cases, especially if spread well around the whole area involved. If the skin shows signs of irritation, the applications should be temporarily discontinued.

The writer does not favor the practice of injecting antiseptic or irritating substances into the center of an inflamed gland. It does not seem to be based upon a rational foundation, and besides he has not seen sufficient benefit follow the treatment to warrant its employment.

Up to a certain point the tendency of every inflamed gland is to undergo resolution and return to a condition nearly if not quite approaching the normal. If, therefore, the further absorption of poison be prevented and the parts put at rest, the symptoms in favorable cases will subside without any other measures.

Constitutional Treatment.—Other conditions being equal, the rapidity of improvement in the cases that undergo resolution will be in direct proportion to the health and vigor of the individual. This is to be explained by the well-known fact that the phagocytes of an individual in robust health are infinitely more efficient in destroying infections than when he is in an enfeebled state. Therefore, as an adjunct to the other measures mentioned, the patient should be instructed to lead a healthful out-of-door life. The tubercle bacillus is killed by the direct rays of the sun, and it cannot be doubted that the effect of sunlight in increasing the resistance of persons to tuberculous infection is very great. Hence, a residence at the seashore, or in the country where the individual may be

in the open air all day, is to be advised. The time devoted to rest and sleep should exceed that proper for a healthy individual. Unless some special indication exists, a generous diet is to be advised. If, however, in addition to this, a liberal quantity of milk, not less than a quart a day for an adult, and an abundance of cream and butter be taken, the best results will be obtained. In other words, "forced feeding" is to be practised; at the same time the limits of the patient's digestive power must be carefully respected.

The indications for internal medication are simple. For anemia, iron or manganese is the sheet anchor. The hypophosphites deservedly enjoy a good reputation. Arsenic given to the limits of toleration is highly indorsed by some writers, and really appears to be of invaluable service in many cases. Cod-liver oil is still very largely employed when the nutrition is poor, and perhaps nothing can be said against this practice if the stomach tolerates it well, although many prefer to administer fat in the form of cream and butter. It has not been demonstrated that cod-liver oil exerts any specific influence upon tuberculous subjects. Cod-liver oil or olive oil may be rubbed into the skin daily.

If the digestion is poor, pepsin or other artificial aid should be given.

Specific Treatment.—The exact value of tuberculin in the treatment of these cases has not been determined, but some writers have reported gratifying results.

The tendency at present seems to be to use the remedy with great caution and to have the patient under close observation. Hence, it has been claimed by some that it should be administered only by those trained in this line of work. The preparations employed are chiefly "O. T." (Old Tuberculin); "T. R." (Tuberculin Rückstand) and "B. E." (Bacillen Emulsion) also called new tuberculin. The "B. F." of Denys is said to be similar to the "O. T." of Koch. All are administered hypodermatically.

The initial dose of "O. T." should be $\frac{1}{1000}$ milligram; of the "B. E." or "T. R." $\frac{1}{10000}$ milligram. The dose is repeated every three to five days and increased gradually, according to the tolerance of the patient.

X-ray Treatment.—The application of *x*-rays to tuberculous lymph nodes has been followed by satisfactory results in some cases. This treatment may be recommended (1) for very small nodes, not sufficiently enlarged to require removal by operation, and (2) after operation, to clear up either minute infected glands that may have been left, or remnants of broken-down nodes or sinus tracts, if softening or suppuration had taken place.

Operation should always be advised when the nodes are large, and when softening has occurred.

Syphilis.—The appearance of the initial lesion of syphilis is promptly followed by enlargement of the adjacent lymph nodes (syphilitic bubo). As the great majority of infections occur on the genitals, the corresponding number of syphilitic bubos are found in the inguinal regions. If the chancre is located on the lips or face the bubo will be submaxillary. Nodes so affected do not break down, but gradually disappear more or less completely by treatment, or, in time, even without treatment. In persons who are not cleanly, and occasionally in other cases, pyogenic infection becomes implanted in the syphilitic bubo and the nodes then take on the character of acute lymphadenitis, the specific characteristics becoming entirely obscured. Such nodes are very prone to suppurate.

In the secondary period there is a general lymphatic adenopathy. The posterior cervical, axillary, epitrochlear and inguinal nodes being especially palpable. The nodes as a rule do not reach a larger size than a bean, and do not show any evidences of inflammation. They therefore remain discreet, are movable, and are free from redness.

In syphilitic lymphadenitis, the nodes besides being enlarged are hard, and grayish on section. Microscopic sections show a general hyperplasia, including the lymphocytes, endothelial cells and the reticulum, and infiltration of the blood-vessels.

Under the influence of mercurial treatment the hyperplastic elements undergo fatty degeneration and the node returns approximately to a normal condition.

In the tertiary stage of the disease a gummatous lesion may develop in the lymph nodes, especially in the node adjacent to a preexisting gumma.

The *diagnosis*, in the presence of a true chancre, followed by the usual secondary phenomena, is easy. In cases of concealed chancre a very careful study of the case will usually indicate the nature of the trouble. The Wassermann test may be applied as confirmation.

Treatment.—Enlarged nodes due to the treponema pallidum solely do not require any special attention. They usually disappear during the administration of the constitutional treatment.

In cases of mixed infection causing inflammatory symptoms, the treatment is the same as that for lymphadenitis. Gummatous nodes usually respond well to constitutional treatment, but if actual softening has occurred drainage may be desirable.

Animal Parasites.—Animal parasites, may, in rare cases, reach the lymph nodes. Of these, the filaria sanguinis, which causes the tropical variety of elephantiasis, is the most prominent. Trichinella and echinococcus embryos, are also mentioned as having been found in a few cases. For treatment, see the diseases mentioned.

Atrophy.—The lymphatic system is more active during childhood and early adult life than at a later period, hence the nodes are larger and of a more pinkish color during this time, in order to meet the physiologic demands of the growing and developing individual. As maturity is reached the demands on the lymphatic system become less and there is a steady diminution of function year by year, and a corresponding atrophy of the nodes. The cellular elements, particularly the lymphocytes, are reduced in numbers, while there is an increase in the fibrous elements. These changes are variable. Sometimes the degeneration of the lymphocytes is the more prominent feature, the node being represented by the capsule containing a small amount of fat; in other cases the glandular elements disappear entirely and the increase in the fibrous capsule leaves a small, hard nodule. These nodes have a pale color due to the diminished blood supply. Atrophy may also occur in wasting and debilitating diseases, especially if the body fluids are deficient in quantity. The degenerative process may take the form of a fatty infiltration.

Hyperplasia.—Nodes subjected to mild chronic irritation undergo hyperplasia. Upon removal of the cause the node may undergo resolution and return to a normal condition; or if the capsule and stroma have been involved, may remain prematurely enlarged.

A compensatory hypertrophy of the lymph nodes after splenectomy has been reported by several writers.

Degenerations.—*Amyloid degeneration* of the lymph nodes may occur in conjunction with a general amyloid process of the various organs, due to chronic suppurative processes; or it may be found as a local change following enlargements due to syphilis, tuberculosis, Hodgkin's disease, lymphomata, etc. These nodes show the characteristic staining qualities of amyloid tissues.

Hyaline degeneration may follow chronic processes in the lymph nodes, such as tuberculosis, lymphadenitis, carcinoma or Hodgkin's disease.

Fatty degeneration affects chiefly the lymphoid tissue

and occurs during the process of resolution of the various types of hyperplasia.

Fatty infiltration may be present in obese subjects and in certain cachexias, and it may accompany the atrophy of old age.

Calcification is sometimes a terminal condition in long-standing processes such as tuberculosis or chronic suppuration of the nodes, and very rarely in old carcinomatous nodes. The lime-salts are found in the areas that are undergoing degeneration.

Pigmentation.—The most common source of pigment found in lymph nodes is carbon, in the form of minute particles of coal-dust or soot. Of the other substances occasionally found hemoglobin stands first in frequency. Lymph-node pigmentation is especially frequent in miners, grinders, potters, stonecutters, and others whose occupation keeps them in an atmosphere containing solid particles. The dust being inhaled is deposited on the mucous membrane of the air passages, and is either picked up by leucocytes or by the lymph current. In either case it is arrested by the nodes.

In addition to the change in color due to the pigment, the node is enlarged in proportion to the amount of the foreign matter and the accompanying phagocytes it contains. As these accumulate the lymphocytes are displaced and the function of the gland correspondingly impaired. There is also a hyperplasia of the connective tissue, due to the chronic irritation, which may involve the perinodal tissues.

Pigmented lymph nodes do not give rise to any symptoms and are without significance except that in extreme cases the individual is deprived of the normal function of these structures.

Treatment is entirely prophylactic. In occupations exposing a person to the danger of this condition means should be taken to prevent the inspiration of an undue amount of foreign material.

Nodes already affected cannot be improved by treatment, and nothing would be gained by their surgical removal, even if in an accessible region.

Lymphatism. *Status Lymphaticus.*—There has been described under these titles a rare and interesting condition in which the lymphoid tissues throughout the body become hyperplastic. It has been observed chiefly in children and adolescents.

The lymph nodes involved are principally the pharyngeal, thoracic and abdominal. The faucial and pharyngeal tonsils, the lymphoid follicles of the large and small intestine, the spleen, thymus and bone marrow are affected in varying degrees.

These subjects have a very much diminished resistance, are underdeveloped and immature. Sudden death without apparent cause has occurred in some cases.

Tumors.—Excluding the chronic cases already mentioned, such as tuberculosis and syphilis, there are other conditions in which a marked or even extreme enlargement of the lymph nodes is one of the most striking features. These conditions have all been grouped by some recent writers under the term lymphoblastomata. They include the cases variously called leukemia, pseudoleukemia, Hodgkin's disease, lymphoma, lymphadenoma, lymphosarcoma, and many others. Whether they should be described as neoplasms or as infections, has not been decided. Just what relation, if any, these various manifestations have to each other is far from clear. It is to be noted, however, that the pathological histology of the nodes in all these cases is practically identical. There is the same marked hyperplasia of the cells of the lymphocyte type. There is also proliferation of the reticular endothelium, in which mitoses are apparent. The nodes at first retain their histological characteristics, but in the later stages the normal structure is nearly or quite destroyed.

A single node may enlarge at first, but soon the entire group becomes involved, and other groups in succession are found to be affected. As would be expected, all grades of transition may be observed from the beginning lymphoid hyperplasia to the tumor-like masses in which the nodes have lost their characteristics and the cells have infiltrated the capsule and surrounding tissue. As a rule, these enlargements show no disposition to soften or form abscesses, but they tend to progress in spite of treatment. They have been classified both as benign and malignant conditions, chiefly, however, upon the rapidity of the course; although the most chronic forms seem to tend toward a fatal termination sooner or later.

As these conditions are still treated separately in most text-books, it seems necessary to refer briefly to each one. They are by no means uniformly distinct, but merge with each other:

Leukemia, Leucocythemia.—Moderate enlargement of the lymph nodes is usually present in this condition. Not only do the prominent groups share in the overgrowth, but deposits of lymphoid tissue appear in the various organs.

The disease may be acute or chronic, the former giving rise to fever and the usual signs of an acute infectious disease.

The diagnosis is made by an examination of the blood, which shows a very high leucocytosis.

The treatment should be directed to the general condition. The lymph nodes do not require any attention. The prognosis is unfavorable (see *Leukemia*).

Lymphadenoma, also called Hodgkin's disease, pseudoleukemia, malignant lymphoma, etc., may occur at any age, but is rather more common in young persons. The first evidence is a painless enlargement of a group of nodes, commonly a cervical group, followed by extensions and involvement of other groups—opposite cervical, axillary, inguinal. Sooner or later, even before the enlargement in some cases, the patient will appear pale, indisposed, and will show gradual loss of vitality. Fever may be present. Enlargement of the affected groups of nodes is sometimes extreme.

Rarely the lymph node enlargement may appear to affect the various groups simultaneously. It is also claimed that the disease may exist without any involvement of the lymphatic system. This statement should be accepted with reservation, however, as it is known that the visceral nodes, *i.e.* mediastinal, mesenteric, etc., may be chiefly involved, and the external nodes largely escape.

Examination of the blood shows a marked anemia.

The diagnosis in the earlier stages is difficult, but the progressive enlargement, the involvement of other groups of nodes, and especially the pallor and weakness which these patients soon show, give the clue. They are to be distinguished from tuberculous nodes, lymphosarcoma, and secondary carcinoma. After a thorough examination of the patient, if any doubt exists, a typical node should be excised for microscopic study. This may usually be done with local anesthesia.

Prognosis.—The disease runs a chronic course, and tends toward a fatal termination.

Treatment.—(See *Pseudoleukemia.*)

There is some difference of opinion as to the advisability of removing the enlarged nodes, but the weight of evidence is that no benefit is obtained. Whether the complete removal of the affected chain in a very early stage would prove beneficial (if a diagnosis could be made at that time) is uncertain, but operation in the later stages is useless. Occasionally the presence of an extreme enlargement may so embarrass the patient as to demand operative relief.

In some cases a mild tuberculous infection of the lymph nodes runs a very chronic course and resembles clinically Hodgkin's disease, even in the anemia. Ex-

amination of an excised node will establish the diagnosis. If the enlargement is tuberculous, the tubercle bacillus may be demonstrated.

Lymphosarcoma.—Closely resembling the preceding is a form of lymph-node enlargement, beginning in one point and rapidly involving the adjacent nodes in one mass. Other groups of nodes throughout the body may subsequently enlarge.

The characteristic of this type, in addition to the rather rapid growth, is the tendency of the cells to break through the capsule and infiltrate the adjacent tissues, to which the growth becomes adherent.

The diagnosis may be made by microscopic examination of a node removed for the purpose.

Treatment.—If discovered early, complete excision of the affected group of nodes is indicated. The disease is usually fatal.

Carcinoma of the lymph nodes is invariably a secondary process. In the excessively active proliferation of epithelium characteristic of carcinoma some of the cells sooner or later escape into the lymph channels and are carried along with the current until arrested in the first lymph nodes encountered. The cells at first accumulate in the lymph sinuses, but gradually the normal lymphatic structure is replaced by the new deposit; the connective-tissue elements, however, show a hyperplasia. Lymph nodes thus affected increase in size, are discrete, very hard, and but slightly if at all painful. One node after another is involved until the whole chain is affected. As the tumor mass enlarges pressure on nerves may give rise to neuralgic pains. In the earlier stages the gross appearance on section may not be characteristic, but in the more advanced stages the carcinomatous deposits are readily recognized as opaque whitish areas.

Carcinomatous nodes may suppurate if infected by pyogenic organisms. This is particularly apt to take place when the primary disease is in the mouth, or other situation where the lesion is exposed to germ-laden secretions.

The diagnosis of carcinoma of the lymph nodes will readily be made if the primary focus is apparent in the area which drains into the affected groups. This will usually be revealed by a careful examination.

Carcinomatous lymph nodes, if situated where safe removal is possible, should be promptly extirpated. It is presupposed that the original disease has been previously dealt with.

The prognosis is in direct proportion to the timeliness of the removal. It is now customary, in operating for primary carcinoma, to perform a block dissection of the regional lymphatics.

Inoperable cases may be much benefited by *x*-ray treatment.

Sarcoma.—True primary sarcoma of the lymph nodes is to be distinguished from lymphosarcoma, by the fact that the former affects but a single node, the capsule of which soon gives way owing to the tension, resulting in metastases to other parts through the blood. The round-celled, spindle-celled, and alveolar varieties have been met with. This form of tumor is of very rare occurrence.

The diagnosis prior to the occurrence of metastasis could be made only by microscopic examination of the tumor.

Sarcoma of the lymph nodes usually leads to a fatal termination, on account of the fact that the diagnosis in the early, and curable stage, is impossible, except by histologic study.

Treatment.—Removal of the affected gland before the tumor had escaped from the capsule would probably result in a cure. Subsequently, operation would be only palliative.

Secondary involvement of the lymph nodes by sarcoma is rare, but it may occur. If present, it must be considered in conjunction with the primary growth.

The naked eye appearance of sarcomatous nodes does not differ from that seen in simple hyperplasia. The diagnosis is to be made by the microscope.

ALFRED C. WOOD.

Lymph Vessels, Diseases of the.—*Anatomy.*—The structure of the lymph vessels is similar to that of veins. Beginning in capillaries, the walls of which consist of a single layer of endothelial cells, they continue as larger trunks, having three coats, *i.e.* intima, media, and adventitia. The vessel walls are thinner than those of veins of the same size, while the valves are more numerous. Anastomoses are less common than in the case of the veins.

The lymph vessels begin in the network of lymph capillaries, which are distributed abundantly through all the tissues of the body. They convey the lymph to the thoracic duct and right lymphatic duct. The former empties into the left subclavian vein; the latter into the right subclavian vein.

The *right lymphatic* duct receives the lymph from the right half of the head and neck, the right upper extremity, the contents of the right half of the thorax, the upper surface of the liver, and the right thoracic wall.

The *thoracic duct* receives the lymph from all the remaining portions of the body.

Physiology.—The lymphatic system is sometimes spoken of as the absorbent system, inasmuch as one of its chief functions is to take up the fluids from the tissues and carry them to the venous circulation This function is shared by the veins, which also act as absorbents to a considerable extent.

LYMPHANGIECTASIS.—The lymphatic vessels, like the veins, are occasionally the seat of dilatation, hypertrophy, and varicosity. This condition, when affecting the skin vessels, produces a soft pulpy mass, proportionate in size to the extent of the change. The most frequent sites of occurrence are on the inner surfaces of the extremities, at the flexures of joints, and about the abdomen and genitalia. The condition is usually congenital, but may be acquired from obstruction to the lymphatic circulation. When the dilatation becomes extreme, rupture may take place. This is followed by a flow of lymph, which is called *lymphorrhagia.* If the condition is sufficiently marked to call for treatment the affected areas may be extirpated by the knife if there is no contraindication; or, in the case of an extremity, an elastic support may be worn. This condition is one of the causes of enlargement of the tongue, known as *macroglossia,* and of the lips, *macrocheilia.*

LYMPHANGIOMA.—When the dilatation of the lymphatic vessels is marked and circumscribed, the condition is called lymphangioma. This corresponds in every way with a venous angioma, with which, in fact, it is sometimes associated. These tumors are soft and semi-fluctuating, giving the same sensation to the touch as a venous angioma, from which they differ, however, in having little or no color, whereas the venous tumors are of a deep purple hue. When the venous and lymphatic dilatations are associated the depth of the color will depend upon the extent to which the blood-vessels are involved. These tumors are congenital in their origin, although they may not develop to a prominent degree for some years. Two forms are described, the cavernous and the cystic. The latter, sometimes called "hygroma" is most frequently met with in the neck, but may occur in the axilla, groin, or other parts. It occurs as a fluctuating mass beneath the deep fascia, without any pain, redness or inflammatory symptoms.

Treatment.—These masses, when not too extensive, may be extirpated. In cases in which this treatment is not applicable, an elastic support would tend to prevent further extension of the condition.

In extreme instances rupture is to be feared, and hence appropriate treatment should be adopted. The cystic variety has been treated by aspiration followed by the injection of tincture of iodine, but without much success. Excision of the sac may be undertaken in appropriate cases, but the walls are frequently exceedingly thin, and may extend deeply in various directions, so that the complete removal is sometimes difficult or even impossible. The operation is therefore not to be lightly recommended.

Lymphedema.—This condition is due to obstruction of the lymph current on account of which the fluids accumulate in the tissues of the part affected. The obstruction may be within the lymph vessels or nodes such as neoplasms or animal parasites or it may be due to pressure from without. Edema is present early and there is a gradual increase in the connective tissue formation. The tropical variety is called elephantiasis Arabum and is due to the presence of the filaria sanguinis hominis in the lymph vessels and nodes which gives rise to thrombosis and inflammation.

Other causes of lymph stasis bring about a somewhat similar condition but in a lesser degree. The removal of the inguinal nodes, for example, has been followed by a persistent lymphedema of the corresponding limb.

Treatment.—Massage, elevation of the part, and an elastic bandage, comprise all that can be done in a palliative way. When these measures fail to give relief, redundant tissue may be excised in suitable cases when the genitals are affected; or the main arterial supply may be cut off by ligation, when the lower extremities are involved. Both of these are severe measures, but are justifiable in extreme instances of the affection.

Injuries.—Injuries of the lymph vessels heal in the same manner as do injuries of the blood-vessels. In all operations, as well as in accidental wounds, these trunks are more or less freely divided according to the extent of the wound. They become obliterated at the points of division by the cicatricial tissues resulting. Usually the collateral circulation takes care of the function of the closed vessels.

The thoracic duct has been wounded in a few instances during operation involving the base of the neck on the left side, the accident being manifested by the free escape of chyle. The flow has been controlled in different cases by a tampon, by pressure forceps, and by suture. Recovery has usually followed without incident. The duct has also been ruptured in severe injuries involving the chest and abdomen. In these cases the chyle escapes into the thorax (chylothorax), or into the abdomen (chylous ascites). The symptoms of these conditions would be those of fluid in the respective cavities, the character of which could be determined only by the use of the aspirating needle. These cases are not amenable to surgical treatment. The patient usually succumbs to inanition, although recovery has been recorded. Agnew proposed, in these cases, to withhold all food for a time in order to favor the closure of the opening. During this period it has been suggested to introduce milk directly into a vein.

Lymphangitis.—Inflammation of the lymphatic vessels is due to the irritating effect of pyogenic microorganisms or of the products of their metabolism, which are absorbed from a local infection, such as a boil, an infected wound that is not properly drained, etc. The majority of the cases of lymphangitis, particularly the severe forms, are due to the streptococcus pyogenes, which has the property of rapidly spreading along the lymph channels. Lymphangitis may also result from gonococcus infection, from treponema pallidum and other microorganisms. The lymphatics of the forearm and arm are most frequently affected, owing to the fact that the fingers and hands are more exposed to traumatism and infection than other portions of the body.

The inflammation involves the entire thickness of the vessel wall as well as the surrounding areolar tissue (perilymphangitis). The lymph in the affected vessels becomes coagulated.

When the superficial vessels are involved, red lines may be seen in the skin, indicating the course of the underlying inflamed vessels. There is more or less soreness or even pain and tenderness, depending upon the extent of the inflammation. The glands in which the affected vessels drain become enlarged and painful. Localized abscesses frequently form in the cellular tissue. In the more severe forms of infection the microorganisms may reach the general circulation in large numbers and give rise to septicemia. If the deep lymphatic vessels are involved the red lines will not be apparent, but the limb will be edematous, due to obstruction of the lymph current. The vessels in severe cases may be permanently obliterated by organization of the thrombus.

Treatment.—The presence of lymphangitis is an indication of an infected wound that is not properly drained. The first step, therefore, should be to drain freely the original site of the infection, making appropriate incisions if needed. After this has been attended to, elevation of the part in the case of an extremity, and the application of evaporating lotions, such as dilute lead-water and laudanum, or magnesium sulphate solution are to be advised. The parts should be inspected daily for the presence of suppuration, and if detected, suitable incisions should be made. In cases of general septicemia the propriety of making an autogenous vaccine from the pus may be considered. At the present time the use of vaccines is rather popular. Their true value, however, has not yet been established.

Tuberculous Lymphangitis.—This is probably a rare affection and occurs in those vessels that drain a focus of tuberculous disease, such as lupus, dactylitis, etc.

The treatment of this condition is secondary to that of the primary lesion. The object should be to prevent further absorption of the poison.

Alfred C. Wood.

Lymphagogues.—Substances capable of inciting increased flow of lymph are called lymphagogues. According to the classic investigations of Heidenhain upon lymph formation the lymphagogues may be divided into two classes. In one group, those substances as extracts of crab-muscles, blood-leech, liver, intestine of the dog, peptone and egg-albumin, strawberry extracts, etc., which cause lymph flow act in some way upon the endothelial capillary wall by which means the endothelium secretes lymph. Under these circumstances lymph formation occurs without raising blood pressure and the blood plasma becomes poorer in proteins whereas the lymph contains more than usual. To the second class of lymphagogues belong such substances as sugar, urea, sodium chloride, and other salts. The lymph produced by the action of the lymphagogues of the second class is much richer in water than usual as is also the blood itself and this formation of lymph is explained by the assumption that diffusion plays a much greater rôle here than with lymphagogues of the first class, although the special secretory activity of the endothelium of the capillary wall probably is responsible for a part of the phenomenon. The lymph formed by the activity of the lymphagogues of the first class is assumed to be formed from the constituents of the blood directly, hence, is sometimes called blood-lymph whereas that produced by lymphagogues of the second class comes from the body tissues and is called tissue lymph. See *Lymph*.

Frank P. Underhill.

Lymphangioma Circumscriptum.—This is an affection characterized by the presence of small vesicles, often arranged in clusters, irregularly distributed, and deeply seated in the skin, and is of rare occurrence. The clusters may have a circular form, or they may be arranged in bands, which sometimes have the appearance of being seated over the course of nerve tracts or of the large lymphatics. The affection has been found most frequently on the upper extremities, and especially in the scapular and axillary regions, and in a large portion of published cases it has appeared on the left side of the body.

These vesicles vary in size from a pin's head to a small pea, and the epidermis over them is often affected by a warty change, so that some of them may on

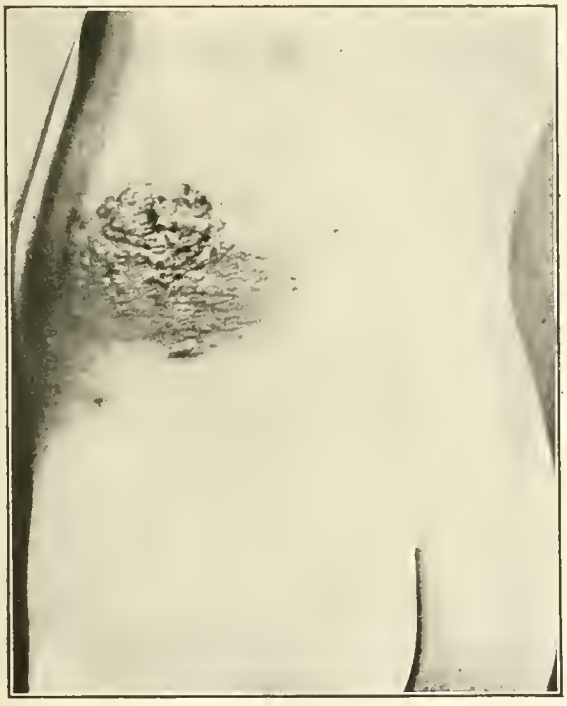


Fig. 3856.—Congenital Lymphangioma Circumscriptum. (Case of Dr. Isadore Dyer of New Orleans, La.)

first sight simulate warts, and occasionally there have been present long warty projections. An interesting feature is the presence usually of telangiectases, or large dilatations of the blood-vessels in the area occupied by the vesicles, as well as in the roof of the vesicles themselves. When the vesicles are ruptured they exude a clear, colorless fluid.

The affection is frequently accompanied by recurrent attacks of an inflammation of the affected area that resembles in type erysipelas, and it has sometimes been classed with the latter disease. These attacks are accompanied usually by some constitutional disturbance and considerable pain. In some instances they have preceded a fresh outbreak of vesicles, in others they have had no perceptible effect on the eruption. They differ from true erysipelas in not spreading to other parts of the body, and have been compared by Besnier to the "erysipelas" that occurs in elephantiasis.

The affection is very slow in its course, appearing either at birth or in infancy or childhood, and often remaining stationary for many years. There is often an hypertrophy of the fibrous tissue in and about the affected area, so that a condition of elephantiasis may be produced. This is seen also in other varieties of lymph-angioma. Thick, firmly adherent crusts are often produced by the bursting of the lesions, and, being deeply embedded, they may persist for a long period.

Etiology.—The disease usually begins in infancy or childhood, in one or two cases only in adult life. It is probable that it is always of congenital origin. Injury and irritation have been thought to affect the process, and in several instances excision has led only to an increase in the number of lesions.

Anatomy.—The writer's examinations of a lesion removed from the arm, which was not associated with any telangiectases, nor with fibrous or warty changes, showed numerous cysts in the upper part of the corium and approaching very near to the epidermis without implicating it. The cysts were filled with fibrin and a few leucocytes, and were often divided into subdivisions by septa formed of the unaltered corium. These cavities possessed an endothelial lining, and there could be no doubt that they represented newly formed or dilated lymph vessels or channels, as they communicated with the lymph channels below. There was a certain amount of leucocytic infiltration about the cysts. A few enlarged blood-vessels were seen.

The implication of the blood-vessels varies in different cases, and in different lesions in the same case. In some instances it has been found that the corium contains numerous dilated blood-vessels, together with the enlarged lymphatics, and that the telangiectases and vascular dots that have been referred to are caused by the presence of dilated capillary blood-vessels between the upper wall of the cysts and the epidermis.

Diagnosis.—This may be made from the appearance of the affection at birth or in early life, by the groups of thick-walled vesicles, often accompanied by telangiectasis and warty surface changes, by the discharge of lymph, when they are incised, and by the slow course. On superficial inspection the effection may resemble most a group of warts.

Prognosis.—The lesions usually increase slowly until they have attained a certain degree of development, when they remain nearly stationary. In one recorded case there has been spontaneous involution. After operative interference, as in all forms of lymphangiomata, the lesions are very likely to reappear.

Treatment.—Excision and causties have been tried, but recurrence after the operation is not uncommon. Electrolysis has been thought by some to offer the most hope of success, but in this case also recurrences have been recorded. Each vesicle is to be transfixed by a needle attached to the negative pole of a galvanic battery, eight or ten cells being employed. The poor results of treatment probably are due to the presence of deep-seated anastomoses.

James T. Bowen.

Lymphatic System.—(*Synonyms:* Absorbent system; Latin, *Systema lymphaticum;* French, *Système lymphatique;* Italian, *Sistema linfatico;* German, *Lymphsystem, Lymphgefässsystem,* or *Saugadersystem.*) The lymphatic or lymph vascular system consists of vessels containing lymph or chyle (colorless or white blood) and lined throughout with a layer of flattened cells constituting the *lymphatic endothelium,* which in the smaller vessels (lymphatic capillaries) may constitute the entire wall of the vessel. The lymphatic system is an appendage of the blood-vascular system, its terminal trunks, usually two, the thoracic duct and the right common lymphatic trunk, ending in the great veins at the base of the neck, on the left and right sides respectively.

A tolerably correct pictorial idea of the entire vascular system may be formed by considering the blood-vascular part as made up of a great tree, the heart forming a short trunk and the arteries, veins, and capillaries, the branches; but there is present the un-tree-like character of the direct union of the terminal twigs of the arteries and veins, that is, the venous and arterial capillaries are continuous. The lymphatic system may then be represented by two vines of unequal size, but which together follow all the blood-vessels to their ultimate ramifications, and in many places even send minute twigs beyond them. The analogy with a vine is further borne out by the lymphatic vessels, as they remain of a more uniform diameter than the blood-vessels; and, finally, the terminal twigs, like those of a real vine, end freely or blindly, often in slight expansions like leaves, thus forming a marked contrast with the terminal twigs of arteries and veins, which cannot be properly said to terminate at all. In a word, the blood-vascular system forms a complete circle or circuit in itself, while the lymph-vascular system joins the blood-vascular system at its central or trunk end, but begins blindly at the periphery.

Lymph Spaces.—Certain tissue spaces and body cavities are closely associated with the lymphatic channels, but it is not yet entirely clear to what extent, and in what sense they, or any of them, form an integral part of the lymphatic system. There are here included: tissue spaces, perivascular spaces and spaces within the tunica adventitia of blood-vessels, the perilymphatic spaces within the inner ear, the subdural and subarachnoid spaces within the membranes investing the brain and spinal cord, the chambers of the eye, and possibly the body cavities (peritoneal, pleural, pericardial). Some of the spaces (within glandular organs) and certain perivascular spaces are clearly lymphatic spaces lined with lymphatic endothelium (see the structure and development).

Lymphatic Tissue (Adenoid, Lymphoid Tissue).—Intimately associated with the lymphatic system and clearly a part of it is a dense cellular tissue which is a seat of more or less marked proliferative activity. This mainly occurs in masses—lymphatic nodes, ganglia or glands (lymphoglandulæ)—in the course of the medium-sized or larger lymphatic vessels. In traversing a lymphatic node the channel of the lymphatic vessels becomes broken up into a network of small channels so that the lymph percolates through the node in somewhat the same manner as water through a sponge or filter. In the mucous membranes of the body and in some organs, lymphatic tissue may exist in a less definite form, as diffuse lymphatic tissue or as nodules grouped or single (see under *Intestine*, *Spleen*, *Tonsils*). This is particularly true of the mucous membranes of the digestive and respiratory systems, although other mucous membranes (*e. g.* conjunctiva of the eye, reproductive passages, etc.) may contain diffuse or nodular lymphatic tissue. In these places, the lymphatic tissue is associated with the beginnings of lymphatic channels (capillaries) rather than interpolated in their course as is the case with the lymphatic nodes.

Lymph.—The fluid contained within the lymphatic channels is termed lymph and consists of a colorless plasma containing numerous cells mostly lymphocytes, derived largely from the lymphatic tissue in the territory drained. As the lymph percolates through a lymphatic node, however, it not only gains an accession of cellular elements, but foreign particles (such as dust particles, microorganisms, cancer cells, etc.) tend to lodge and be retained within the node. The relation of the lymphatic nodes to the lymphatic vessels and to the territory drained is thus of great clinical importance. The lymph coming from the intestine during times of absorption is more or less milkly (whitish) in color due to globules of absorbed fat contained in it. The lymph vessels within and coming from the intestine have thus been generally termed *lacteals;* the fat-containing lymph being called *chyle.*

Historical.—It is not to be wondered at that the lymphatic system should not have been discovered and investigated before the circulation of the blood and the general relations of the blood-vascular system had been investigated and understood; and yet, from the prominence of the lymphatic nodes or glands they were seen by Hippocrates; but, having no notion of their true relations, he classed them with the other glandular structures of the body; so, too, there is strong reason for believing that the lacteals were seen in animals by the two famous Alexandrian physicians, Erasistratus and Herophilus; but their significance was not comprehended. About the middle of the sixteenth century (1564), Eustachius found the thoracic duct in the horse, and traced it, both to its beginning in the abdomen, where he became bewildered, and to its termination in the great veins in the neck. He did not profess to understand the significance of this vessel, but named it, from its color and position, *vena alba thoracis.*

It was not until 1622, when Asellius saw the lacteals in a dog, that the real significance of these vessels was appreciated. The whole scientific world was about this time aroused by the epoch-making discussions and discoveries of Harvey on the circulation of the blood, and everything like a vessel was scrutinized with inquiring eyes. The story of Asellius in connection with the discovery and comprehension of the significance of the lacteals will never lose its interest as long as the human mind is striving to comprehend the universe, either in its details or in the *ensemble.* Having opened the abdomen of a living dog, to show to some friends the arrangement of the nerves and the working of the diaphragm, Asellius saw in the mesentery some white cords in addition to the nerves and vessels with which he was familiar, and upon cutting one of them and seeing a white liquid exude, he immediately recognized that they were a new kind of vessel. Most fortunately for him and for science, the dog killed on the following day, to find out still more about these curious white veins, showed none of them. Fortunately, because it led Asellius to consider the conditions under which they appeared in the first dog, and wherein the conditions differed in the second. With the sure comprehension of a scientific mind, he saw that the only essential difference lay in the presence of partly digested food in the first case, and in the absence of food in the second. When this condition was realized in a third dog, the lacteal vessels reappeared, and the relation between the products of digestion and these vessels was fully established for the dog.

Not content with the experiments on the dog, Asellius examined many other animals, showing in every case that there was a constant relation between digestion and the presence of the white fluid in the lacteal vessels. Owing to the powerful influence of the prevailing opinion that all matter must first go to the liver to be assimilated, Asellius supposed that the newly found lacteals extended to the liver. It is difficult to comprehend how a mere hypothesis could blind the eyes of so skilled an anatomist, but so it was, and the belief that the lacteals passed to the liver continued to prevail for nearly twenty-five years.

About 1650, the great facts concerning the lymphatic system, as they are understood at the present day, were discovered by four men in different quarters of Europe. In France, Pecquet showed that the *venæ aquosæ hepatis*, or lymphatic vessels connected with the liver, were not the continuation of the lacteals to the liver, but were vessels extending either to the lacteals, or with them into a common reservoir into which both opened, and that the reservoir was continued as a somewhat smaller vessel (the thoracic duct) through

the thorax, to terminate in the great veins in the neck. The same facts were observed by Rudbeck, in Sweden, at about the same time, and completely overthrew the notion that all absorbed food must first pass to the liver for assimilation before entering the blood; for here was *apparently* the only path of the absorbed food, and it terminated directly in the great veins on their way to the heart.

At about this date, Bartholin in Denmark, Jolive in England, and Rudbeck in Sweden, discovered the general lymphatics of the body. They also showed that these lymphatics (*vasa lymphatica* of Bartholin, *vasa aquosa* of Rudbeck), or serous vessels, either united with the lacteals in the *cisterna chyli* or joined the thoracic duct, and consequently the lymph and chyle or lacteal fluid unite, and together flow into the great veins. In other words, they showed that the lacteals form only a special part of a great system distributed throughout the entire body. It may be said, in passing, that when the facts concerning these new vessels were presented to Harvey, he did not welcome the newly acquired knowledge. Doubtless the weight of years had quenched the enthusiasm of investigation, and he may have been troubled lest these newly discovered vessels might in some way prove a stumbling-block to his simple and easily comprehended explanation of the blood-vascular system.

Not much was added to the knowledge of the lymphatic system for nearly one hundred years after the main facts were established, and naturally, in those early times, with both undeveloped methods and superstition as impediments, knowledge was only general and obtained principally by investigating the lower animals. And yet, in 1628, a criminal was properly fed before execution, and the lacteals demonstrated in the mesentery after death, thus showing conclusively that the absorbed food in man takes the same course as in animals.

Between 1760 and 1787 there was a renewed activity in investigating the lymphatic system. In England the Hunters, Hewson, and Cruikshank, not only investigated the human lymphatics, but pushed their investigations to all forms of vertebrates, and they were found abundantly in all forms. The Munros, in Scotland, were also very active. In Italy the great anatomist, Mascagni, was preparing his magnificent work on the human lymphatics, a work which remains a standard to the present day; and reduced copies of his splendid folio plates are still to be found in every extensive account of this system. (Figs. 3861 and 3876.)

As in all departments of human activity, the crowning discoveries in the lymphatic system are due to the work of an almost untold number of men; and yet a few present the principal and salient features so unencumbered with useless, distracting, or foreign details that they are, for the majority of minds, the true discoverers. They make the special knowledge a part of the knowledge of the race. So in the above historical sketch many names have been omitted, and undue prominence may have been given to others; barring these defects, it is hoped that it represents fairly well the progress from vague and uncertain to certain knowledge of this system.

Since the work named above, something noteworthy has appeared almost every decade, but it has been usually toward the elucidation of special details of function, origin, distribution, or structure, rather than an investigation of the whole field. The work of Sappey[1] forms an exception to this general statement. His investigations have extended over more than forty years, and with a rare skill and all the refinement of modern anatomy, he has not only done much on the general subject both in human and comparative anatomy, but some of the difficult points have been elucidated by him. His atlas is probably, without qualification, the most important monograph that has appeared since Mascagni's.[13] Among those who have more recently contributed to our knowledge of the anatomy of the lymphatic system, may be mentioned Bartels, Cunco, Gerota, Huntington, Most, Poirier, Sabin, Sakata.

General Structure in Man and Animals.—Considered as a whole, the lymphatic system consists, then, of (*a*) endothelial lined channels—capillary networks free from valves, lymphatic vessels richly provided with valves and larger trunks with a less regular valvular equipment; (*b*) lymphatic tissue in the form of nodes or less compact masses; (*c*) the lymph and its cellular elements; (*d*) closely associated apparently on the physiological side, but probably morphologically distinct, are the so-called lymph spaces, minute or large.

Like the blood-vessels, the lymphatics may be divided into groups according to their position, as *superficial*—subcutaneous, subserous, and *deep*,—subfascial, submucous, or internal, and also as *visceral*—those belonging to the heart, lungs, urinary and generative organs, and the alimentary canal. Part of these, *i.e.* those from the small intestine, are called lacteals or chyle vessels. All of the larger vessels possess more numerous valves than do the veins.

In distribution, the lymphatics follow mostly the course of the blood-vessels, but this does not apply to the subcutaneous lymphatics, as will be seen by comparing Figs. 3863, 3864 and 3865, with figures showing subcutaneous veins. Furthermore, in many situations lymph vessels, or lymph capillaries as true lymph spaces, extend beyond the blood-vessels and more intimately envelop the tissue elements.

In general, however, it may be stated that the superficial lymphatic trunks follow the veins, and the deep lymphatic trunks follow the arteries. This anatomical relation was shown in 1836 by Breschet[4] for the adult, and in 1902 by Dr. Florence Sabin[10] for the embryo.

The lymphatic capillary network, although agreeing in general appearance with a blood capillary network, is composed of larger vessels and its mesh is coarser. With the larger vessels the anastomoses are more frequent, but differ in character from the anastomoses of blood-vessels inasmuch as the parallel vessels divide equally or unequally, and unite at a very acute angle, making a long, narrow-meshed network (Fig. 3864); and nowhere is found such great disparity in the size of the vessels as is found with the great arterial and venous trunks. Even the terminal lymphatic trunks are minute as compared with the veins into which they empty. The entire lymphatic system is supposed to have a capacity one-half as great as the arteries, and perhaps more, but no very close approximation can be made on account of the structural peculiarities of the lymphatics, and the immense number of valves. In man and the higher forms, all lymph is believed to traverse one or more lymphatic nodes before joining the common lymphatic trunks. The exceptions to this rule which have been reported from time to time have not been verified.

In the higher mammals the general arrangement and distribution of the lymphatics is as in man. So far as has been investigated, however, the lymphatic vessels are fewer in number; this is markedly the case with the cutaneous and subcutaneous vessels. The lymphatic nodes, although abundant in the horse and ox, are less numerous in most other forms. Groups of nodes in man are often represented by a single one or are wholly absent. Although this is the case, a vessel apparently never joins the main trunk without first traversing one or more nodes (Figs. 3879, 3880, and 3884). In the lowest mammals there is a strong tendency to symmetry in the lymphatic system, the right and left terminal trunks being more nearly equal in size, and in area from which the vessels come. This tendency is also marked in the horse, and especially so in the rabbit; it is frequently observed in the cat, and occa-

sionally in man. The crossing of considerable trunks from one side to the other is more marked in the lower mammals than in the higher, but even in man considerable trunks not infrequently cross from one side to the other (Figs. 3858, 3879, and 3882); and in all the forms there is the closest possible relation between the two sides through the lymphatic plexuses, that is, networks formed by groups of lymphatic nodes and their connecting lymphatic vessels. While it is not uncommon to speak of a network of lymphatic vessels as a plexus, the term is coming to be restricted rather to a lymphatic network in which the glands form the nodal points of the mesh (see Fig. 3857).

Of the animals below the mammalia, the birds possess few lymphatic nodes, and these are mostly restricted to the neck. A cutaneous and subcutaneous lymph network has not been demonstrated in the birds. Those that have been shown, it is supposed, correspond with the deep and visceral lymphatics of mammals. The two trunks opening into the veins of the neck are symmetrical, that is, equal right and left trunks. There are also two openings for the lymphatics in the pelvic veins, and lymph hearts are found in this region, but they have muscular walls in only a few adult forms (ostrich, cassowary, stork, and seagull), although they are contractile in the embryos of birds so far as investigated. Contractile lymph hearts are never present in man and the other mammals (but see below under Development). They are found in reptiles, amphibia, and some fishes. They are mostly situated in the pelvic region, and possess striated muscle which is paralyzed by curare like the skeletal muscles (Kölliker and Ranvier). In the tailless amphibia (Ranidæ) there is a pair of lymph hearts on the thoracic ducts as well as in the pelvic region; and with some elongated amphibia, *Salamandra maculosa* and *Siredon pisciformis*, eight to twelve lymph hearts exist along the sides of the body and tail, at the junction of the dorsal and ventral body muscles. Finally, in some elasmobranch fishes the number of lymph hearts is very great (Sappey).

Below the birds the lymphatic nodes are absent, their place being supplied by lymphatic tissue and by special fine vascular networks into which the vessels break up in their course (Owen has described mesenteric nodes in the crocodile). Perfect valves like those present in mammals are found in birds, less perfect ones in reptiles and amphibia, and finally in the fish-like forms none at all are found, so that the system may be injected toward the periphery like the arteries.

Topographical Anatomy of the Lymphatics.—While it would seem more philosophical to treat the various parts of the lymphatic system in their entirety throughout the whole body—viz., the superficial, or subcutaneous; the deep or subfascial, and the visceral lymphatics with the corresponding nodes and lymphatic tissue—it is better practically, both for the purposes of demonstration and study, to consider all the lymphatic structures belonging to a given region at one time. This method is also really in accord with nature, because all the lymphatic structures in any moderately well-defined region of the body are, sooner or later, intimately associated and really form one whole for the given region.

Following the plan ordinarily pursued, the lymphatic vessels will be considered as extending in the direction in which their contents flow as with the veins, and also in the order in which they must be demonstrated by injections. This will require the investigation to commence at the periphery and extend toward the center. In the descriptions here given, usually only the trunks containing valves will be considered. The origin of the vessels in the tissues and the valveless networks will be considered below, under the origin and relations of the lymphatics. When the term plexus is used in this article it will be restricted to a lymphatic plexus composed of lymphatic nodes with their connecting lymphatic vessels, and will not apply to a network of vessels without nodes. After the vessels of a region have been described, there will be given a list of the groups of the lymphatic nodes and the plexuses belonging to the region, together with the source and destination of the afferent and efferent vessels. This will serve both to give the proper information concerning the number and position of the regional nodes, and also to form a condensed summary of the lymphatic system in the region.

Lymphatic Vessels of the Head, Face, and Neck.—The superficial or subcutaneous lymphatic vessels of the head and face are very abundant and follow, in general, the course of the occipital, temporal, and facial blood-vessels, converging somewhat toward the great vessels of the neck; they traverse one or more of the lymphatic nodes which form an irregular zone nearly around the base of the head (Fig. 3857), and finally enter the internal jugular plexus, and terminate in the thoracic duct on the left, or the common lymphatic trunk on the right (Fig. 3876). In addition to the general description just given, the lymphatics of the eyelids, nose, and ear require special mention.

The lymphatics of the eyelids and palpebral conjunctiva form a very abundant network, although it is somewhat difficult to demonstrate. Those from the conjunctiva wind round the edges of the lids and mingle with those of the integument, which are especially abundant at the edges of the lids. The branches unite into two great groups at the canthi of the lids, those at the lateral canthus extending to the anterior auricular and parotid lymphatic nodes, while those at the nasal canthus join those from the middle of the forehead and the nose, and extend to the submaxillary lymphatic nodes (Fig. 3857). An occasional lymphatic vessel passes by the regional nodes to terminate in the superficial cervical nodes. Small buccal (infraorbital) nodes may occur in the course of the vessels.

The skin of the nose, especially the thicker part around the tip, where the large sebaceous glands are so abundant, is possessed of a very dense network of lymph capillaries and minute trunks. These trunks are joined by the abundant lymphatics from the vestibule, which in turn are continuous with the lymphatics of the nasal mucosa. Finally, the collecting trunks from the vestibule and the nasal integument extend obliquely across the face to the submaxillary lymphatic nodes. The lymphatics of the skin of the bridge of the nose drain into parotid nodes. Occasional buccal nodes are found in the course of the vessels.

The lymphatics of the external ear and meatus form three principal groups: 1. Those of the helix, antihelix, and convex (posterior) surface. Those of the helix and antihelix wind round the free border of the ear to the convex surface, where they join the trunks of that surface, and uniting into several (four to five) considerable vessels, they extend to the mastoid or posterior auricular nodes. 2. The lymphatics of the external auditory meatus, also the membrana tympani (see below), the concha and tragus, terminate by two or three trunks in the anterior auricular nodes. 3. The lymphatics of the lobule unite into seven or eight considerable trunks which extend to the caudal or lower of the mastoid (inferior auricular) nodes.

Deep Lymphatics of the Face and Head.—These are exceedingly abundant, and extend mostly to the deep cervical nodes, but the relations of the vessels and the terminal nodes are so various that a special description is required for each of the principal organs. Nasal cavities and sinuses opening into them: The existence of lymphatic vessels in the nasal mucosa was not demonstrated until 1859, when E. Simon showed by successful puncture injections that they were numerous. He also showed their relation with the network of the nasopharynx. The existence of these vessels was verified by Sappey in man and numerous animals.

According to Sappey, the demonstration is comparatively easy wherever the mucosa is of considerable thickness. The connection of the lymphatics of the nasal cavity with the subdural space is mentioned below (see Central Nervous System).

The lymphatic network covers the entire nasal mucosa, both on the olfactory and the respiratory part, and that lining the septum. In man this network is

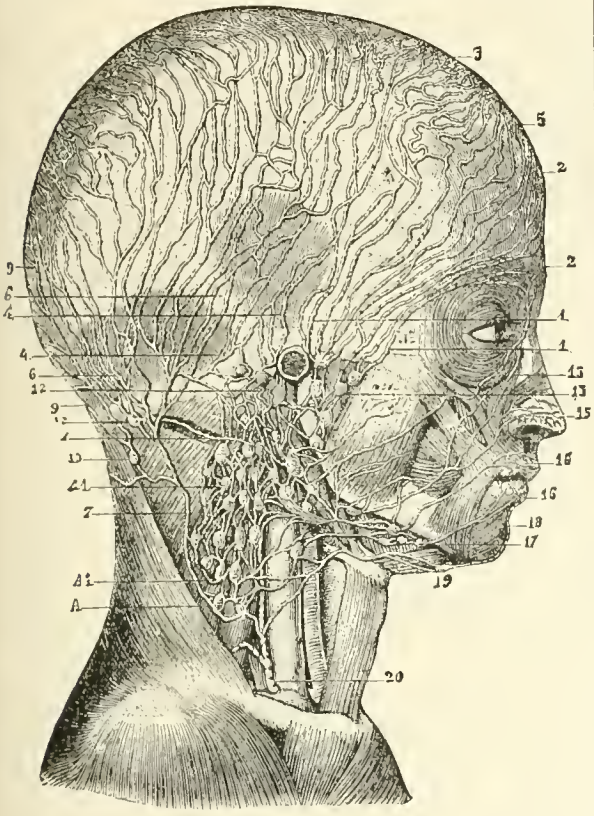


Fig. 3857.—Superficial Lymphatics of the Head and Face, the Deep Lymphatics of the Neck, and the Right Common Lymphatic Trunk. (Sappey.[4]) 1, Lymphatics from the frontal region going to the anterior auricular lymphatic nodes; 2, 2, vessels arising near the middle of the forehead, the upper ones going to the anterior auricular, the lower ones to the submaxillary lymphatic nodes; 4, 4, vessels from the parietal and temporal region extending to the mastoid nodes; 6, 6, vessels from the parietal and occipital to the superior deep cervical nodes; 10, 10, occipital bones; 11, superior deep cervical nodes and plexus; 12, mastoid nodes; 13, parotid nodes; 14, part of supraclavicular nodes; 15, 15, lymph vessels from the nose to the submaxillary nodes; 16, 16, lymphatics from the lips to the same nodes; 17, submaxillary nodes; 18, vessel from the lip to 19, the suprahyoid (submental) node; 20, right common lymphatic trunk opening into the veins at the angle formed by the junction of the subclavian and internal jugular veins.

directly continuous with that of the vestibule of the nose, but the collecting trunks extend toward the pharynx. The network is also continued into the frontal, and presumably the other, sinuses opening into the nasal fossæ. As they approach the pharynx, the collecting trunks of the nasal mucosa are continuous with those of the dorsal surface of the soft palate and of the pharynx, especially the dense network around the Eustachian orifice. From these situations the collecting trunks accompany those of the soft palate and the pharynx, sending one trunk through the wall of the pharynx to the large lateral retropharyngeal node (Fig. 3860) ventrad of the atlas. This node, according to Sappey, is the most cephalic (superior) of any in the body, and becomes involved in diseases of both the nose and the pharynx. The other trunk traverses the pharyngeal wall, and extends along the neck to the level of the perforation of the sternomastoid muscle by the accessorius nerve where it bifurcates and enters the two deep cervical nodes, covered by the sternomastoid muscle at this point (superior medial cervical nodes). No doubt, also, minute branches join the palatine trunks which follow the posterior pillars of the fauces, and enter the deep cervical nodes near the thyrohyoid ligament (Plate XLV., 13). In the dog all the lymphatics from the nasal mucosa are shown by Key and Retzius as entering the deep cervical nodes (3, 3, of Fig. 3883). Sappey figures and describes the exceedingly abundant lymphatics of the nasal mucosa in the horse and ox. In both these animals, but especially in the horse, the lymphatics of the mucosa lining the nasal septum are very abundant, and in both animals, besides the trunks extending toward the pharynx, there are large trunks extending toward the prenares, where they become subcutaneous, and extend with the superficial facial vessels to the submaxillary lymphatic nodes.

Lymphatics of the Eye and the Orbit.—The lymphatics of the palpebral conjunctiva wind round the edge of the eyelid, and join those of the integument, and finally reach the regional nodes as described above. Sappey denies the presence of lymphatics in the eyeball itself, and subsequent work has failed to demonstrate true lymphatics within this organ. This is most conclusively true of cornea, lens and vitreous body; the statement may be less definitely applied to the coats of the eyeball (tunica chorioidea, tunica sclerotica). The retina is developed from the brain (neural tube) and the perivascular spaces surrounding its blood-vessels are to be interpreted in the same manner as those within the central nervous system (which see). The perivascular spaces surrounding the blood-vessels within the other coats of the eye (*e. g.* venæ vorticæ) have not been conclusively shown to be true lymphatic spaces. Of the larger "lymph" spaces of the eye—the anterior and posterior chambers, spaces of Fontana, perichorioideal cleft or space, space of Tenon, subdural and subarachnoid spaces surrounding the optic nerve—the perichorioideal space was regarded by Altmann and by Alexander as a lymphatic space, but this interpretation has not received general acceptance. The spaces about the optic nerve are extensions of the corresponding intracranial spaces and should be interpreted with them. The space of Tenon is apparently in the nature of a "synovial" space for facilitating the movements of the eyeball, and the perichorioideal space has been similarly interpreted (Toldt), as favoring the movement of the chorioid in accommodation.

In as much as the space of Tenon communicates on the one hand with the subdural space at the apex of the orbit, and on the other hand by means of perivascular spaces with the perichorioideal space and spaces within the sclerotic coat and through these (by way of the spaces of Fontana?) with the anterior chamber of the eye, there is probably a circulation of fluid through these clefts as well as through the perivascular spaces of the retinal vessels; but the details as to the direction of flow, etc., have not been clearly determined.

Within the cornea are tissue spaces (pericellular spaces) and it is a matter of considerable theoretic importance that by puncture injection of the cornea through the mediation of the corneal spaces the conjunctival lymphatic vessels may be reached (Waldeyer[11] Guttmann[14], Bartels[15]).

With the exception of the lacrymal gland, lymphatics have not been demonstrated as existing in the orbit. The lymphatics of the lacrymal gland appear to belong regionally to the conjunctival set or system.

Lymphatics of the Ear.—The lymphatics of the membrana tympani are like the blood-vessels in three layers, corresponding to the cutis, the mucosa, and the inter-

mediate fibrous framework. They extend to the external auditory meatus and, joining these, finally enter the auricular lymphatic nodes, as described above for the external ear. Those of the tympanum or middle ear are numerous, but apparently confined mostly to the submucosa. They are directly continuous with the lymphatics of the Eustachian tube, and extend with them to the abundant network in the pharynx around the Eustachian orifice, and finally to the lateral retropharyngeal nodes (Most[16]) and thence (Fig. 3860) to the deep cervical nodes. It is probable that the lymphatics of the middle ear (particularly the mastoid cells) send afferents also to the mastoid or posterior auricular nodes. As in the case of the eye, no lymphatics have been demonstrated within the internal ear. The so-called perilymphatic space communicates with the subdural space by way of the aquaeductus cochleæ (ductus perilymphaticus) and of this space it was originally a part. It must be interpreted with the intracranial spaces (see Central Nervous System). Perivascular spaces and perineural spaces (auditory nerve) also occur through which also the perilymphatic space is in apparent communication with the intracranial spaces (subarachnoid space?).

Lymphatics of the Mouth, Pharynx, and Larynx.— The immense richness of the lymphatic network in these regions, their connection with the nose (and possibly through the nose with the cranial lymph spaces), with the middle ear, esophagus, and trachea, and the varied termination of the collecting trunks, give the lymphatics of this group an especial anatomical interest. They are not less important pathologically from their involvement in the grave disorders of the mouth, nose, and throat.

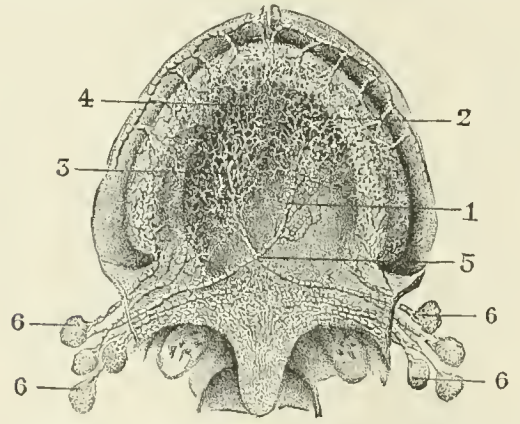


Fig. 3858.—Lymphatics of the Roof of the Mouth and the Gums in a Child at Birth. (Sappey, Atlas.) 1, The lymphatics injected by one puncture at 2; the trunk formed on the right crosses to the left, and those from the left to the right. Crossings of the lymphatics in man are most frequent in this situation, according to Sappey. In the lower animals such intercrossing is not infrequent; 2 and 4 point where the cannula was inserted to make the injections; 3, lymphatics of the gums, connected on one side with those of the palate and on the other with those of the cheeks, the trunks usually extend with those of the cheeks to the submaxillary nodes, those nearest the parotid nodes frequently enter them instead of going to the submaxillary nodes; 5, crossing point of the trunks from the roof of the mouth; 6, 6, group of deep cervical nodes near the bifurcation of the common carotid.

The lymphatic network of the buccal mucosa, gums, roof, and floor of the mouth, palate, and pharynx, may be said to be continuous, but the collecting trunks in different regions have quite different destinations. At the lips the network is also continuous with that of the integument, but the course of the lymph stream is away from the lips. The subcutaneous lymphatics of the lower lip extend to the submental nodes (Fig. 3857) and to the anterior submaxillary nodes. From the gums of the maxilla or upper jaw, the lymphatics extend between the teeth and join those of the mucosa of the cheek; these follow in general the contour of the jaw and penetrate the cheek at various points, extend in part to the parotid lymphatic nodes, but mostly to the submaxillary and the superficial cervical nodes. Nearer the pharynx they join the palatine lymphatics (Fig. 3858). A large number of those from the gums of the lower jaw join the lymphatics of the cheek and extend to the submaxillary lymphatic nodes. A part also join those of the pillars of the fauces. From the gums of both upper and lower jaws lymphatics also pass to the deep cervical nodes (superior, medial). Lymphatics within the teeth (pulp) have been demonstrated but recently, by Schweitzer in the dog. Their drainage is that of the gums into the submaxillary nodes and also to the deep cervical nodes (medial, superior). Occasionally the parotid nodes and superficial cervical nodes may be included.

The lymphatics of the hard and soft palate, while directly continuous with those of the gums, have a direction toward the pharynx, the trunks of the two sides often crossing. They join those of the pillars of the fauces, and go with them to the deep cervical nodes near the larynx (Fig. 3858; Plate XLV.). Some also extend to the nodes near the bifurcation of the common carotid with the trunks from the soft palate (Fig. 3858). The lymphatics of the soft palate on the pharyngeal or superior surface are only moderately developed, and communicate with those from the nose and from the Eustachian tube; the collecting trunks extend in part along the posterior pillar of the fauces to enter the nodes along the larynx (Plate XLV., 13). But a greater number of collecting trunks pass laterad and penetrate the pharyngeal walls to enter the lateral retropharyngeal nodes. The ventral or lower face of the soft palate differs from the dorsal or upper face in having a greater number of lymphatic vessels, and the uvula is so richly supplied that it appears superficially almost like erectile tissue, increasing two or three times in volume when successfully injected. The collecting trunks from the uvula and ventral aspect of the soft palate extend along the two pillars of the fauces, and join the trunks from the base of the tongue; but the greater number pass laterad through the wall of the pharynx and extend to the deep cervical lymphatic nodes around the bifurcation of the common carotid.

The lymphatics of the tongue escaped discovery until 1847, when Sappey demonstrated them. They are difficult to demonstrate in the adult on account of the number and caliber of the veins, but in the infant and child the veins cause less trouble, and the lymphatics are easily injected. They form a rich network over the entire free surface to a point slightly beyond the circumvallate papillæ. Around the circumvallate papillæ they reach their greatest development. The network of lymphatics within the body of the tongue (musculature) is slightly developed as compared with the submucous network, the vessels traversing the tongue being mainly collecting trunks from the mucosa. Around the edges of the tongue the network of the dorsal and ventral surfaces freely anastomose, and the intercommunication of the lymphatics of the two sides of the tongue is free. Furthermore, some of the trunkules appear to cross from side to side, as illustrated for the palate in Fig. 3858. Free communication of the superficial network in front of the line of circumvallate papillæ with the network behind does not appear to exist. The tongue (Fig. 3859) possesses three lymphatic territories, (*a*) anterior, draining superficially to the submental nodes and also deeply, following the course of the Art. profunda linguæ, to the deep cervical nodes (med. superior); (*b*) middle, draining to the submaxillary nodes and more deeply, following the Art. sublingualis, to the deep cervical nodes (medial, superior); (*c*) at the back or root of the tongue the lymphatic vessels go

to the most superior of the deep cervical nodes. Small nodes (lingual) may occur in the course of vessels from the first two of these territories. (Plate XLV., 13). The lymphatics on the ventral side of the tongue extend mostly through the substance of the organ, traversing the lingual nodes when present, and finally extend with those which penetrate from the dorsal side, to the lymphatic nodes around the bifurcation of the common carotid.

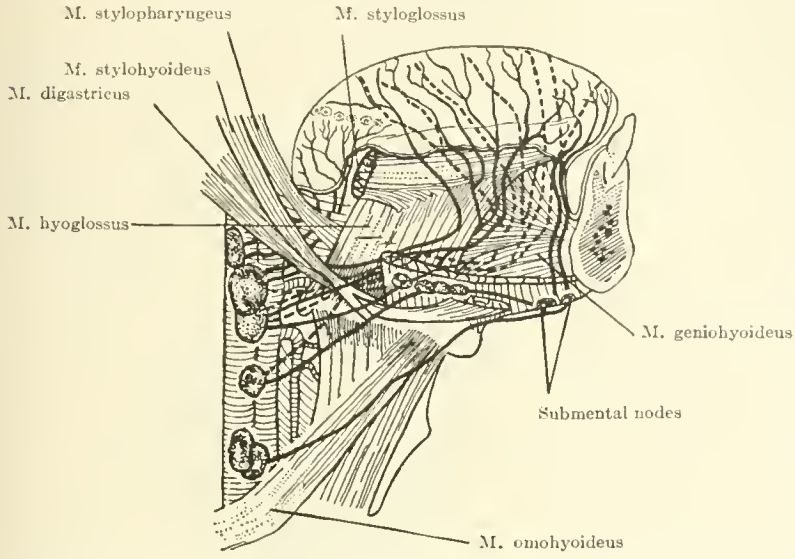


Fig. 3859.—Diagram of Side-view Origins and Terminations of the Lymphatic Vessels of the Tongue. (After Poirier, from Cunningham, text-book of anatomy, modified.) The lymphatics from the root of the tongue are shown draining to the highest of the median upper deep cervical nodes which are drawn with the carotid arteries (common, external, internal), as a background. The lymphatics from the root of the tongue are distinct from those of the body of the tongue. The latter, superficial and deep, shown by continuous and broken line respectively, drain to the middle nodes of the group. Lymphatics from the tip of the tongue drain to submental nodes and thence to lower nodes of the upper deep cervical group.

The tonsils, although composed of lymphatic tissue, were not shown to possess a lymphatic network until Sappey succeeded in demonstrating it, in 1876. This network, which covers the surface and extends into the depths of the tissue, is much more easily injected in the new-born child than in the adult. The lymphatics pass mainly to one of the superior medial group of the deep cervical nodes (Fig. 3859) located upon the posterior belly of the digastric muscle next the internal jugular vein, near the thyrohyoid ligament (Plate XLV.).

The lymphatics of the pharynx also resisted demonstration for a long time. They were found by Sappey to be directly continuous with those of the bordering structures, and while the trunks all communicate at their origin, there are three groups on each side: 1. A dorsal group extending along the dorsal or posterior wall of the pharynx nearly to the postnares, and then turning laterad and penetrating the pharyngeal walls, enters the retropharyngeal and the superior deep cervical nodes (Fig. 3860). 2. Several lateral trunks which extend along the side of the larynx and enter superior medial deep cervical nodes near the thyrohyoid ligament. 3. Several ventral trunks extending mostly in a caudal (inferior) direction to join the lower nodes of the superior deep cervical group as well as nodes along the esophagus and trachea (pretracheal).

Larynx.—The lymphatics of the larynx form one of the densest networks known in the body. Commencing with the epiglottis the number is almost infinite, the appearance being as if all the soft structures were composed of nothing but lymphatics. With the infant the abundance of lymphatics is most marked, but as age advances, the network in the larynx quite suddenly diminishes, so that, commencing with the vocal cords, the network in the larynx and trachea is comparatively slight. The vocal cords are relatively free from lymphatics and mark a general boundary between two territories which intercommunicate principally upon the dorsal wall. From the epiglottis and ventricle of the larynx lymphatics pass through the thyrohyoid membrane to the adjacent deep cervical nodes. Below (on the dorsal side) and above the cricoid cartilage (ventrally), lymphatics leave the larynx reaching the prelaryngeal and paratracheal nodes and thence the pretracheal and deep cervical nodes (Cf. Fig. 3874; Plate XLV., 13).

Lymphatics of the Central Nervous System.—The spaces and membranes of the brain and spinal cord are so directly continuous that a discussion of the lymphatics of both seems desirable. The question as to whether or not lymphatic vessels are present in the brain and spinal cord is one of the oldest questions connected with the lymphatic system, the discussion having lasted for nearly three centuries. Sappey denied the existence of lymphatics in the entire nervous system, central and peripheral, and up to the present time the evidence has sustained him. Although Poirier has stated that lymphatics have been seen by him in the membranes of the brain, it seems probable that definitely walled lymphatic channels are lacking there as well as in the central nervous system itself.

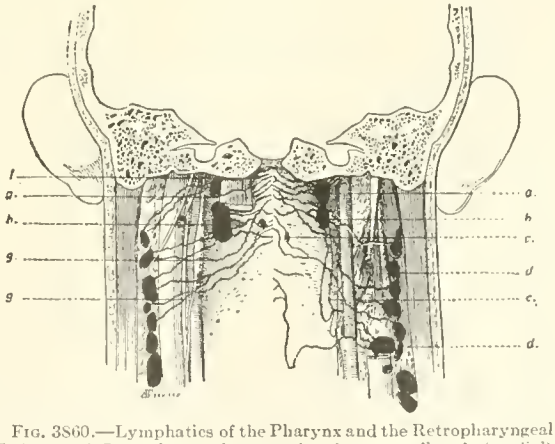


Fig. 3860.—Lymphatics of the Pharynx and the Retropharyngeal Nodes. *a*, *b*, Lateral retropharyngeal nodes; *c*, small node (medial) in the course of afferents to lateral retropharyngeal nodes; *d*, node of the deep cervical plexus; *e*, *f*, efferents from the retropharyngeal nodes passing to the deep cervical nodes; *g*, lymphatic vessel from the pharynx passing directly to the deep cervical nodes; *h*, afferents of the lateral retropharyngeal nodes. (From Poirier.)

Although the absence of definite lymphatics seems quite well established there are spaces, frequently termed lymph spaces, whose nature has not been as definitely determined. These include the *peri-*

vascular spaces, within and (possibly) without the adventitia of the blood-vessels. These communicate with clefts within the pia mater which in turn communicate with the subarachnoid spaces which, again, are in direct communication with the ventricles of the brain and spinal canal through the median and lateral apertures of the fourth ventricle (foramina of Magendie and Luschka-Retzius respectively). Outside the arachnoid is the cleft-like subdural space which appears to be nowhere in direct communication with the subarachnoid space. An epidural space, outside the dura mater, is recognized by some.

From the results of a number of investigators (Schwalbe,[17] Key and Retzius,[2] Michel, Flatau, Cuneo[18] and André) it would appear to be quite well established that the subdural space directly communicates with the extracranial lymphatics, the perineural spaces of the olfactory nerve (and possibly other peripheral nerves), the perilymphatic spaces of the ear, and the corresponding space in the case of the eye. Thus Schwalbe and later Key and Retzius showed that the nasal lymphatics could be injected from the subdural space. Key and Retzius further believed that the injection was equally successful from the subarachnoid space, but this result has not yet been confirmed. They also found that while in most cases the perineural sheaths of the olfactory nerves were injected at the same time yet true lymphatics did not communicate with these but had special passages through the lamina cribrosa and were often injected when the perineural sheaths were not injected; and sometimes the perineural sheaths were injected without the injection of the lymphatics. They were not successful in injecting the nasal lymphatics of man from the cranial lymph spaces although the perineural spaces of the olfactory nerves were in some cases filled, a freshly killed dog or rabbit furnishing the most successful preparations. The injection of the nasal lymphatics from the subdural space in man has, however, been since accomplished by Cuneo. Despite the statements of Key and Retzius it is probable that the subarachnoid space has no direct lymphatic connections. Spaces within the cranial and spinal nerves exist, including the perineural spaces, and these may sometimes be injected from the subarachnoid space (Sabin[22]). It is possible that through such intra- and perineural spaces the subdural and subarachnoid spaces are in communication.

It would seem that such lymphatic drainage from the cranial cavity as there is, is mainly through the jugular foramina and enters the deep cervical lymphatic nodes. Possibly lymphatics leave through other foramina. Much remains to be done, however, before the relations are clearly established.

As stated, the subarachnoid and subdural spaces of the brain are directly continuous with the corresponding spaces of the myel, and are also projected out with the nerves, most completely with the optic. Very little is as yet known concerning lymphatic drainage from the spinal cord and its membranes. Lymphatics have been described as following the blood-vessels, and terminating in the nodes in course of the blood-vessels which they follow.

Lymphatics of the Neck.—These are superficial and deep and include the lymphatics of the structures of the neck proper, and also all the trunks from the head and face. The vessels from the integument extend mostly to the superficial cervical nodes, but part of them enter the supraclavicular or inferior deep cervical nodes directly (29, 29 of Fig. 3865).

Thyroid Gland.—The lymphatics of the thyroid gland have been only recently worked out by Bartels and by Most. There exists a fine dense network surrounding the lobules and on the surface of the gland which is drained by lymphatics both superiorly and inferiorly. The superior lymphatic vessels may be either medial or lateral. Both sets terminate in the superior medial deep cervical nodes. The lateral inferior thyroid lymphatics proceed to the inferior deep cervical (supraclavicular) nodes. Medial lymphatic vessels may go to the pretracheal and paratracheal nodes (Fig. 3874), and thence to the highest nodes of the anterior mediastinal group.

Of the detailed relations of the lymphatics within the thyroid gland, to the follicles (acini) and to the tissue spaces, but little definite is known. The occasional presence of colloid substance within the lymphatics of the gland has led some to regard the association of the follicular epithelium and lymphatic capillaries as particularly close. Colloid may also occur within the thyroid blood-vessels, however.

Parathyroids.—No clear demonstration has as yet been made of the existence of lymphatics within the parathyroid bodies in man or animals.

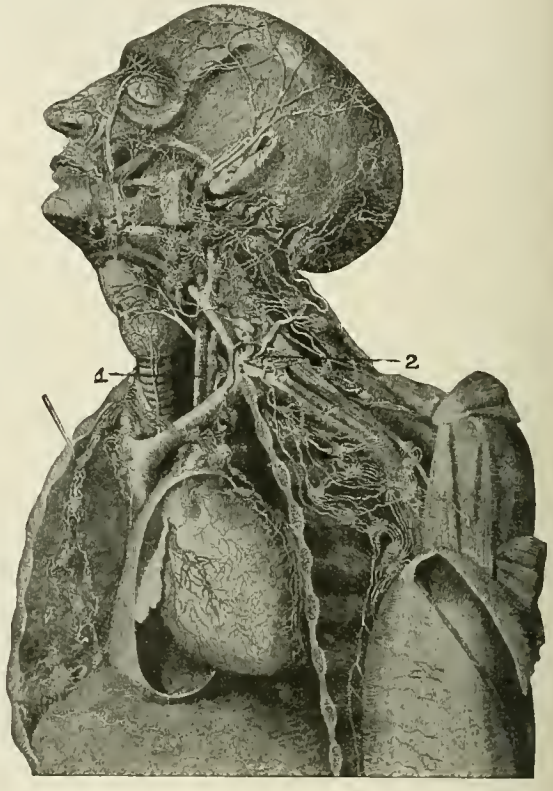


Fig. 3861.—General View of the Head, Neck, and Thorax, also the Termination of the Thoracic Duct. (Mascagni.) 1, Thoracic duct as it emerges from the thorax opposite the first rib; 2, termination of the thoracic duct at an angle formed by the junction of the subclavian and internal jugular veins. In the original folio plate there is a considerable swelling shown on the thoracic duct about fifteen millimeters before its termination. At the lower part of the figure is the arching diaphragm with vessels extending to the sternal nodes; the heart is displaced to the left from the opened pericardium. This cut does scant justice to the beautiful original, in which every detail is clear and clearly marked by letters or numerals.

Lymphatic Nodes of the Head and Neck.—These are very numerous and important. They are all confined to the sides of the face, around the base of the head, and along the great cervical blood-vessels, none having been found within the skull. They have been divided into two great paired groups or plexuses, the superficial or external, and the deep or internal jugular lymphatic plexuses; the external jugular plexus including all the superficial nodes and finally pouring its lymph into the internal plexus, which includes all the deep cervical nodes. This, while communicating with the nodes in the thorax and axilla, sends a main

efferent trunk, *truncus jugularis*, to join the thoracic duct on the left, the common lymphatic trunk on the right; or in some cases the jugular trunk ends partly or wholly independently in the veins (4 and 5 of Fig. 3881). These plexuses form a kind of double and closely connected chain along the course of the great cervical vessels (Fig. 3857), and yet, for convenience of description and reference, they have been described as several groups; but here, as in other parts of the body of man, the groups merge so insensibly into each other that the same node might be placed in one group by one anatomist and in the adjoining group by another. Furthermore, it should not be lost sight of that from a limited region lymphatics may go to quite widely separated groups of nodes, and also that the number and size of the nodes in a group are subject to considerable individual variation. (For examples, see Fig. 3864 B 17, also the description of the lymphatics of the liver, Fig. 3869.)

The superficial nodes of the head and neck, *i.e.* the nodes of the superficial or external jugular lymphatic plexus, are divided into the six following groups:

1. The occipital lymphatic nodes (*lymphoglandulæ occipitales, glandulæ lymphaticæ occipitales, s. suboccipitales*), one or two, usually small nodes on the complexus muscle between the cranial attachment of the trapezius and the sternomastoideus. The afferent vessels are from the occipital, partly, also, from the temporal and parietal regions; the efferent vessels extend mainly to the superior deep nodes. Some lymphatic vessels from the occipital region pass to the supraclavicular nodes (Figs. 3857 and 3861).

2. Anterior auricular lymphatic nodes (*lymphoglandulæ auriculares anteriores; glandulæ parotideæ*). There are usually two or three, on the surface of the parotid gland, in front of the ear. Their afferent vessels are from the temporal (and frontal) regions, eye-lids and conjunctiva, from the anterior portion of the external ear and external auditory meatus. Efferents pass to the superior deep cervical nodes.

3. Parotid lymphatic nodes (*lymphoglandulæ parotideæ; glandulæ lymphaticæ parotideæ*). There are a number of these, within the parotid gland. Their afferents come from the same territory as those of the anterior auricular nodes, and from part of the mucosa of the cheeks and the gums of the maxilla or upper jaw. The efferent vessels pass mainly to the submaxillary and superior deep nodes (Fig. 3857).

4. Mastoid or posterior auricular lymphatic nodes (*lymphoglandulæ auriculares posteriores; glandulæ lymphaticæ mastoideæ, s. subauriculares, s. auriculares posteriores*). Several small nodes on the cranial attachment of the sternomastoid muscle, near the mastoid process and base of the ear. The afferent vessels are from the parietal, temporal, and occipital regions in part, from the helix, antihelix, convex surface, and lobule of the ear. The efferent vessels extend to the superior cervical nodes. Some of the lower nodes are sometimes distinguished as the inferior auricular nodes, receiving afferents from the lobule of the ear and inferior portion of the external auditory meatus.

5. Submaxillary lymphatic nodes (*lymphoglandulæ submaxillares; lgl. mandibulares; lgl. paramandibulares; glandulæ lymphaticæ submaxillares*) (Figs. 3857 and 3859). There are several of these extending along almost the entire extent of the body of the mandible. In this group are included the nodes on the buccinator muscle, sometimes described as a separate group (glandulæ buccales, s. buccinatores) and sometimes classed with the deep nodes. The submaxillary nodes extending near the chin are also sometimes called submental (mentales) and a single one near the meson has been named suprahyoid by Sappey. The afferent vessels of this group are from the middle of the forehead, the nasal canthus of the eye, the integument of the nose and vestibule, and in the horse and ox also partly from the nasal fossæ; from the cheeks and lips, the gums of the mandible in part, and the floor of the mouth, including the tip of the tongue; part of the efferent vessels from the parotid nodes or other nodes in the territory of the facial group. The efferent vessels pass to the superficial deep cervical nodes.

6. Superficial cervical lymphatic nodes (*lymphoglandulæ cervicales superficiales; glandulæ lymphaticæ cervicales superficiales, s. jugulares superficiales*). Several small nodes along the external jugular vein, but extending on both sides of it. They are between the platysma and the sternomastoid muscles. The afferent vessels are from the superficial structures of the neck, including possibly some of the efferent vessels from the superficial facial groups. The efferent vessels extend to the superior deep cervical nodes.

The superficial or external jugular lymphatic plexus in the larger animals—horse and ox—is approximately like that of man; but in the rabbit it is represented only by the submaxillary lymphatic nodes and two small nodes near the ear (3 and 4 of Fig. 3884). In the dog only the submaxillary lymphatic nodes seem to belong to this plexus (3 of Figs. 3879 and 3882); in the cat the mastoid nodes are large and may be injected from the inner or concave aspect of the external ear. It is possible that the small node on the trunk following the external jugular vein, shown in Fig. 3880, may also belong to the superficial plexus. One cannot help being struck with the fewness of the nodes in the dog, cat, and rabbit.

The deep nodes of the head and neck, or the nodes of the internal jugular plexus are situated on the course of the great vascular trunks and extend from the atlas to the thorax. The lymphatics of the entire head and neck ultimately traverse this plexus.

The nodes of this plexus have been quite commonly divided into three great groups, with some minor groups—the deep facial, the superior and inferior deep cervical. The first of these groups, the deep facial group (*lymphoglandulæ faciales profundæ; lymphoglandulæ buccales*) is a poorly defined group along the course of the facial and internal maxillary vessels. It includes infraorbital (maxillary), buccinator, supramandibular (mandibular) nodes and is closely associated with the submaxillary group to which its efferents mostly pass. The retropharyngeal nodes (lateral and medial) may also be added to this irregular assortment (Fig. 3860).

The remainder, or the nodes of the internal jugular plexus proper, are divided into two groups, viz., those extending from the level of the base of the cranium, along the deep vessels to the level of the omohyoid muscle and those in the supraclavicular triangle of the neck: (1) superior deep cervical, and (2) supraclavicular or inferior deep cervical nodes respectively. Both groups are often conveniently divided into medial and lateral series of nodes.

(1) Superior deep cervical lymphatic nodes (*lymphoglandulæ cervicales profundæ superiores; glandulæ lymphaticæ cervicales profundæ, s. glandulæ lymphaticæ jugulares cephalicæ*).

The nodes in this group are numerous and quite widely separated from one another extending from the mastoid process to the side of the larynx above the omohyoid muscle.

The afferent vessels of this group are from the nasal cavity, the cheek, roof and floor of the mouth, in part from the tongue, pharynx, tonsil, tympanum, and Eustachian tube, the larynx, and the thyroid. The efferent vessels pass to the supraclavicular nodes; partly directly to the jugular lymphatic trunk.

(2) The supraclavicular nodes (*lymphoglandulæ cervicales profundæ inferiores; glandulæ lymphaticæ supraclaviculares, s. cervicales profundæ inferiores, s. jugulares inferiores*). These nodes are arranged along the carotid artery and internal jugular vein in the supraclavicular triangle and near the junction

of the subclavian and internal juglar veins. Most of the efferent trunks from the external jugular plexus and from the superior cervical nodes enter this group; also many of the lymphatics of the pharynx, esophagus, trachea, and the lymphatics accompanying the vertebral artery and vein, also some of the superficial and deep lymphatics of the neck and the clavicular region. They also communicate with the anterior mediastinal and with the axillary nodes. The efferent vessels form a single or multiple trunk (*truncus lymphaticus jugularis*) which terminates on the left in the thoracic duct, or on the right in the right common lymphatic trunk, or sometimes partly or wholly by an independent opening into the great veins (Figs. 3857 and 3881).

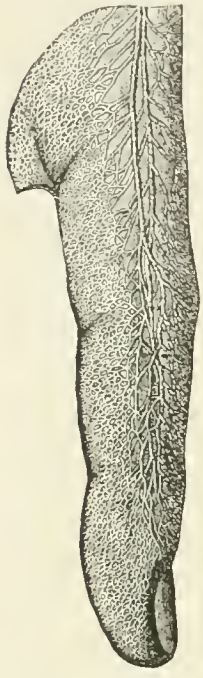


Fig. 3862.—Superficial Lymphatics of a Finger. (Sappey.) To show the extreme abundance of the lymphatics and the fineness of the network on the end and the palmar aspect, also that the vessels from both the dorsal and ventral surfaces extend to the side where two or three considerable trunks, parallel with the collateral artery, convey the lymph toward the hand. By comparing Fig. 3863, it will be seen that these trunks always extend upon the dorsum of the hand.

In the horse and ox the nodes of the neck are approximately like those of man; but in the cat, dog, and rabbit there is but a single deep cervical lymphatic node, and the jugular trunk is usually large and long, and not infrequently opens partly or wholly into the vein independently (Figs. 3880, 3881, 3885).

Lymphatic Vessels of the Thoracic Limb (Arm and Shoulder).—The lymphatics of the arm and shoulder form a superficial and deep set, as in most parts of the body. The lymphatics of the hand arise by a complex network on the dorsal and palmar surface of the fingers, and extend toward each side of the finger, where they unite into two or three anastomosing trunks which follow the direction of the collateral arteries to the hand when they reach the dorsal surface. From the palm many vessels wind round both edges to the dorsal side also; but many next the wrist extend directly upon the ventral or flexor aspect of the arm and extend to the axillary region. The trunks on the dorsum of the hand and the extensor side of the entire arm gradually wind round to the flexor surface in their course to the axilla. Most of the vessels enter directly the axillary nodes but a few of those from the fourth and fifth fingers and the ulnar side of the antibrachium traverse one or two nodes superficial brachial or epitrochlear nodes in the flexure of the elbow (Fig. 3863) before proceeding to the axillary nodes. Frequently, if not constantly, one or more trunks follow the cephalic vein and go to the subclavian nodes instead of going to the axilla, and not infrequently there is a node in the course of these near the insertion of the deltoid, or even farther along (13 of Fig. 3863; see also Fig. 3865). The superficial lymphatics of the shoulder either join the trunk following the cephalic vein or extend round to the axilla. The deep lymphatics of the arm arise in the deep structures and follow the principal blood-vessels much more closely than do the superficial lymphatics. In the antibrachium there are, therefore, three groups following the radial, ulnar, and interosseous blood-vessels. There are occasionally a few small lymphatic nodes in the antibrachium (antibrachial nodes) through which a part of the vessels pass; but usually none are reached until in the flexure of the elbow, where, extending along the brachial vessels, there are regularly met three or four nodes (deep brachial or cubital nodes), which most of the vessels traverse. Before reaching the axillary nodes, according to most authors, there is free anastomosis between the superficial and deep lymphatics at the wrist and elbow, but Sappey denies any such anastomosis.

According to the description of most veterinarians, the lymphatics of the arm and shoulder of the horse and ox are quite comparable with those of man both as to nodes and vessels, except that there is a larger lymphatic node in the fold between the scapula and the neck—the prescapular node. In the dog and cat the arrangement is exceedingly simple. All of the vessels, except a few cutaneous ones whose course is somewhat irregular, which can be injected from the pads of the manus (forepaw), finally extend upon the dorsum of the paw, and extend from there by two or more frequently anastomosing trunks along the radial nerve to the elbow, and then follow the cephalic vein to the prescapular node, no axillary nodes being present (Figs. 3879, 3882). Occasionally, in the cat, one or more branches turn in the bend of the elbow to follow the brachial vessels to the axilla, and finally enter the nearest pectoral node.

In the rabbit, vessels likewise follow the radial nerve to the elbow, then extend obliquely around the radial side of the brachium to the axillary nodes. Other trunks follow the large blood-vessels, and enter the axillary nodes. The lymphatic vessels of the arm, whatever their course, traverse but a single node in the dog and cat, sometimes two nodes in the rabbit.

Lymphatic Nodes of the Arm and Shoulder.—Superficial brachial nodes (*lymphoglandulæ cubitales superficiales; glandulæ brachiales superficiales, s. cubitales superficiales, s. supratrochleares*), two nodes often found in the course of part of the trunks from the fourth and fifth fingers and the ulnar side of the arm. The node in the course of the trunk following the cephalic vein has been designated as a deltopectoral node.

The deep nodes. There are sometimes a few in the antibrachium (*glandulæ lymphaticæ antibrachiales*), through which traverse the deep antibrachial lymphatics, on their way to the deep brachial nodes (*glandulæ lymphaticæ brachiales entales, s. profundæ, s. cubitales profundæ*). These are just proximal of the elbow-joint on the brachial vessels. Through them pass part of the deep lymphatics. Nodes also occur in course of the deeper lymphatics in the upper arm (*lymphoglandulæ brachialcs*).

The axillary lymphatic nodes (*glandulæ lymphaticæ axillares*, Fig. 3865) are situated in the axillary region around the great vessels and nerves, and covered by the pectoral muscles and extending from the edge of the great pectoral into the subclavian fossa, where they are in communication with the supraclavicular nodes. All the lymphatic vessels of the arm and most of those of the shoulder enter these nodes; also many from the supraumbilical part of the abdomen, side, and back; also the lymphatics of the mammary gland and the other structures of the breast, including the efferent vessels from the pectoral muscles. The efferent trunk (*truncus subclavius*) is one of the important tributaries of the common lymphatic trunks. As here used the axillary group of nodes includes the subclavian or infraclavicular nodes into which flow the trunks following the cephalic vein, and the pectoral nodes as well.

The axillary group is a difficult one to subdivide because of variability and the indefiniteness of boundaries. The following groups (Fig. 3871) are disclosed by proceeding laterally from the medial border of the axilla and then following the course of

the axillary vessels upward: (1) pectoral nodes (anterior pectoral nodes); (2) subscapular nodes; (3) brachial nodes; (4) subpectoral (including interpectoral) nodes; (5) intermediate nodes; (6) infraclavicular (subclavian) nodes; (7) delto- (deltoideo-) pectoral nodes.

The afferents from the mammary gland will be discussed in considering the lymphatics of the thorax.

In the dog and cat no axillary nodes are present, all the trunks going to the prescapular node *glandula pre(scapularis)* (Figs. 3879–3883). In the rabbit all go to axillary nodes more nearly as in man (Figs. 3284 and 3285).

Lymphatic Vessels of the Pelvic Limb.—The superficial lymphatics of the foot, leg, and thigh are almost precisely like those of the hand and arm. The vessels of the toes and sole extend mostly to the dorsum of the foot, and then wind round the leg to the inguinal region, and enter the subcutaneous inguinal (subinguinal) lymphatic nodes (Figs. 3264 and 3265). A limited number of vessels from the heel and fibular side of the foot accompany the short saphenous vein to the popliteal space where they enter the popliteal nodes and join the deep lymphatics.

The subfascial or deep lymphatics also resemble those of the arm, following the main vascular trunks; hence in the crus there are three groups: one on the extensor side of the crus following the anterior tibial vessels, and sometimes traversing one or two anterior tibial nodes about the middle of the crus. The lymphatics penetrate the interosseous ligament near the knee to enter the popliteal nodes. The other two groups follow the peroneal and posterior tibial blood-vessels to the popliteal nodes. After traversing the popliteal nodes the lymphatics follow the femoral vessels to the inguinal region, where they enter

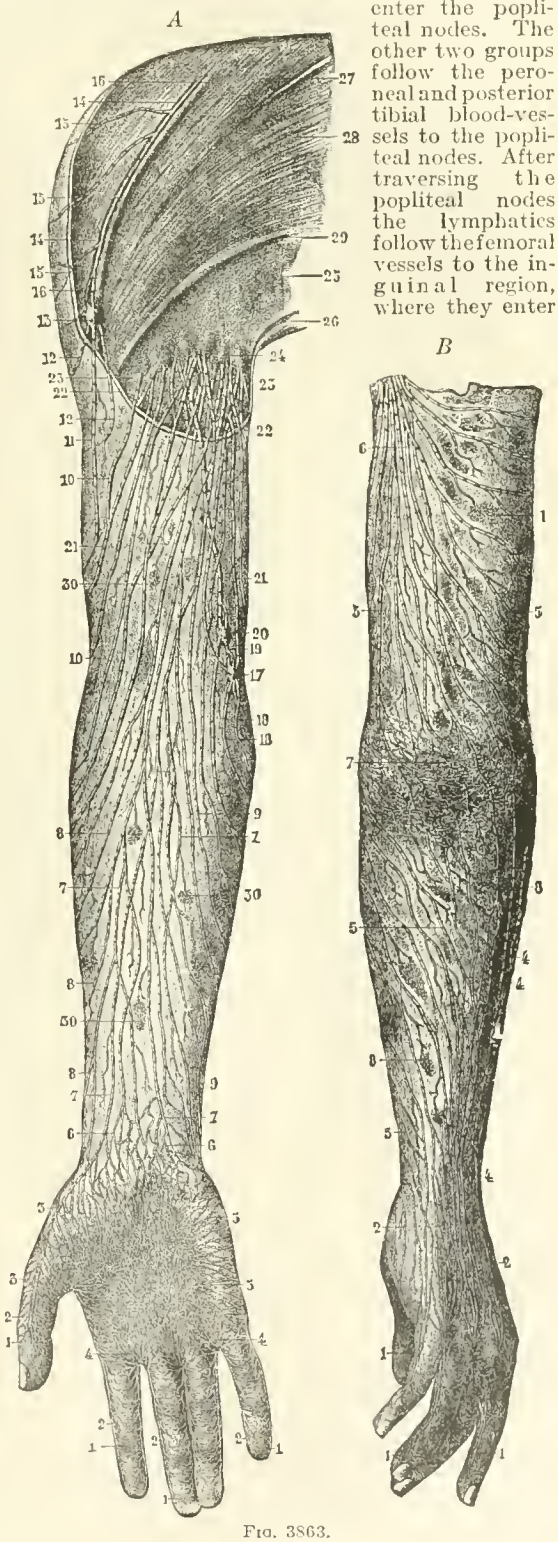


Fig. 3863.

Fig. 3863.—Superficial Lymphatics of the Hand and Arm, (Sappey, Atlas.) To show the number and course of the trunks and the fineness of the network in the hand and arm. Except a small area around the shoulder and in the axilla where the skin is removed, the lymphatics are represented as if the skin were transparent. *A*, Ventral aspect of the right arm. 1, 1, Network of lymphatics on the palmar aspect of the fingers; 2, 2, the collateral trunks on each side of the fingers—the collecting truncules from both palmar and dorsal side wind round the finger to the edge and, uniting into two or more trunks (Fig. 3862), extend upon the dorsum of the hand; 3, 3, trunks coming from the palm to join those from the thumb; 4, 4, collecting trunks from the distal part of the palm which wind round between the fingers to reach the dorsal surface (see *B*); 5, 5, collecting trunks at the ulnar side of the hand, likewise winding round upon the dorsal surface; 6, 6, collecting trunks from the palm next the wrist—they extend directly along the flexor aspect of the arm; 7, 7, large trunks formed by the union of many of those from the palm and thumb; 8, 8, trunks winding round the radial side of the antibrachium from the extensor to the flexor side; 9, 9, similar trunks winding round the ulnar side of the antibrachium, from the dorsal or extensor to the ventral or flexor side; 10, lymphatic trunks curving round from the dorsal or extensor to the ventral or flexor side of the brachium to enter the axillary nodes; 11, trunk following the course of the cephalic vein and traversing the node at 13; 12, 12, trunks winding round the arm and shoulder to join the delto-pectoral node; 14, 14, lymphatic trunk accompanying the cephalic vein and entering the subclavian nodes; 15, vessels from the scapular region to the trunk accompanying the cephalic vein; 16, cephalic vein in the furrow between the deltoid and pectoral muscles; 17 and 20, brachial or epitrochlear lymphatic nodes—through these pass part of the vessels from the little finger and the ulnar side of the arm; 18, 19, trunk entering the more distal and joining the two nodes—the efferent trunk from 20 is one of the largest of the arm, it penetrates the tissues and accompanies the basilic vein to the axillary nodes; 21, 21, collecting trunks extending toward the axilla; 22, 22, cut edge of the skin; 23, 23, brachial fascia; 24, axillary lymphatic nodes showing through the fascia; 25, axillary fascia covering the nodes; 26, border of the axillary space formed by the teres and latissimus muscles; 27, clavicular fascia of the pectoralis separated from the deltoid by the groove containing the cephalic vein with its accompanying lymphatic trunk; 28, sternal fascia of the pectoralis; 29, border of the pectoralis, forming also the border of the axilla; 30, 30, 30, points on the brachium and antibrachium where the fine network of vessels has been injected—in a completely injected preparation the entire skin would be covered with such a network. *B*, Ulnar side of the hand and extensor aspect of the antibrachium and part of the brachium, to show that the trunks from the fingers and palm extend largely upon the dorsal aspect and then wind round the arm to reach the ventral or flexor aspect. 1, 1, 1, Lymphatics of the fingers, the collecting trunks extending upon the dorsum of the hand; 2, 2, vessels on the dorsum of the hand; 3, 3, lymphatic trunks winding round the ulnar side of the antibrachium to reach the flexor aspect; 4, 4, 4, vessels winding round the radial side of the antibrachium to reach its flexor surface; 5, 5, vessels on the brachium curving round to the axilla; 6, group of vessels converging toward the axillary lymphatic nodes; 7, lymphatic network at the convexity of the elbow; 8, 8, 8, spots in which the fine lymphatic network of origin is shown.

the deep inguinal (subinguinal) nodes and after traversing these accompany the femoral vein and artery into the abdomen to the iliac nodes. Besides these there are lymphatic trunks accompanying the sciatic and gluteal vessels, which traverse one or more small nodes belonging to the hypogastric group—gluteal, ischiatic, and obturator nodes, at the sacrosciatic foramen. The trunk following the obturator artery constantly traverses, according to Cruveilhier, this last node (*lymphoglandula obturatoria*).

In the dog, cat, and rabbit there is the same simplicity of the lymphatic trunks as pointed out for the arm. Injections into the pad of the pes (hind paw) demonstrate vessels on the dorsum and great-toe side of the foot. Part of these trunks follow the course of the long saphenous vein, others, usually larger trunks, wind round the calf, with the short saphenous vein, to the popliteal space and enter a popliteal node (Fig. 3879, 16). In the rabbit, branches extend to the popliteal space from both sides of the crus (Fig. 3884). From the popliteal node the main efferent vessels in all pass between the peroneal and tibial nerves, and accompany the femoral artery and vein, freely anastomosing with the trunk along the saphenous artery. No inguinal nodes are present, and the vessels extend directly to the lumbar (aortic) nodes (Fig. 3879, 22).

Lymphatic Nodes in the Leg.—The most distal node is the anterior tibial, situated on the interosseous ligament near the middle of the crus. Through it pass the deep trunks, following the anterior tibial vessels on their way to the popliteal nodes. This node is frequently absent. The popliteal nodes (*glandulæ popliteæ*, Fig. 3864) are in the fat in the popliteal space. Two are near the surface and receive the lymphatics accompanying the short saphenous

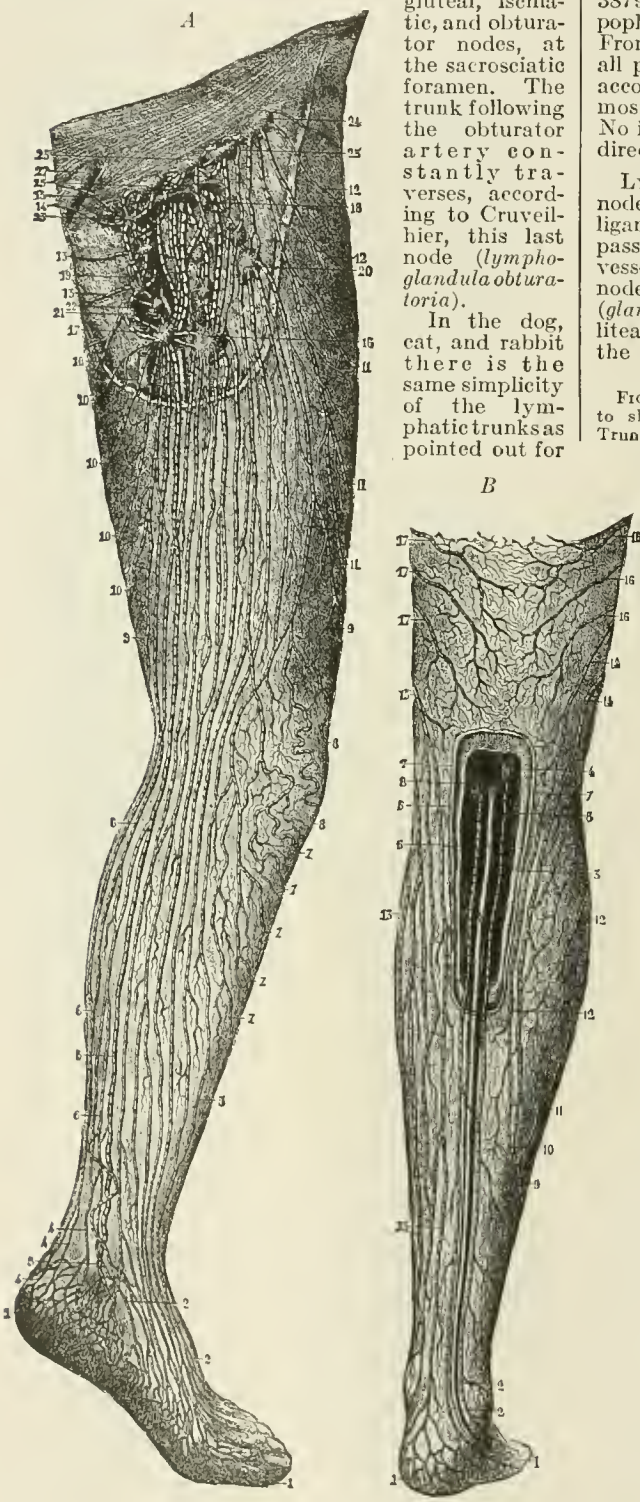


Fig. 3864.

Fig. 3864.—Superficial Lymphatics of the Foot and Leg, to show the Origin, Number, and Course of the Lymphatic Trunks, and the Popliteal and Inguinal Lymphatic Nodes. The skin is represented as transparent, except where removed in the popliteal space and in the inguinal region. Sappey, Atlas.) *A*, The tibial side of the foot and entire leg. 1, 1, Truncules arising from the sole, great toe, and side of the foot; 2, 2, trunks arising at the toes and extending across the dorsum of the foot to reach the tibial side of the leg; 3, great trunk arising from the plantar aspect near the instep, and skirting the tibial or internal malleolus on its way to the inguinal region; 4, 4, 4, trunks coming from the heel and extending along the ankle and leg; 5, 5, and 6, 6, trunks extending along the crus parallel with the calf; 7, 7, 7, 7, trunks winding round the edge of the tibia to reach the tibial or inside of the leg; 8, 8, lymphatic trunks winding round the knee to reach the inside of the leg. They are very tortuous when the knee is extended, more nearly straight when it is flexed; 9, 9, trunks curving round from the extensor side of the meros, or thigh, to reach the inguinal nodes; 10, 10, 10, 10, numerous trunks winding round from the flexor side of the thigh to the subinguinal nodes; 11, 11, 11, trunks curving round from the extensor side of the thigh to the inguinal nodes; 12, 12, trunks from the gluteal region; 13, 13, trunks from the perineal and anal region to the inguinal nodes; 14, trunks from the scrotum (cf. Fig. 3865); 15, trunk from the penis; 16, the large distal node of the superficial inguinal group, into which enter so many of the trunks of the leg; 17, another large node at the same level; 18, large efferent trunk from 16, it follows the course of the femoral artery; 19, lymphatic trunks following the course of the femoral vein; 20, large node receiving many of the trunks from the extensor sides of the thigh; 21, node receiving many of the trunks from the flexor side of the thigh; 22, 22, cut end of the vena saphena magna; 23, node in the groin to which extend many of the lymphatics from the penis (cf. Fig. 3865); 24, large corner node receiving most of the trunks winding round the ilium from the lumbar and gluteal region; 25, 25, proximal row of nodes in the fold of the groin to which extend many of the trunks from the ventral wall of the abdomen; 27, inguinal ring with the contained spermatic cord. *B*, Flexor Aspect of the Distal Half of the Leg. 1, 1, Trunks from the heel and fibular side of the foot; 2, 2, two lymphatic trunks following the course of the vena saphena to the popliteal nodes; 3 and 5, the two lymphatic trunks, 3 on the fibular, 5 on the tibial side of the vein; 6, vena saphena parva; 7, and 8, cut edge of the skin, and fascia removed to bring the popliteal nodes into view; 9, great trunk on the fibular side of the crus; it follows the contour of the calf, and by its branches furnishes nearly all the trunks on the fibular or outside of the crus; 10–12, bifurcations and branches of 9; 13, 13, trunks on the tibial side of the crus. They curve round to the inner side of the leg, and extend to the inguinal nodes; 14 and 16, trunks on the fibular side of the thigh, which wind round to the extensor aspect, and then to the inguinal nodes (cf. 11 and *A*); 15, large trunks on the tibial or inside of the knee, on ita way from the heel, crus, and thigh, to the inguinal nodes; 16 and 17, trunks winding round the thigh in opposite directions to reach the inguinal nodes.

vein. Their efferent trunks pass to the two more deeply situated nodes around the popliteal blood-vessels; through the deeper ones pass all the deep vessels of the foot and crus and part of those from the knee. The efferent vessels pass with the femoral blood-vessels to the inguinal nodes.

Inguinal nodes (*lymphoglandulæ inguinales; glandulæ lymphaticæ inguinales*, Figs. 3864 and 3865). — There are two layers of these—the superficial or subcutaneous and the deep or subfascial.

These are also frequently subdivided into inguinal and subinguinal nodes (*lymphoglandulæ subinguinales*) by a horizontal line through the point where the long saphenous vein pierces the cribriform fascia.

The superficial inguinal nodes form an oblong irregular four-sided figure with one border next Poupart's ligament. The afferent vessels are the superficial lymphatics of the entire leg (to the subinguinal group) the subumbilical part of the body, and the external genitalia (mainly to the inguinal group). The efferent vessels traverse the cribriform fascia and enter the deep inguinal (subinguinal) nodes; frequently a few trunks pass into the body cavity and join the iliac nodes. The inguinal nodes receive efferents from the subinguinal nodes and send their efferents mainly to the iliac nodes.

The deep inguinal (subinguinal) nodes are situated along the femoral artery and vein in the inguinal region and are usually three or four in number, although there may be six or seven. They are covered by the femoral fascia and are in intimate contact with the femoral vessels; one of them is found almost constantly in the mouth of the inner femoral or crural ring, which, according to Henle, it assists in closing. The afferent vessels of this group are derived from the deep lymphatics of the foot, crus, and thigh (in part); the efferent trunks from the popliteal and most of those from the superficial inguinal (subinguinal) nodes.

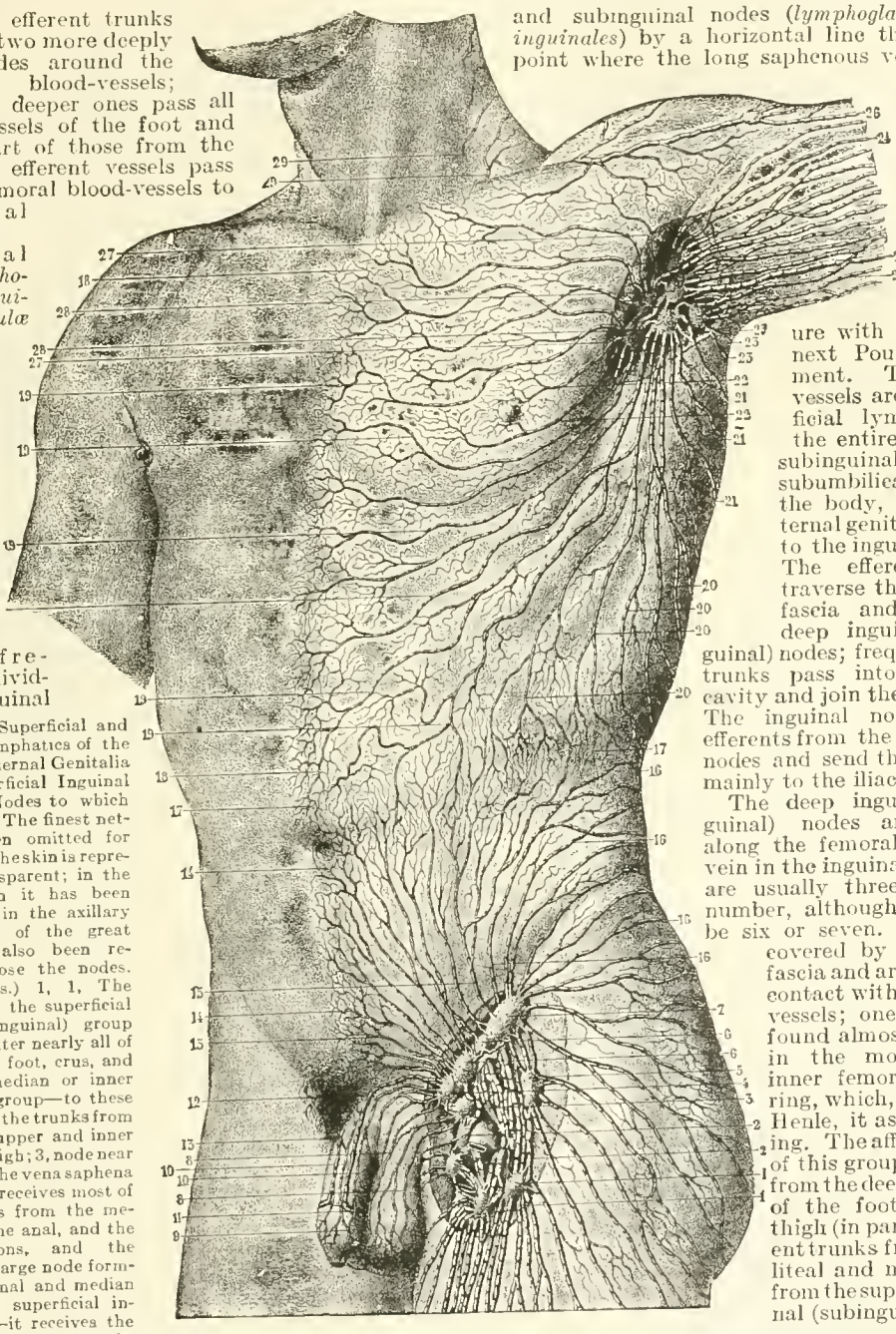


Fig. 3865.—Superficial and Cutaneous Lymphatics of the Trunk and External Genitalia and the Superficial Inguinal and Axillary Nodes to which they Extend. The finest network has been omitted for clearness, and the skin is represented as transparent; in the inguinal region it has been removed, and in the axillary region a part of the great pectoral has also been removed to expose the nodes. (Sappey, Atlas.) 1, 1, The distal nodes of the superficial inguinal (subinguinal) group—into these enter nearly all of those from the foot, crus, and thigh; 2, 2, median or inner nodes of this group—to these come many of the trunks from the tibial or upper and inner aspect of the thigh; 3, node near the cut end of the vena saphena magna, which receives most of the lymphatics from the median gluteal, the anal, and the perineal regions, and the scrotum; 4, a large node forming the proximal and median corner of the superficial inguinal group—it receives the lymphatics from the penis, or, in the female, from the clitoris and part of the labia; 5, the lateral or outer node of this group, receiving many vessels from the thigh; 6, 6, proximal nodes next the abdomen—they receive the lymphatics from the ventral subumbilical region; 7, large node forming the lateral and proximal angle of the inguinal group—to it extend the trunks from the lumbar, gluteal, and partly, also, from the abdominal region; 8, 8, lymphatics of the scrotum; 9, vessels from the prepuce; 10, 10, vessels from the integument of the penis, extending along a single dorsal vessel, but here they remain separate and extend in a parallel course to the pubis, where each one turns to the corresponding inguinal node; 12 and 13, the two trunks from the corona of the glans—when these unite into one they bifurcate opposite the pubis and extend to the two sides as do these independent trunks; 14, 14, subumbilical lymphatics of the abdomen—they interdigitate at the midventral line with those from the right side of the body, just as is shown by those extending toward the axilla, so that in this intermediate area an injection might fill the vessels going in both directions, although there might be no true anastomoses of the two groups of vessels; 15, 15, subumbilical lymphatic trunks; 16, 16, trunks arising from the lumbar and gluteal region; 17, 17, area or zone where the subumbilical and thoracic lymphatics interdigitate; 18, 18, area of interdigitating vessels along the midventral line; 19, 19, 19, 19, 19, 19, beginnings of the trunks along the midventral line; 20, 20, trunks on the lateral aspect of the thorax on their way to the axilla; 21, 21, trunks from the dorsal part of the thorax, on their way to the axillary nodes; 22, 22, trunks from the mammary region (cf. Fig. 3274); 23, 23, trunks from the dorsal scapular region; 24, 24, trunks from the arm (cf. Fig. 3863); 25, large trunk from the superficial, or brachial or epitrochlear nodes (cf. Fig. 3863); 26, trunk accompanying the cephalic vein and terminating in the subclavian nodes (cf. Fig. 3863); 27, cut through the tissues to bring into view the axillary nodes; 28, axillary lymphatic nodes—only part of them are exposed; 29, 29, vessels from the dorsal and lateral aspects of the neck—they terminate in the supraclavicular glands.

A part of the efferent vessels traverse the abdominal wall with the femoral artery, but some of them accompany the femoral vein through the crural canal. They join the iliac nodes, sending a few branches, however, to the hypogastric nodes (Fig. 3867).

In the larger domestic animals (horse and ox) the nodes of the leg are about as numerous as in man, but with the cat, dog, and rabbit they are represented only by the popliteal node, the inguinal nodes being absent, unless the node on the external epigastric vessels may represent the superficial inguinal nodes. As the iliac nodes are also absent, vessels may pass from the foot (*i.e.* those accompanying the saphenous artery) directly to the aortic or lumbar nodes (Figs. 3879, 3882, and 3884).

Lymphatics of the Abdomen and External Genitalia.—The superficial lymphatics of the abdomen have three quite sharply defined areas of origin, that bound them, and from these boundaries the vessels extend in opposite directions. The areas are the middorsal line, the midventral line, and a somewhat irregular zone surrounding the body at the level of the umbilicus (Fig. 3865). The vessels cross these boundaries and interdigitate in a complex manner; frequently a puncture made in the boundary will give rise to an injection in both directions, although injections made at either side would inject only the corresponding side. In the lower animals especially investigated for this—cat and opossum—the communication from side to side is more intimate, an injection of one side often filling that of the other. This is especially marked opposite the pubis of the opossum, where there is constantly a large transverse lymphatic, recalling the transverse vessels between the jugular veins.

As seen in Fig. 3865, the lymphatics of the umbilical region of the body extend in the most direct manner on the abdomen to the inguinal or the axiliary nodes. Those from the lumbar and gluteal regions extend around in great curves, often following the crest of the ilium, to the lateral inguinal nodes. Others from the gluteal region curve round the nates to the perineal and anal regions, finally to join the perineal and anal vessels and extend with them to the median nodes of the superficial inguinal group.

The lymphatic network around the anal opening is very dense and is continuous with the lymphatics of the rectum. Those of the perineum are less dense. From both these regions the vessels wind round the thigh to the median or inner of the superficial inguinal nodes. In the female the number of the trunks from the perineum is reduced apparently in direct proportion to the reduction in area of the region. The lymphatics of the external genitalia of the male are naturally divisible into those of the scrotum and the penis. The vessels of the scrotum are very numerous, perhaps more so than in any other equal area of integument in the body. As in the trunk the meson—here indicated by the raphe—forms a natural dividing line for the two sides. The vessels extend in great curves, partly to the pubis and partly on the thigh, to enter the median row of superficial inguinal lymphatic nodes; those on the thigh communicating with the vessels from the perineum, and those of the pubis with the cutaneous vessels of the penis. The vessels of the integument of the penis, commencing on both surfaces of the prepuce and from the line of the urethra, wind round the two sides to the so-called dorsum of the organ when they extend toward the pubis, and curve laterally toward the two sides to enter the large node forming the corner of the superficial group (Fig. 3865, 4). The lymphatics of the glans penis are exceedingly numerous, and in several superimposed layers of networks. The collecting trunks converge toward the frænum preputii, where they are joined by the trunks from the urethra.

The urethral lymphatics begin at the prostate, anastomose with the prostatic lymphatics, with the network of the ejaculatory canals, and through them with the *vesiculæ seminales*. They extend to the *meatus urinarius*, forming a hollow cylindrical network of large, densely packed lymphatics (Fig. 3866), which reaches its greatest development opposite the fossa navicularis. Opposite the frænum two or three trunks penetrate the urethral wall and join the trunks from the glans, then penetrate the substance of the penis and reach the dorsal aspect of the *corpus spongiosum*, where the trunks of the two sides usually unite into one, which follows the course of the deep blood-vessels to the pubis, when it again divides, sending a branch to each side, finally to terminate in the large median node of the superficial inguinal group (Fig. 3865). According to some authors, the urethral and glandular lymphatics of the penis follow the internal pubic blood-vessels into the abdomen and enter the hypogastric nodes. But Sappey is very definite, both in his atlas and anatomy, in stating that they enter the large node forming the corner of the superficial group.[1]

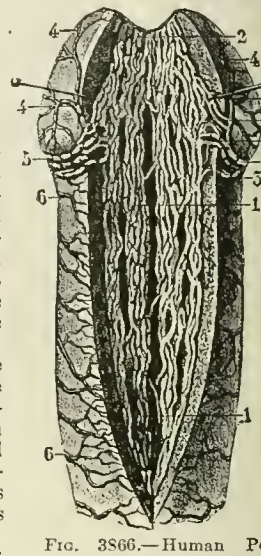


Fig. 3866.—Human Penis opened Longitudinally to show the Urethral Lymphatics. (Sappey, Atlas.) 1, 1, The very abundant longitudinal network of vessels in the urethral mucosa; 2, continuity of the urethral lymphatics with those of the glans at the meatus urinarius; 3, 3, 3, trunks traversing the urethral wall opposite the frenum and joining those of the glans; 4, 4, 4, 4, trunks from the periphery of the glans joining those from the urethra; 5, 5, large trunks formed by the union of the urethral lymphatics and those from the glans; they penetrate the substance of the penis and follow the deep blood-vessels to the pubis, whence, according to Sappey, they extend to the inguinal, but, according to many authors, to the hypogastric lymphatic nodes; 6, 6, lymphatics of the integument of the penis.

The lymphatics of the external genitalia of the female very closely resemble those of the male in their arrangement and termination. The collecting trunks from the clitoris and the surrounding parts extend nearly directly to the pubis, where they curve to the right and left, and terminate in the large median node forming the corner of the superficial inguinal group, and, according to Krause,[6] they also communicate with the lymphatics of the round ligament of the uterus. The lymphatics of the female urethra are less abundant than in the male. The trunks from the urethra, meatus urinarius, labia, and the external or inferior fourth of the vagina extend laterally to reach the vulvocrural fold, in which they wind around the thigh, with a few small trunks from the perineum to the median of the superficial inguinal nodes, only a few reaching the large corner node to which so many from the male genitalia extend.

The deep lymphatics of the abdominal wall and the lumbar part of the trunk follow the deep blood-vessels; part, therefore, extend to the sternal and axillary nodes; part, with the deep epigastric vessels, to the iliac nodes; part, with the lumbar and iliolumbar vessels, to the aortic nodes. Still others follow the circumflex iliac vessels often traversing one or more nodes along the crest of the ilium before finally entering the iliac nodes.

With the dog, cat, and rabbit, the lymphatics of the abdominal wall and the external genitalia are as in man, except that the tendency to form anastomoses across the middle plane (line) is perhaps

more marked, and that there is constantly present along the external epigastric vessels, about opposite the brim of the pelvis, a considerable node. To this node pass the superficial abdominal lymphatics, also part of those from the elongated mammary glands and from the external genitalia. There is another node along the external epigastric blood-vessels about opposite the umbilicus, in the cat at least. After traversing these nodes the efferent vessels either join or accompany the femoral lymphatics to the lumbar (aortic) nodes. In the cat they penetrate the abdominal wall with the epigastric artery, and extend, in part, to the hypogastric, and in part to the lumbar (aortic) nodes (Fig. 3879, 14, 21). The epigastric nodes may represent the superficial inguinal nodes of man. In the rabbit there is also constantly present a node on the iliolumbar vessels, next the abdominal wall, and along the edges of the sartorius muscle; the efferent vessels pass to the lumbar (aortic) nodes (see 22 of Fig. 3884).

Lymphatics of the Pelvic and Abdominal Viscera.—*Internal Genitals of the Male—Testicle, Spermiduct, Vesiculæ Seminales, and Prostate.*—Probably no organ in the masculine body is more richly supplied with lymphatics than the testicle. Those of the albuginea are sometimes described as the superficial lymphatics of the testis. They are only moderately numerous, and extend upon the spermiduct to join those from the testicle proper. Those of the testicle proper follow the seminal tubules to the epididymis, and joining those of the epididymis extend with the spermatic cord through the inguinal canal. After reaching the body cavity they follow the blood-vessels, and finally terminate in the lumbar nodes (*Lgl. para-aorticæ, Lgl. preaorticæ*) near the end of the spermatic vein.

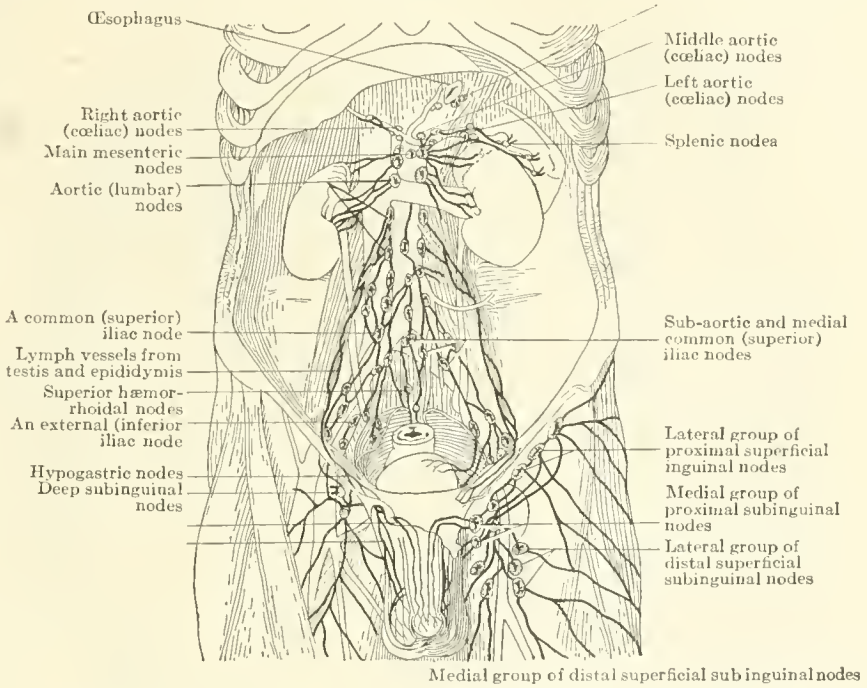


Fig. 3867.—Semi-diagrammatic View of the Lymph Nodes and Vessels of the Proximal Parts of the Lower Extremities, the Pelvis Major and the Posterior Part of the Abdomen. (From Cunningham's Text-book of Anatomy.)

The lymphatics of the testis of a mature animal are exceedingly easy to inject by the puncture method, and the collecting trunks accompanying the spermatic vein are so prominent, straight, and well supplied with valves that they are among the most striking of the lymphatic trunks in the body.

The lymphatics of the spermiduct are abundant at the ends, but very few along the middle part. Those from the testicular half follow the lymphatics of the testis, while those from the other half join the lymphatics of the vesiculæ seminales. The lymphatics of the vesiculæ seminales form a close network, which was first described by Hewson; they unite into two principal trunks. Those next the spermiduct join the lymphatics of the latter, and together they enter one of the iliac nodes. The other trunk passes between the prostate and vesiculæ seminales, so as to join an iliac node. The lymphatics of the prostate were discovered and described by Sappey in 1854, who found them abundant, and with two collecting trunks on each side. One of the trunks passes quite directly to one of the hypogastric nodes, while the other extends upon the walls of the urocyst or urinary bladder, and then curves to the side to enter a hypogastric node. The trunks extending upon the urocyst were mistaken by Mascagni and Cruikshank for the lymphatics from the bladder itself. Lymphatics from the prostate do, however, anastomose with those from the bladder and enter vesical nodes (anterior and lateral).

Internal Female Genitalia—Vagina, Uterus, Fallopian Tubes, and Ovaries.—As described above, the external or inferior third or fourth of the vagina sends its lymphatics to the superficial inguinal nodes; from the remaining portion the collecting trunks extend toward the uterus, penetrate the walls of the vagina, and traverse the uterovaginal lymphatic node on the way to the hypogastric and (inferior, medial) iliac nodes. Lymphatics were demonstrated in the muscular wall of the vagina in the human being by Morau, closely associated with the rectal lymphatics. The anorectal nodes thus appear to receive lymphatics from the vagina as well.

Our knowledge of the uterine lymphatics is still imperfect. Those of the mucosa are particularly difficult or impossible to demonstrate in a gravid uterus, and also in a non-gravid adult uterus, and Sappey further states that he never succeeded in demonstrating them in the uterine mucosa of any of the lower animals. It is only in girls before puberty that these lymphatics are demonstrable by the ordinary methods (Sappey). No doubt they exist in the adult woman, and also in the uterine mucosa of the lower animals, but they have not been satisfactorily demonstrated. There appears, however, to be little doubt of their presence in the mucosa. At the os uteri the lymphatic network is continuous with that on the vaginal part of the uterus and the vaginal mucosa.

The lymphatics of the uterine walls are numerous and easily demonstrated in most animals. The collecting trunks extend laterally in the broad ligament on each side to three different groups of nodes; those from the summit follow the Fallopian tubes out to the ovary where they join the ovarian network, and ac-

company the collecting trunks of the ovary to the aortic or lumbar nodes (*Lgl. aorticæ*) around the termination of the ovarian veins (Fig. 3867). Those from the body of the organ extend across the broad ligament, curve round the Fallopian tubes, and enter the superior medial iliac nodes; while those from the cervical region extend to the inferior medial iliac nodes. Occasionally uterovaginal and hemorrhoidal nodes are included.

Lymphatics have been demonstrated only on the uterine and ovarian ends of the Fallopian tubes, but it is probable that they are present throughout the whole extent. The collecting trunks accompany the ovarian lymphatics.

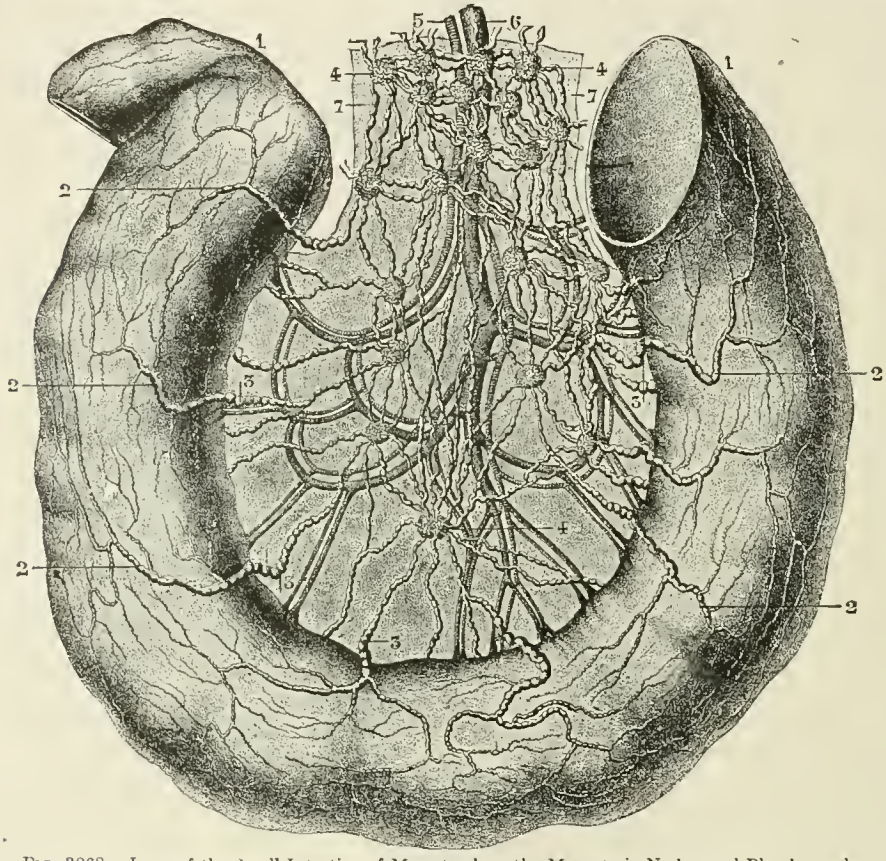


Fig. 3868.—Loop of the Small Intestine of Man, to show the Mesenteric Nodes and Blood-vessels, and the Lymphatics from the Muscularis. (Sappey, Atlas.) 1, 1, The ends of the loop of intestine; 2, 2, 2, 2, 2, lymphatic vessels arising in the muscular layer; 3, 3, 3, swellings or enlargements in these vessels near the mesenteric edge of the intestine; 4, 4, 4, mesenteric nodes along the course of the lymphatics; 5, branch of the superior mesenteric artery; 6, mesenteric vein; 7, the mesentery.

The lymphatics of the ovary, like those of the testis are in prodigious numbers, and are very easily injected. The collecting trunks are very long and straight and accompany the ovarian vein, and consequently those on the left are opposite the hilus of the kidney (Fig. 3867). The regional nodes are the same as in the male.

In the lower animals, so far as has been investigated, the lymphatics of the internal genitalia agree in all essential particulars with those of the human being. In the dog, cat, and rabbit, while the ovarian and testicular lymphatics follow the same general course, they almost always enter the aortic (lumbar) nodes, and therefore do not follow the spermatic or ovarian veins to their termination (Fig. 3879, 21, 22).

Urinary Organs and Adrenal.—Nearly up to the present time all efforts to demonstrate lymphatics in the mucosa of the urocyst or urinary bladder have failed both with men and with animals, but more recently they appear to have been demonstrated (in man) by Lendorf, just below the subepithelial capillary network. The muscular coat has been shown to be plentifully supplied; the vessels form a wide-meshed network at the summit and on the body. This network unites into one or more trunks on each side, and the trunks extend nearly or quite to the neck when they turn aside and enter the hypogastric and the iliac nodes, as well as nodes more closely associated with the bladder (anterior and lateral vesicular nodes).

The muscularis of the ureters has been shown to possess lymphatics in the horse and in man, but the attempts to demonstrate them in the mucosa have not been fully satisfactory. Although not clearly demonstrated they are presumably present.

The lymphatics of the kidney form a superficial network over the surface and a deep network in the substance of the organ. The trunks were first seen in 1532 by Massa, but first described carefully by Nuck in 1590. Those of the surface form a wide-meshed network, the collecting trunks of which extend in part directly toward the hilus of the kidney and join the deep lymphatics and part extend toward the convex border and then wind round the ends to the hilus. Next the adrenal the lymphatics of the two organs are closely connected. The deep lymphatics follow the blood-vessels and terminate in a group of the aortic or lumbar nodes situated near the renal vessels (preaortic and para-aortic).

Although the blood-vessels of the adrenal have been long known, the lymphatics were not so early discovered. It is now known that the lymphatics are as abundant as the blood-vessels, extending throughout the substance as well as upon the surface. The collecting trunks, many of them join those of the kidney, and all extend to para-aortic nodes. The left suprarenal appears to send lymphatics as well to an inferior posterior mediastinal node, while the right connects with a small node upon the crus of the diaphragm (*Lgl. retrovenosa*) (Fig. 3867).

Lymphatics of the Intestine and Stomach.—Throughout the entire alimentary canal, it has been shown that where a distinct muscular coat exists the lymphatics form two layers or sets, one in the mucosa, including the submucosa, and one in the muscularis. In those parts supported by duplicatures of serosa (mesenteries) the finer network of the mucosa proper extends to a coarse and characteristic network in the submucosa (Fig. 3892), and finally the collecting trunks penetrate the wall at the attached edge and join the lymphatics of the muscularis. The lymphatics of

the muscularis are throughout its entire thickness, but soon become subserous and wind round to the attached edge, and with those from the mucosa extend between the layers of the supporting membrane mostly in company with blood-vessels to lymphatic nodes which are also situated between the serosal walls of the mesentery (Fig. 3868, 2, 3, 4; Plate XLIV).

The intestinal lymphatics at the anus are directly continuous with those of the skin. The trunks from the muscularis and mucosa of the rectum extend between the folds of the mesorectum, often traversing minute (anorectal) nodes in their course, and then enter the superior hemorrhoidal (inferior mesocolic) nodes and ultimately go to the lumber (aortic) nodes on their way to the cisterna chyli. The lymphatics of the main part of the *colon descendens* pass to mesocolic nodes and thence to the aortic (lumbar) plexus Those of the *cecum, colon ascendens et transversum,* also part of the *colon descendens* pass through one or more of the numerous mesocolic nodes and then enter the mesenteric nodes and mingle with the lacteals from the small intestine, and with these go through the *truncus intestinalis* to the cisterna chyli.

Lacteals.—The lymphatics of the small intestine are usually called lacteals or chyle vessels, from the fact that during digestion they have a cloudy or milky appearance owing to the contained chyle.

As the small intestine has two planes of lymphatics like the rest of the alimentary canal, it is really only those of the mucosa which absorb and convey the chyle, and which, therefore, should properly be denominated lacteals as those from the muscularis always convey lymph only. The distinction is a purely superficial one and it is probable that the lacteals contain lymph like other lymphatics, except during digestion. It is also common to call all the vessels from the small intestine lacteal vessels, without regard to their origin from the muscularis or the mucosa. Whatever the origin, all the vessels unite at the attached border and extend to the nearest node, where their contents are mixed, so that usually all the collecting trunks in the mesentery appear milky and are called lacteals or chyle vessels, although some of them might really have come from the large intestine. In man there are usually three tiers of mesenteric nodes through which the chyle passes before emptying into the large trunk (*truncus lymphaticus intestinalis*). The intestinal trunk together with efferent vessels from the superior aortic (celiac) and mesocolic nodes is either single or multiple, and forms one of the most imporantt confluents of the cisterna chyli (Figs. 3879–3885).

Stomach.—The lymphatics of the stomach are continuous with those of the esophagus and duodenum. Those of the muscularis form a most beautiful network throughout the entire thickness of the coat; the collecting trunklets penetrate the tissue and become subserous, and from an intermediate area on both faces extend to the nearest of the chain of lymphatic nodes extending almost around both curvatures; those in the lesser curvature being known as the superior gastric nodes, and those around the great curvature as the inferior gastric nodes (Plate XLVI). Nodes of both series from an irregular ring at the cardia, the component nodes being hence known as the cardiac nodes. The lymphatics of the gastric mucosa form a remarkable network throughout the entire thickness of the coat, being very fine in the mucosa proper and coarser in the submucosa. The collecting vessels penetrate the muscularis along the curvatures, join those of the muscularis, and extend to the same nodes (Plate XLIV). The lymphatic drainage of the stomach divides it into three fairly well-defined areas. The first drains toward the superior nodes; the second comprises the lower pyloric and the third the upper fundus portion of the greater curvature. From all three regions lymphatics pass to the pancreatic-splenic group of nodes as a second station, sometimes passing by the gastric nodes. From the pancreatic-splenic nodes efferents extend to the aortic (celiac, upper lumbar) nodes.

Pancreas.—The lymphatics of this organ are difficult to demonstrate, but when well injected are found to form a fine network around the tubules, and the collecting trunks emerge quite directly to the surface, and form on the surface a round-meshed, rather coarse network around the lobules. From this network vessels extend in three directions—part of them going to the tail or splenic end of the pancreas to join the nodes at the hilus of the spleen, part to the gastric edge of the pancreas to enter some of the numerous nodes along the course of the splenic vessels—pancreatic, superior gastric, and hepatic nodes. Still others extend toward the duodenum to enter a large node which also receives part of the lymphatics of the duodenum (*Lgl. pancreatico-duodenalis*). The lymph finally reaches the intestinal trunk after traversing one or more of the aortic (celiac) nodes (Fig. 3867). From the pancreas afferents also pass to the aortic (celiac) and mesenteric nodes.

Spleen.—The only lymphatics apparently that exist within the spleen are perivascular (periarterial) deep networks to which the splenic lymphatic nodules belong, and a superficial network which extends into the interior in the trabeculæ and thus is in communication with the perivascular (deep) network. The splenic pulp appears entirely free from lymphatics. Our knowledge is based almost entirely upon conditions in animals; the relations in man being imperfectly known.

The collecting trunks pass to the hilus of the organ and terminate in the numerous nodes (*Lgl. lienales*) there situated. The efferent trunks from these nodes pass to the aortic (celiac) nodes and the intestinal lymphatic trunk, or some may enter the cisterna chyli directly (Fig. 3867).

Liver.—The lymphatics of the liver were very early seen, and the efferent trunks *from* the hilus were, for a long time, supposed to be the continuation of the lacteals *to* the liver. It has been found that the lymphatic system of the liver is quite as remarkable as the blood supply. In general there are both superficial and deep lymphatic vessels, and the ducts and gall-bladder possess a rich supply. The collecting trunks form three great groups and take three main courses, following the portal vessels to the hilus, the hepatic vessels to the postcava, and the supensory ligament to the diaphragm.

The superficial lymphatics of the convex surface extend in four directions, according to their position. Most of those near the caudal or inferior border penetrate the surface and join the deep lymphatics. In the right cephalic (superior) part, they wind round the border and join the nodes at the head of the pancreas, (*Lgl. pancreatico-lineales*), or extend to the nodes (*Lgl. mediastinales anteriores diaphragmaticæ*) around the postcava as it enters the thorax. On both sides of the suspensory ligament the trunks collect in great numbers, and extend between the folds of the suspensory ligament to the diaphragm, which they penetrate, and enter two or three nodes (*Lgl. sternales; diaphragmaticæ mediales*) whose efferents join the sternal plexus (14 of Fig. 3872 and 13 of Fig. 3873). Still farther to the left, a group passes round to the postcava as it enters the thorax on the right, still others penetrate the triangular ligament and enter the nodes around the esophagus. Many of the apparently superficial lymphatics of this lobe penetrate the substance of the liver and join the deep lymphatics as with the right lobe. In fact, in most animals this is the normal condition, and a true superficial set of lymphatics is not present. On the concave surface of the liver, many of the surface lymphatics penetrate the liver substance and join the deep lymphatics, but the greater number join the nodes in the hilus (*Lgl. hepaticæ*) and thus mingle with the deep lymphatics

(Fig. 3869) while some attain the aortic (celiac) nodes. The deep lymphatics, according to Sappey, are divided into two distinct, although anastomosing sets, one set following the portal vessels and bile-ducts, the other the hepatic vessels. Those following the hepatic vessels enter the thorax, traversing some nodes on the postcava, and mingling with the superficial lymphatics, follow the pillars of the diaphragm to join the thoracic duct. The lymphatics following the portal veins reach the hilus of the liver, and traverse one or more of the nodes there situated (Fig. 3869). From these arteries frequently gives them their best characterization. Although there are no sharply defined limits and grouping of the two hundred to four hundred nodes in this part of the body, groups have been made as in the neck for convenience. Following Bartels, the nodes of the peritoneal cavity may be divided into (*A*) *pelvic* and (*B*) *abdominal;* and again into (I) *visceral* and (II) *parietal*, the latter being retroperitoneal, beneath parietal peritoneum and grouped about the aorta and its larger branches, the former related to the viscera and covered with visceral peri-

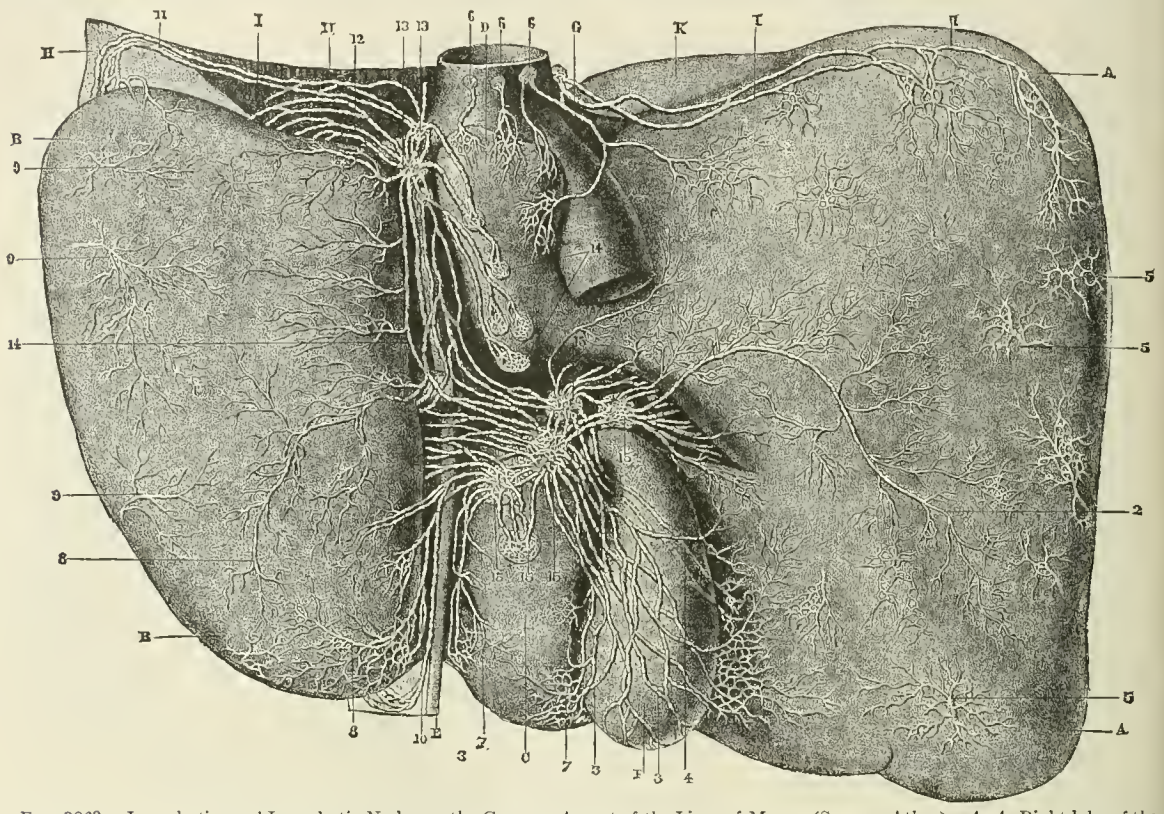


Fig. 3869.—Lymphatics and Lymphatic Nodes on the Concave Aspect of the Liver of Man. (Sappey, Atlas.) *A*, *A*, Right lobe of the liver; *B*, *B*, left lobe; *C*, quadrate lobe; *D*, Spigelian lobe; *E*, round ligament or remnant of umbilical vein; *F*, cholecyst or gall-bladder; *G* postcava receiving the hepatic veins just as it traverses the diaphragm; *H*, left triangular ligament of the liver; *I*, diaphragm; *K*, the most projecting part of the convex surface of the liver. 1, 1, Two trunks near the cephalic edge of the right lobe extending to the node on the postcava just within the thorax; 2, single trunk from the middle of the right lobe to the lymphatic nodes in the hilus of the liver by the neck of the cholecyst; 3, 3, trunks upon and at the border of the cholecyst to the nodes in the hilus; 4, two vessels having the same origin and termination, but covered by the cholecyst; their course is indicated by the dotted lines; 5, 5, trunks arising on the surface of the right lobe, but penetrating the substance of the liver to accompany the deep vessels; all the vessels from the surface take this course in most animals; 6, 6, 6, trunks from the Spigelian lobe, and the nodes around the postcava receiving them; 7, 7, vessels belonging to the quadrate lobe; 8, 8, principal trunks of the left lobe; 9, 9, vessels arising on the surface, but soon entering the liver to join the deep lymphatics like 5 of the right lobe; 10, trunks from the convex surface of the liver following the round ligament and finally entering the nodes at the hilus; 11, 11, 12, several trunks from the convex surface of the left lobe, winding over to the concave surface and entering nodes in the fissure of the ductus venosus; 13, 13, lymphatic nodes in the fissure of the ductus venosus, their efferent vessels extend to the nodes in the hilus; 14, nodes corresponding to the terminal end of the esophagus; 15, 15, lymphatic nodes receiving the lymphatics from most of the concave surface of the liver and the deep lymphatics following the portal vein.

nodes in the hilus, branches extend to the nodes in the lesser curvature of the stomach (superior gastric nodes; particularly the cardiac nodes), and to those on the splenic vessels; but finally all pass to the aortic (celiac) nodes, and then some branches may enter the cisterna chyli independently, but most of them join the intestinal trunk.

Lymphatic Nodes, Plexuses, and Trunks of the Abdominal and Pelvic Cavities.—The nodes in the abdominal and pelvic cavities form a continuous network from the inguinal nodes to those in the esophageal opening; they also extend out on the great vessels of the viscera; in fact, their grouping about the larger

toneum. The lymphatic nodes of the peritoneal cavity may thus be grouped as (*A*), parietal series, including (1) sacral, (2) hypogastric, (3) iliac, (4) aortic; and (*B*), visceral series, including (5) anorectal, (6) parauterine, (7) vesical, (8) hemorrhoidal, (9) mesocolic, (10) mesenteric, (11) gastric, (12) hepatic, and (13) pancreatico-splenic. In general, the lymph from visceral nodes passes through some parietal node before entering the thoracic duct, the mesenteric nodes being a partial exception. As the efferent vessels of all these groups unite to form the *cisterna chyli* and thoracic duct by three main trunks, these also have received names: (1, 2) The two lumbar trunks (a *truncus lymphaticus lumbalis* of each side)

EXPLANATION OF
PLATE XLIV.

EXPLANATION OF PLATE XLIV.

Which represents the arteries, veins, and lymphatics of the different layers of the stomach, and the lymphatics of the layers of the small intestine of the dog. (From Franklin P. Mall.)

Fig. 1.—"Reconstruction of a Small Portion of the Middle Zone of the Stomach. The long diameter of the drawing is in the direction of the longitudinal muscle fibers. It was built up from thirty-six drawings, and each drawing is an exact representation of a specimen." Enlarged about 10 times. (*a*) Mucosa; (*b*) muscularis mucosæ; (*c*) submucosa; (*d*) circular muscular layer; (*e*) longitudinal muscular layer. Arteries, red; veins, blue; lymphatics, brown.

As shown in the drawing the arteries and veins form a coarse network in about the middle of the thickness of the submucosa, and from this meshwork branches pass directly through the circular muscular layer on one side and through the muscularis mucosæ on the other. Between the muscular layers another meshwork of vessels is formed, but after passing through the muscularis mucosæ the arteries in the dog extend directly into the mucosa and break up into capillaries between and around the glands. In the cat a network of arteries is formed after traversing the muscularis mucosæ, and from this network twigs pass into the mucosa and break up into capillaries.

The veins form a meshwork near the free surface of the mucosa. From this first meshwork branches pass down to the muscularis mucosæ and there form a somewhat coarser network at the base of the gastric glands. From this mucosal network the vessels penetrate the muscularis mucosæ and accompany the arteries.

The lymphatics begin by blind, branched, finger-like vessels between the gastric glands. These finger-like beginnings unite and form a meshwork between mucosa and muscularis mucosæ.

Another meshwork is formed on the opposite side of the muscularis mucosæ and from that point a coarse network is formed in the submucosa and between the muscular layers. Valves appear in the lymphatics as they penetrate the muscularis mucosæ. The vessels penetrate the walls of the stomach and pass to lymphatic glands along the greater or lesser curvature as shown in Plate XLVI.

Fig. 2.—Segment of the Small Intestine of a Dog to Show the General Distribution of the Lymphatic Vessels. Mucosa and villi, white; muscularis mucosæ, blue-green; submucosa, pink; circular muscular layer, orange; longitudinal muscular layer, yellow; lymphatic vessels, blue. (*Fl*) Lymph follicles in the mucosa (cf. Fig. 3); (*M.L.*) mucosal lymphatic network; (*S.M.L.*) submucosal lymphatic network; (*J.Msl–L*) intermuscular lymphatic network. The efferent lymph vessels from the submucosal and intermuscular networks are shown below at the mesenteric edge of the intestine. From this point they pass to the lymphatic glands (cf. Figs. 3868, 3879–3884).

Some of the villi are represented with the club-shaped central lacteal or lymphatic. It will be noticed also that at the base of the villi there is a lymphatic network, and that in passing from one layer to another of the intestines the vessels pursue a nearly straight course (cf. Fig. 3). The passage through the muscularis mucosæ is indicated by blue dots, thus giving it a sieve or punctate appearance.

Fig. 3.—Section of the Small Intestine of a Dog to Show the Arrangement of the Lymphatics in the Villi and in the Different Layers. Lymphatics, blue; villi, two crypts of Lieberkühn, muscularis mucosæ, a lymph follicle, and the longitudinal muscular layer, pink; mucosa and circular muscular layer, white; submucosa and one lymph follicle, gray. One of the villi is shown in an uncontracted condition. The others were strongly retracted by the use of ten-per-cent. nitric acid.

In this figure is well shown the club-shaped central lacteal or lymphatic with a slender, spiral projection extending nearly to the end of the villus. In the second villus from the left two central lacteals are shown.

From the network at the base of the villi the vessels extend directly to the mucosal network (Fig. 2, *M.L.*). From this point on they possess valves. Surrounding the lymph follicles is a dense lymph network. The figure shows also that the muscularis mucosæ is not present over the lymph follicles.

FIG. 1

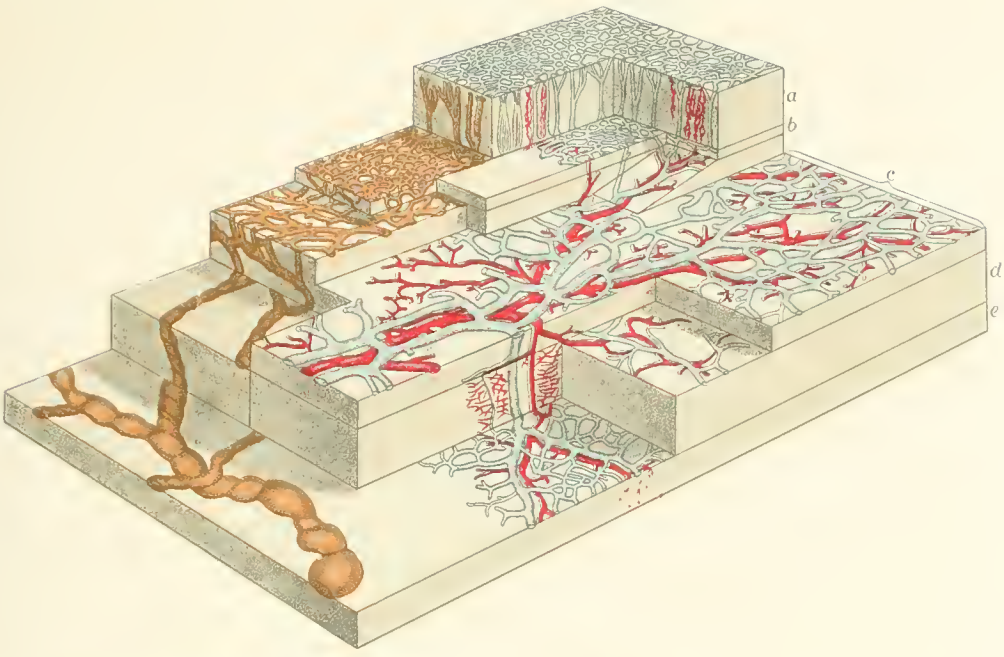


FIG. 2

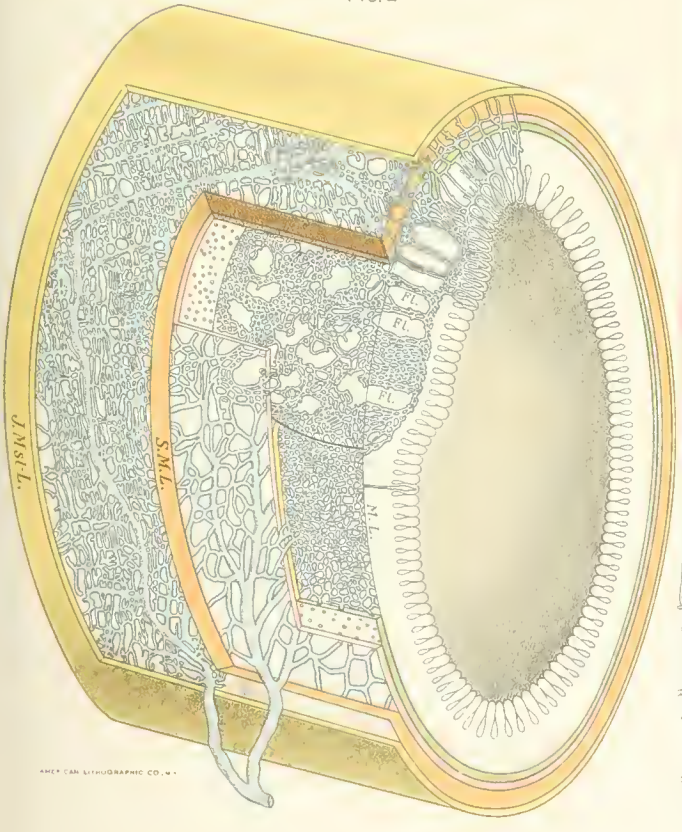


FIG. 3

Blood Vessels and Lymphatics of the Dog's Stomach
and Lymphatics of the Dog's small Intestine.
(FROM FRANKLIN P. MALL.)

from the iliac, hypogastric, sacral, and aortic plexuses, and (3) a single trunk (*truncus lymphaticus intestinalis*) from the mesenteric and mesocolic nodes. As was remarked in discussing the cervical nodes, different authors may assign a collecting trunk from an organ to different groups of nodes, although the same node is meant. The division into groups is more or less artificial, since the nodes vary considerably in different individuals in position and in number. Confusion is not easily avoided.

1. Sacral Nodes and Plexus (*lymphoglandulæ sacrales; glandulæ lymphaticæ sacrales; plexus lymphaticus sacralis*). This group of nodes is between the folds of the mesorectum next the sacrum. The afferent vessels come from a part of the pelvic wall, from the vertebral canal, and from the rectum. Like the other pelvic plexuses it is connected with all the others, particularly the hypogastric, but its efferent trunks pass to the aortic (lumbar) plexus of nodes.

2. Hypogastric Nodes and Plexus (*lymphoglandulæ hypogastricæ glandulæ lymphaticæ hypogastricæ, s. iliacæ internæ, s. pelvinæ; plexus hypogastricus, s. iliacus internus, s. pelvinus*). These are on the sides of the pelvis, around the hypogastric and internal iliac blood-vessels. The afferent lymphatics are from the gluteal, sciatic, and obturator vessels, part of the spermiduct, the prostate, urocyst, most of the vagina, the uterine mucosa, and neck of the uterus. According to some authors, the deep lymphatics of the external genitalia in both sexes pass to these nodes. Sometimes also part of the inguinal efferents pass to this group. This plexus is closely connected with the iliac and sacral, but its principal efferent trunks pass to the aortic or lumbar plexus (Fig. 3867).

3. The Iliac Lymphatic Nodes and Plexus (*lymphoglandulæ iliacæ; glandulæ iliacæ; plexus lymphaticus iliacus, s. iliacus externus, s. anterior*) form a chain along the external and common iliac blood-vessels. At the crural ring this plexus is continuous with the inguinal plexus (Fig. 3867). The afferent vessels are from the inguinal (and subinguinal) plexus, those accompanying the internal epigastric and circumflex iliac blood-vessels, those from the penis and clitoris, bladder, and vagina; to a certain extent, those from the vesiculæ seminales and the body of the uterus (those from the last two sources are often said to extend to the hypogastric plexus). This plexus is connected with the hypogastric and sacral by several communicating branches, but the main efferent trunks pass to the aortic (lumbar) plexus (Fig. 3867). They are frequently subdivided into the superior (common iliac) and inferior (external iliac) groups of iliac nodes.

4. The Aortic or Lumbar Nodes and Plexus (*lymphoglandulæ aorticæ; lymphoglandulæ lumbales et celiacæ; glandulæ lymphaticæ lumbales, s. lumbares; plexus lymphaticus lumbalis*). The aortic plexus includes the lumbar and celiac plexuses of most authors. The nodes form three irregular rows, one mesal and two lateral, extending along the aorta from the bifurcation to the origin of the superior mesenteric artery. (Fig. 3867). For more detailed description they may be subdivided as preaortic, para-aortic, and retroaortic. The afferent vessels are the efferent trunks from the iliac, hypogastric, and sacral plexuses, lymphatics accompanying the iliolumbar and part of the lumbar blood-vessels, those from the testis, spermiduct in part, ovary, summit of uterus, Fallopian tubes, kidney, adrenal, and most of the colon descendens. It is also the recipient of afferents from the stomach, pancreas, liver, duodenum and spleen, as well as from the lower portion of the esophagus and the diaphragm. These reach its nodes mostly by way of the lymphatic nodes associated with those organs. It is this portion situated in front of the aorta about the origins of the celiac and superior mesenteric arteries, that is usually distinguished as the celiac plexus. Its efferent vessels unite to form two principal trunks, a right and left lumbar lymphatic trunk (*truncus lymphaticus lumbalis*), which with the intestinal trunk form the *cisterna chyli*, the enlarged beginning of the thoracic duct. Some efferents from upper (celiac) nodes join the intestinal trunk.

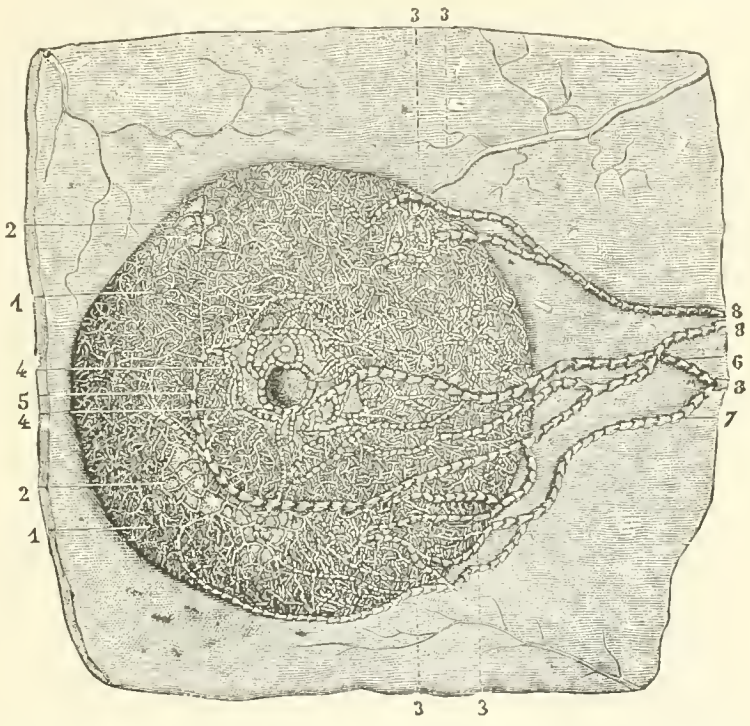


Fig. 3870.—Left Mammary Gland of a Woman during Lactation. The skin and adipose tissue have been removed to bring the lymphatics plainly into view. At three of the corners of the figure blood-vessels are represented. (Sappey, Atlas and Anat.) 1, 1, Network of lymphatics so dense that they make almost a continuous layer. The entire gland is filled throughout in this way; 2, 2, truncules surrounding the lobules, the finer network being omitted; 3, 3, 3, large trunks at the border of the gland; 4, 4, network of large vessels around the nipple; they originate in the depth of the mamma; 5, 5, great trunk arising at the mesal side of the nipple, and extending across the gland and pectoral region to the axillary lymphatic nodes; 6, large trunk from the lateral aspect of the nipple extending directly toward the axilla; 7, large trunk from the caudal (inferior) border of the mamma, and uniting with the preceding on its way to the axilla; 8, 8, the two great trunks from the mammary gland going to terminate in the axillary lymphatic nodes.

5, 6, 7. The anorectal, parauterine and vesical nodes are small pelvic nodes in the course of the lymphatics particularly from those organs—rectum, uterus, bladder. Their efferents mainly pass to the hypogastric nodes, although there is close association with the hemorrhoidal and sacral nodes.

8. Hemorrhoidal Nodes (*lymphoglandulæ hemorrhoidales*). Located along the course of the hemorrhoidal vessels, they are intermediate between the

parietal and visceral pelvic groups; closely associated with the sacral nodes, under which they are sometimes included, and connected with the hypogastric nodes. Their efferents pass to the lower mesocolic nodes and superior iliac nodes, and possibly to the sacral and hypogastric nodes as well (Fig. 3867).

of the mesentery. The afferent vessels are from the small intestine, except part of the duodenum, and the large intestine to the sigmoid flexure. The efferents of the mesocolic nodes pass to the mesenteric nodes whose efferent vessels receive some of the efferents from the upper aortic (celiac) nodes, and then ter-

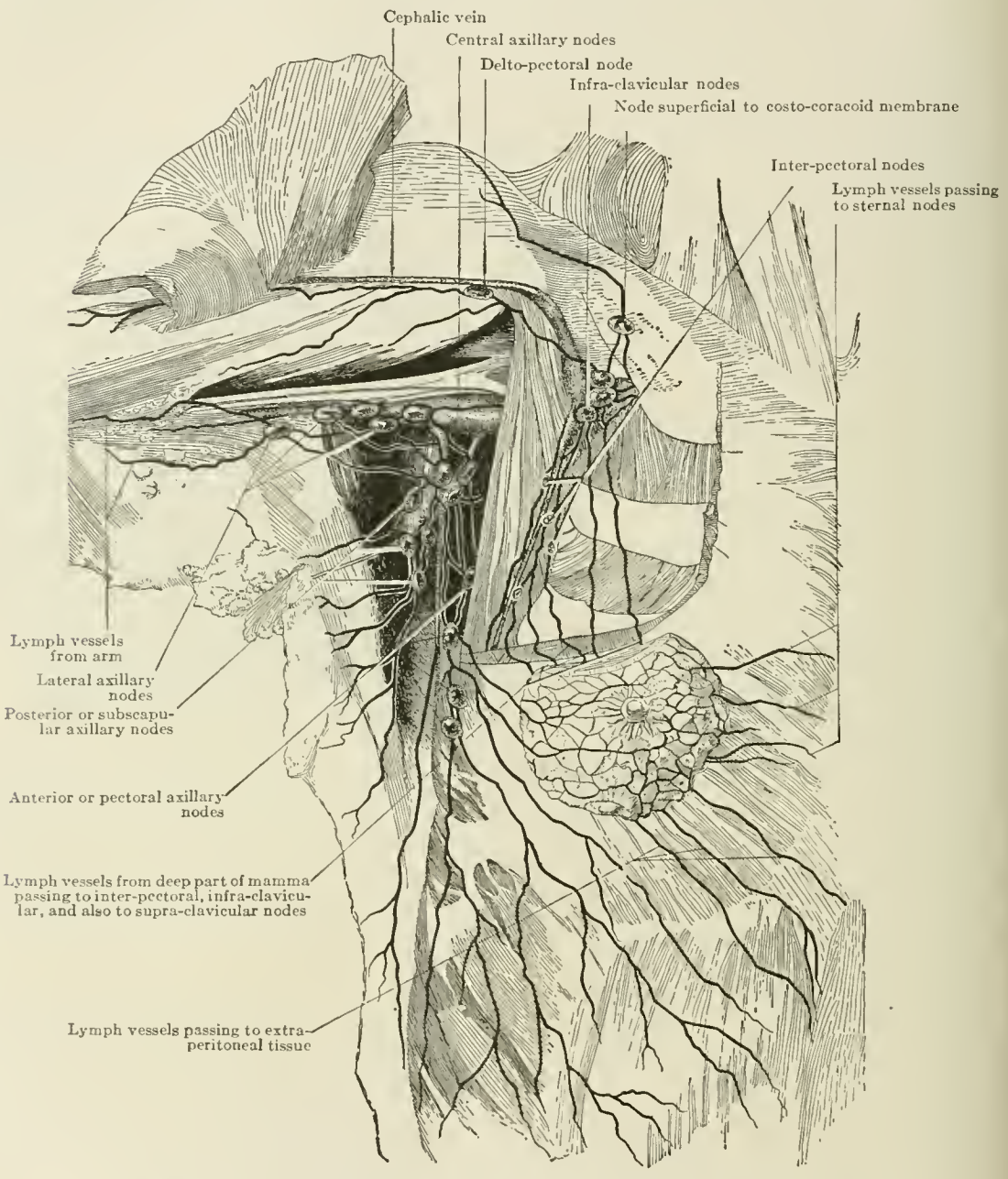


Fig. 3871.—Dissection of Axilla and Anterior Part of Thoracic Wall, showing Lymph Nodes and Vessels. (Semi-diagrammatic.) Redrawn from Cunningham, Text-book of Anatomy, Fig. 806.)

9, 10. Mesocolic Nodes; Mesenteric Nodes and Plexus (*lymphoglandulæ mesocolicæ; Lgl. mesentericæ; glandulæ mesentericæ, s. mesaraicæ; plexus lymphaticus mesentericus, s. mesaraicus*). These nodes and their plexus (100 to 200) lie along the blood-vessels between the folds of the mesentery and the mesocolon. They are usually in three irregular tiers, one tier being near the intestine, one near the middle, and one near the root

minate in the cisterna chyli as the intestinal trunk (*truncus lymphaticus intestinalis*).

11, 12, 13. Gastric, Hepatic, Pancreatico-splenic Nodes (*lymphoglandulæ gastricæ, hepaticæ, pancreaticolienalis*). These visceral nodes have been referred to in considering the lymphatics of the organs in question. Their afferents come from the stomach (part), liver (part) duodenum (part), and spleen; in

part also from the diaphragm and esophagus. Their efferents pass mainly to the superior aortic (celiac) nodes.

As will be seen by a glance at Figs. 3879–3884, the lymphatics and the nodes in the abdominal cavity of the dog, cat, and rabbit are essentially as in man, but there is a great concentration of the nodes, so that the groups are well defined. No sacral nodes were certainly found in any of them.*

Lymphatics of the Thorax.—The thoracic lymphatics are divisible into three fairly distinct, although communicating, groups: (1) Those of the skin and other surface structures; (2) the deep lymphatics of the thoracic walls, including the diaphragm; (3) the lymphatics of the thoracic viscera—heart, lungs, trachea, and esophagus.

The superficial lymphatics, like those of the abdomen, are quite sharply divided into those of the right and those of the left side, although on both the mid-dorsal and midventral lines the vessels interdigitate.

The beginning of many of the subcutaneous trunks of the thorax is likewise from an oblique zone surrounding the body at about the level of the umbilicus (Fig. 3865), and there is a somewhat similar, although less clearly defined, limiting zone between the neck and thorax. The collecting trunks extend in the most direct manner to the axillary lymphatic nodes (Fig. 3865). Part of those, however, in the subclavicular and adjoining pectoral regions pass to the supraclavicular nodes. This is supposed to explain the involvement of these nodes in some cases of cancer of the breast.[1] (See below.)

Belonging to this superficial group are the lymphatics from the mammary gland (Figs. 3870, 3871). In the male they are but little more developed than the surrounding integument; but in the female, especially apparently in preparation for and during lactation, they are present in enormous numbers, and their size is also greatly increased. Those of the mammary integument are especially numerous in the areola, but it is in the glandular substance itself that they reach their highest development. From the substance of the gland the deep lymphatics reach the surface and the subcutaneous network by following the ducts. From the subareolar network they extend as four principal trunks toward the axilla, but most often unite to form two large trunks before entering the pectoral group of the axillary nodes (Fig. 3870). Small (paramammillary) nodes sometimes occur in course. In addition, it is clear that, frequently at least, lymphatics penetrate the chest wall and enter the sternal nodes; while other, deep, intramuscular vessels pass through the M. pectoralis major to reach the interpectoral nodes or infraclavicular nodes of the axillary group (Fig. 3871). Since the various members of the axillary group are closely connected with each other and with the supraclavicular nodes, the lymphatic connections of the mammary gland are quite extensive. Furthermore, it should be remembered that communication through the subcutaneous lymphatic network exists across

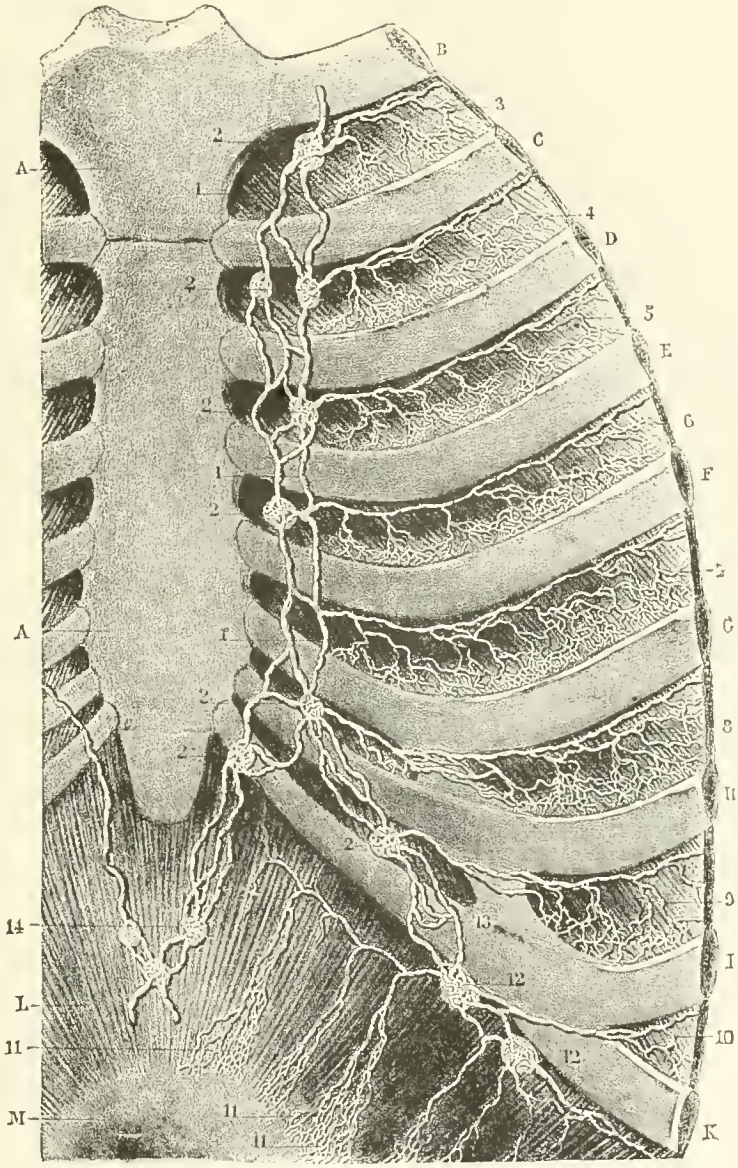


Fig. 3872.—The Internal or Pleural Aspect of the Sternum, Parts of the Ribs and the Diaphragm, to show the Sternal Plexus. (Sappey, Atlas.) *A*, *A*, Sternum; *B* to *K*, the first nine ribs; *L*, *M*, the ventral part of the diaphragm, part of the central tendon being shown at *M*; 1, 1, 1, 1, 2, 2, 2, the sternal plexus of lymphatic nodes and the connecting vessels; 3 to 10, lymphatic network and trunks in the intercostal spaces. The trunks extend along the caudal margin of the ribs to reach the sternal nodes. These trunks are directly continuous dorsad with the intercostal plexus (cf. Fig. 3878); 11, 11, vessels on the pleural surface of the diaphragm, finally extending to the sternal nodes; 12, 12, 13, sternal nodes opposite the eighth and ninth ribs and their efferent trunks; 14, nodes receiving the lymphatics from the suspensory ligament of the liver.

*Sappey describes and figures in his Atlas[1] (Plate XLVIII, Fig. iii.) the lumbar trunks in the rabbit and the trunks from the ovary entering them without traversing any nodes. He says further concerning the lumbar trunks, in describing the figure: "Gros troncs lymphatiques provenant des membres postérieurs et du bassin; ils se rendent directement dans l'origine du canal thoracique sans avoir traversé dans leur trajet aucun ganglion [lymphatique]." Such a condition was never observed by the writer in any of the white rabbits dissected.

the middle line with the opposite side. There is also the possibility of connection with the abdominal lymphatics through the superior epigastric lymphatic node, or more deeply.

Besides the lymphatics from the mammary glands, many of those from the superficial muscles pass to the axillary nodes. These trunks pass along the great pectoral muscles and the vasa thoracica longa, and usually traverse a few small nodes (pectoral nodes) in their course.

The lymphatics of the diaphragm were discovered by Rudbeck, and fully described by Nuck. They are among the most easily demonstrated of any in the body, and from the thinness of the diaphragm and the

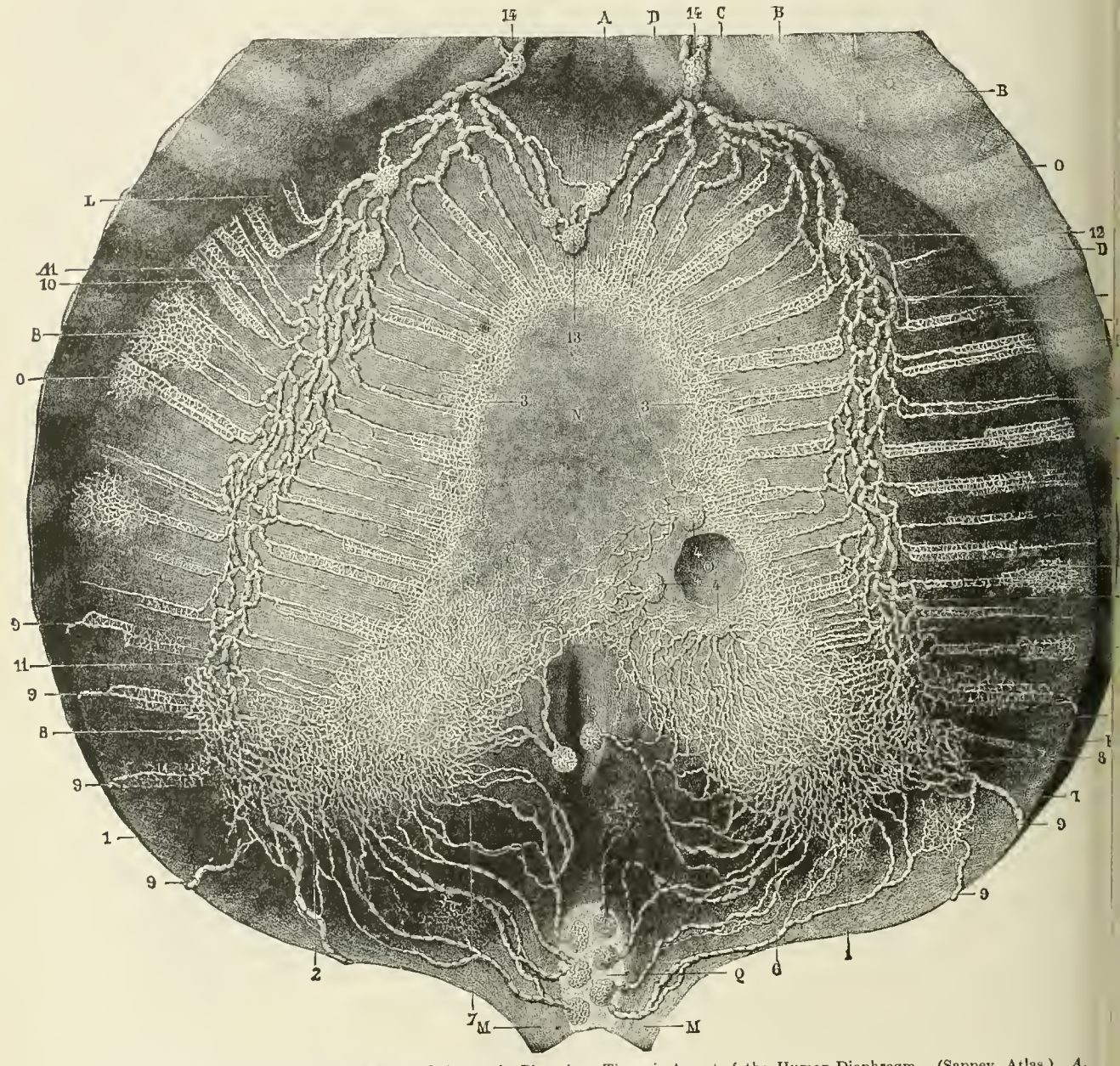


Fig. 3873.—The Lymphatic Vessels and Nodes on the Pleural or Thoracic Aspect of the Human Diaphragm. (Sappey, Atlas.) *A*, Xiphisternum; *B*, *C*, *D*, *E*, *F*, *G*, *H*, *K*, 5, 6, 7, 8, 9, 10, 11, and 12, ribs; *L*, *L*, muscular part of the diaphragm next the ribs; *M*, *M*, pillars of the diaphragm; *N*, the three parts of the central tendon of the diaphragm; *O*, passage for the postcava; *P*, esophageal orifice; *Q*, hiatus aorticus between the two pillars of the diaphragm. The nodes in the opening are in the abdomen and belong to the celiac lymphatic plexus. 1 and 2, The network in the right and left dorsal points of the central tendon; 3, 3, network around the border of the ventral or mesal part of the central tendon; 4, 4, 4, nodes around the postcaval opening for the reception of part of the lymphatics of the Central tendon; 5, 5, two nodes at the esophageal opening, they receive the neighboring lymphatics; 6, 7, trunks coming from the dorsal part of the central tendon along the pillars of the diaphragm to enter the nodes in the aortic opening at (*Q*); 8, 8, 8, fine lymphatic network of the muscular part of the diaphragm; 9, 9, 9, 9, lymphatic trunks winding around the edge of the diaphragm to enter the cœliac lymphatic nodes; 10 and 11, truncules and trunks extending toward the sternal plexus; 12, lymphatic node on the diaphragm near its ventral attachment opposite the seventh rib; it is double on the left side; 13, three lymphatic nodes ventrad of the pericardium, and usually buried in fat. To them extend the lymphatics from the suspensory ligament of the liver; 14, 14, nodes of the sternal plexus receiving the efferent vessels from 12 and 13 (cf. Fig. 3872.)

clearness with which the lymphatics may be followed, this organ is a favorite object for study. The lymphatics extend from the peritoneal to the pleural surface, hence it is upon the thoracic face that the great trunks are found (Fig. 3873). These are arranged into three paired and one azygos group. The lymphatic trunks of the diaphragm practically surround the whole organ and the openings through it. From the ventral group, occupying somewhat more than the ventral half, the trunks extend toward the sternum, traverse a node about opposite the seventh rib, and then extend to the sternal plexus, those of the right going to the right lymphatic trunk, and those of the left going to the thoracic duct. The azygos group appears opposite the xiphisternum, and is represented by three nodes (supraxiphoid of Sappey, inferior-anterior mediastinal of authors), and their efferent trunks. These are not properly diaphragmatic lymphatics, for they come from the surface of the liver and suspensory ligament (see Liver). The efferent trunks join the sternal plexus.

From the dorsal part of the diaphragm the trunks converge to the aortic or esophageal opening (dorsal group), and enter the nodes there situated. Other trunks wind round the pillars of the diaphragm and enter the abdomen. As part of the nodes in the aortic, and also in the esophageal opening, are in the abdomen, it follows that part of the lymphatics starting on the peritoneal or abdominal side of the diaphragm extend to the pleural or thoracic side, and then turn back through these trunks into the abdomen before finally terminating in the thoracic duct.

The deep structures of the thoracic walls are drained by lymphatics following the intercostal spaces. As will be seen by consulting Figs. 3872 and 3878, the collecting trunks form a half circle, the vessels extending both toward the sternal and toward the intercostal plexus. In their course along the intercostal spaces they usually traverse one or more nodes. Near the spinal column is a row of nodes whose efferent trunks may extend directly to the thoracic duct, but usually two or three of them unite to form a common trunk, which opens into the thoracic duct. It is a remarkable fact that those from the last three intercostal spaces unite to form trunks on each side, which extend through the diaphragm into the abdomen to join the cisterna chyli, instead of entering the thoracic duct in the thorax (cf. Fig. 3878, where vessels pass from the abdomen to the thorax).

From the first few intercostal spaces the collecting trunks on the right side pass to the right lymphatic trunk; and from the sternal half of all of the spaces the collecting trunks join the sternal plexus, those on the right usually extending therefrom to the right lymphatic trunk, and those on the left to the thoracic duct. This offers a very striking illustration of the close connection between the right and left lymphatic trunks in man, a condition much more fully realized in many of the lower animals. The lymphatics of the spinal canal and the muscles of the back follow their blood-vessels and enter the intercostal plexus, the greater number finally reaching the thoracic duct.

Esophagus.—The lymphatics of the esophagus are in two sets, as in the rest of the alimentary canal, viz., those of the muscularis and those of the mucosa; they penetrate the muscular wall and enter the small nodes scattered along its course. The lymphatics are directly continuous with those of the pharynx at one end and with those of the stomach at the other. At the gastric end the collecting trunks, after reaching the surface, extend toward the stomach, and part of them traverse the esophageal opening and enter the nodes around the cardia of the stomach (Plate XLVI). Those of the middle region enter the dorsal (posterior) mediastinal nodes, while those in the neck join the internal jugular plexus. The lymphatics of the muscularis have been demonstrated only recently in man, by Sakata.[19]

Heart.—The cardiac lymphatics are in two groups—a subpericardial and a subendocardial network—but in both cases they are derived from the muscular substance, and not from the serosa. Within the musculature (myocardium) a coarse lymphatic network exists. The superficial or subpericardial network commences with the apex of the heart and extends over the whole surface, but the larger trunks occupy the dorsal and ventral grooves or depressions containing the large cardiac blood-vessels. The deep or subendocardial vessels unite into collecting trunks which penetrate the myocardium near the apex and near the auriculoventricular groove, and anastomose with the superficial lymphatics, and all together extend to the groove between the auricles and ventricles, and form an anastomosing circle around the base of the ventricles. The rather few lymphatics of the auricles mostly extend toward the auriculoventricular groove and join the anastomosing ring, but some extend directly to the main trunks along the two sides of the pulmonary artery. From the anastomosing ring in the auriculoventricular groove two trunks

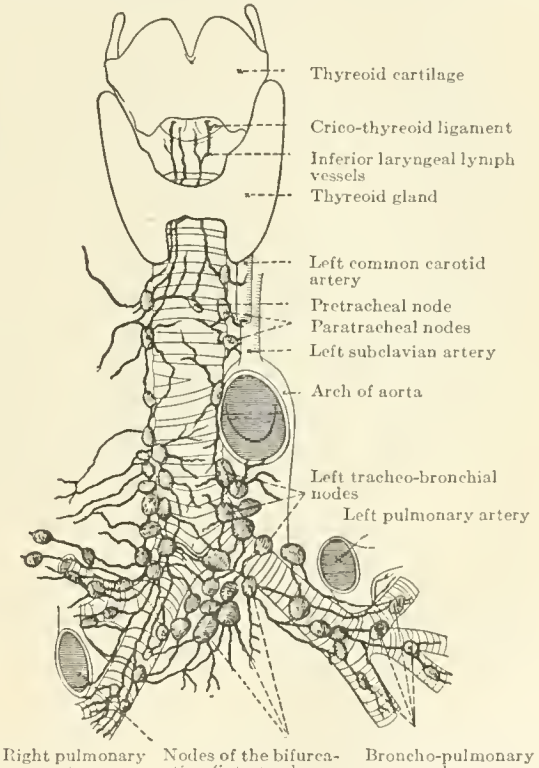


Fig. 3874.—The Nodes in Relation to the Trachea and the Main Bronchi. (From Cunningham, Text-book of Anatomy.)

arise, the one representing the left heart extends along the left side of the pulmonary artery, and between it and the left auricle to the anterior mediastinal nodes, and probably finally to the thoracic duct. The trunk representing the right heart follows the right side of the pulmonary artery, and passes between this vessel and the arch of the aorta to reach anterior mediastinal nodes, ultimately to terminate probably in the right common lymphatic trunk. It is stated by some that the drainage from the heart is to left and right bronchial nodes respectively.

Lungs.—The lymphatics of the lungs are exceedingly numerous. They arise in the lung substance between the alveoli, and in the bronchial mucosa. Those near

the surface (Fig. 3875) extend toward the periphery and become subserous, and then extend to the root of the lung to enter the bronchial nodes (Fig. 3874). The deep lymphatics follow the bronchi and finally, after traversing a few small nodes on the bronchi (the so-called pulmonary lymphatic nodes), they enter the bronchial nodes. From these nodes extend trunks to the left to enter the thoracic duct, and to the right to enter the right common lymphatic trunk.

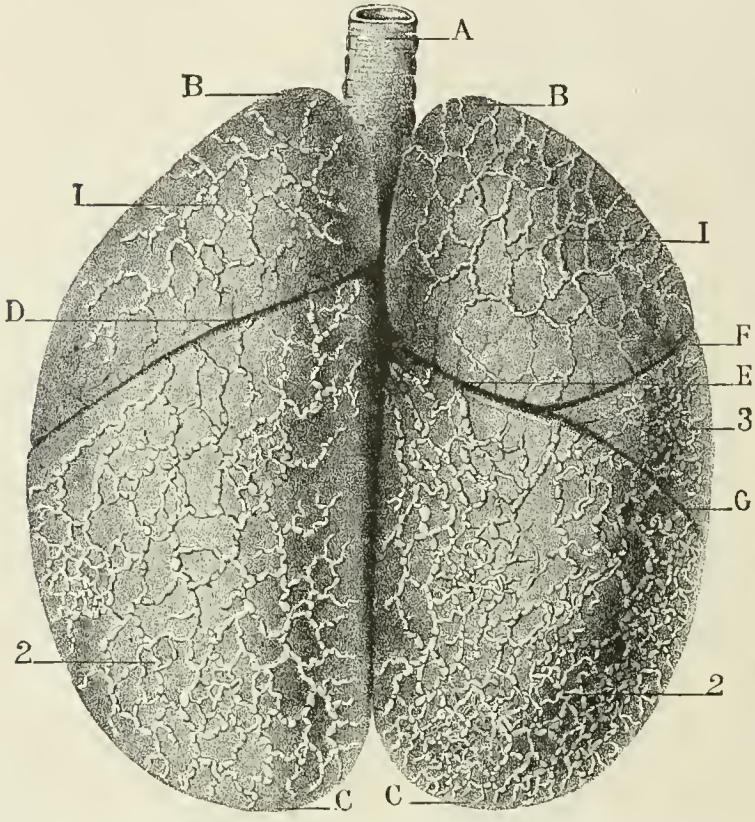


Fig. 3875.—Superficial or Subserous Lymphatics of the Dorsal Surface of the Lungs of a Child at Birth. (Sappey, Atlas.) *A*, Trachea—the line points to the membranous portion; *B*, *B*, summit of cephalic lobes of the two lungs; *D*, the fissure dividing the left lung into two lobes; *E*, *F*, *G*, fissures dividing the right lung into three lobes. 1, Lymphatic network on the cephalic lobe; 2, 2, network on the caudal lobe; network on the middle lobe of the right lung. The fine network surrounding and covering the pulmonary lobules is not shown in this figure.

Trachea and Bronchi.—As seen above, the epiglottis and entire laryngeal opening possess a very large number of lymphatics (Plate XLV) which appear to be more numerous in the infant than in the adult. In the smaller bronchi the lymphatic network is abundant. The vessels arise in the mucosa and the intercartilaginous tissue, penetrate the tracheal wall, and are distributed to the nodes so abundant along the trachea and bronchi (Fig. 3874).

Thoracic Lymphatic Nodes.—The lymphatic nodes of the thorax are only second in importance and number to those in the abdomen. Within the thorax they form a continuous network, and are closely connected with those of the abdomen on the one hand, and with those of the neck on the other. Those without the cavity are continuous with the axillary nodes.

The pectoral nodes (*glandulæ lymphaticæ pectorales, s. thoracicæ superficiales*) are situated along the caudal (inferior) border of the great pectoral muscle, and some more deeply along the vasa thoracica longa. Through them pass many of the trunks following the long thoracic blood-vessels, and many of those from the thoracic region on their way to the axillary lymphatic nodes, under which group they have been here included. They are frequently considered as a separate group (Fig. 3871).

Within the thorax there are several named groups with corresponding plexuses. The sternal nodes and plexus (*lymphoglandulæ sternales; glandulæ lymphaticæ sternales, s. substernales, s. thoracicæ profundæ, s. mammariæ, s. presternales; plexus lymphaticus sternalis, s. mammarius internus*) commence opposite the xiphisternum and extend along the thorax on each side of the sternum in company with the sternal blood-vessels (Fig. 3872). The afferent vessels of this plexus come from the deep abdominal muscles in the supraumbilical region of the abdomen, the ventral two-thirds of the diaphragm, part of the convex surface of the liver through the supraxyphoid nodes (*lgl. sternales diaphragmaticæ*), the structures in the intercostal spaces in the ventral part of the body. The afferent vessels appear sometimes to join the anterior mediastinal nodes, and with their trunks pass to the two great common lymph trunks. Sometimes one or more, or all, of the trunks pass directly to the great lymph trunks without traversing the mediastinal nodes.

The intercostal nodes and plexus (*lymphoglandulæ intercostales; glandulæ lymphaticæ intercostales; plexus lymphaticus intercostalis*) are found on each side of the thorax, in the intercostal spaces, and along the vertebral column roughly in two series (lateral and medial). The afferent vessels are from the intercostal structures, possibly the spinal canal, and the deep muscles of the back. The efferent trunks pass mostly to the thoracic duct, but part of those on the right may pass to the right lymphatic trunk (Fig. 3878).

The posterior mediastinal nodes and plexus (*lymphoglandulæ mediastinales posteriores; glandulæ lymphaticæ mediastinales dorsales, s. posteriores; plexus lymphaticus mediastinalis dorsalis, s. posterior*) are situated along the thoracic aorta and the esophagus, in the dorsal or posterior mediastinal folds. The afferent vessels are from the esophagus, the dorsal third of the diaphragm, and some from the liver. The efferent vessels enter the thoracic duct, directly, or join the bronchial nodes.

The anterior mediastinal nodes and plexus (*lymphoglandulæ mediastinales anteriores; glandulæ lymphaticæ mediastinales ventrales, s. anteriores, s. gl. l. cardiacæ; plexus lymphaticus mediastinalis ventralis, s. anterior*) are in the ventral mediastinal fold, and are principally concentrated around the arch of the aorta and the roots of the great blood-vessels. The nodes called supraxiphoid by Sappey (14 of Fig. 3872) are frequently assigned to this group. The afferent vessels are from the sternal plexus, and though this many vessels from the convex surface of the liver; the lymphatics of the thymus, and, according to some authors, the lymphatics of the heart. The efferent vessels either go to the bronchial nodes or join the vessels from these, and extend from the right half to the right lymphatic trunk, and from the left half to the thoracic duct.

The bronchial nodes and plexus (*lymphoglandulæ*

bronchiales; glandulæ lymphaticæ bronchiales; plexus lymphaticus bronchalis) are situated in the bifurcation of the trachea (Fig. 3874) and extend upon the trachea (where they are called tracheal lymphatic nodes) to the internal jugular plexus, and others extend out along the bronchi into the lungs (pulmonary lymphatic nodes). Nodes intermediate in position are termed bronchopulmonary nodes. In childhood and youth they are pink, but with advancing age they become dark and even black, if the individual has inhaled a

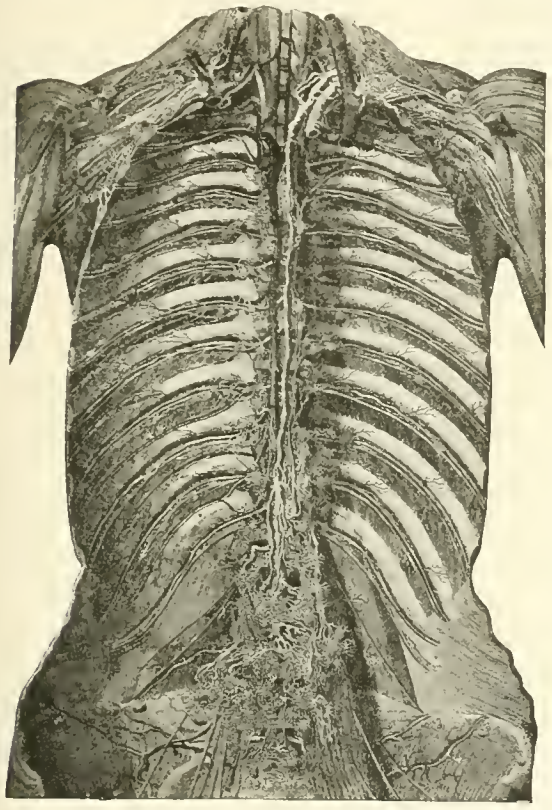


Fig. 3876.—The Thoracic Duct with its Main Confluents, and Associated Lymphatic Nodes, showing its General Position and Relations. Everything had been removed from the thorax and abdomen save the thoracic duct, azygous veins and certain tributaries. The cut veins (right and left innominate veins) and arteries (aorta, and right subclavian arteries) are shown in the upper thorax. The openings of the thoracic duct and the right common lymphatic trunk, respectively, into the veins at the angulus venosus on either side is also shown. (After Mascagni (1787) plate XIX.)

plentiful supply of coal dust or other carbonaceous matter. These nodes are very large and important. The afferent vessels are from the lungs and the bronchi. The efferent vessels extend from the left side to the thoracic duct, and from the right to the right lymphatic trunk. They may have afferents reaching them from the heart and from the esophagus. With the posterior mediastinal nodes, and possibly to a slight extent with the anterior mediastinal nodes there is apparently anastomosis. They may also be connected with the supraclavicular nodes. Frequently, perhaps usually, the efferent vessels of the sternal, anterior mediastinal, and bronchial nodes unite to form a large single or multiple trunk (*truncus lymphaticus bronchomediastinalis s. bronchomediastinus, s. bronchomediastinicus*), which extends to the common lymphatic trunk of the right or left. Such a trunk is more common on the right. On the left the efferent trunks are usually smaller and less concentrated.

Common Lymphatic Trunks.—In man and the mammals there are but two common lymphatic trunks, one on the right and one on the left side; and these trunks terminate at two points in the great veins of the neck (Fig. 3876), usually in the angulus venosus, at the junction of the jugular and subclavian

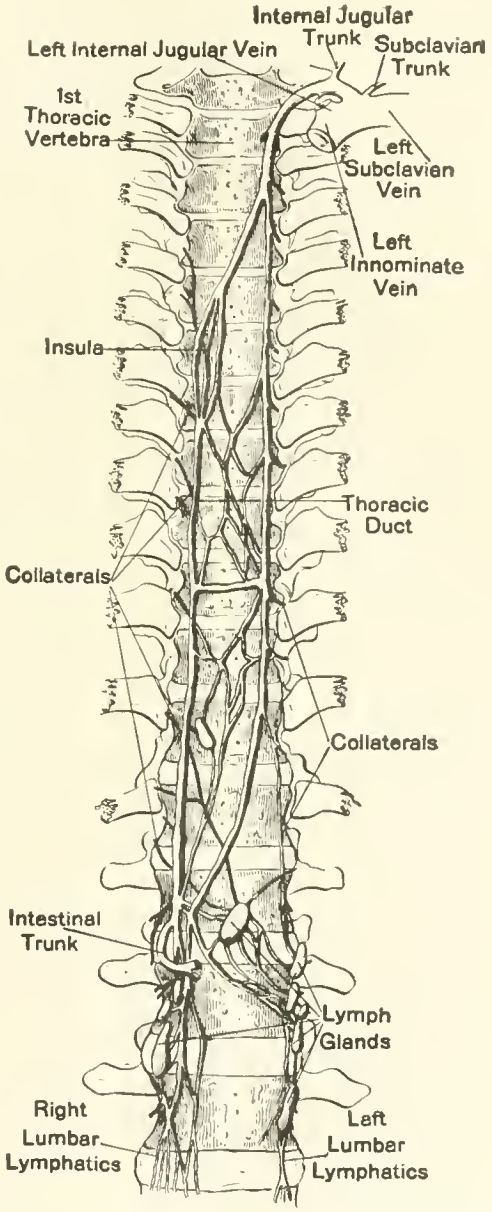


Fig. 3877.—Drawing of the Thoracic Duct and its Main Confluents in Man. This was the only case of its type in twenty-two examined. Note the lymphatic network and the absence of a cisterna chyli. (From Davis.)

veins—that is, just before the formation of the brachiocephalic venous trunks (innominate veins) or in animals like the rabbit (Fig. 3885) with a right and left precava, just before the formation of these. In man and the higher animals these trunks are of different length and size, and receive the lymphatics of very unequal portions of the body, that on the left side being normally much the more extensive. In the lowest mammals the tendency is very strong to equalize these trunks, and also the area drained by

them; and in the animals below mammals, the two are approximately equal and the lymphatics bilaterally symmetrical.

Thoracic Duct (*ductus thoracicus, chyloductus, s. truncus, s. canalis lymphaticus communis sinister, s. major, s. ductus chyliferus, s. lumbothoracicus; vena alba thoracis* [Eustachius, 1564]).—The common lymphatic duct, canal, or trunk of the left side collects and empties into the venous system, the lymph of the pelvic limbs, the reproductive and urinary organs, the alimentary canal, pancreas, spleen, much of that of the liver, of the left half of the body cephalad of (above the umbilicus and a part of that from the right half of the thoracic wall (Figs. 3876–3885).

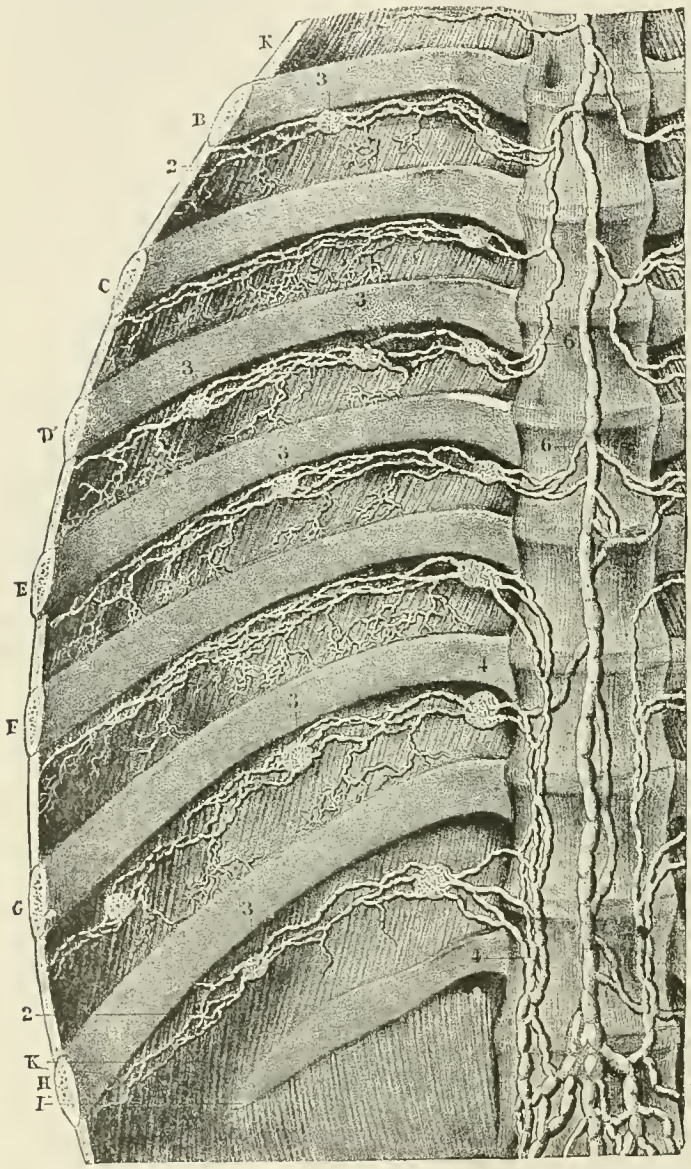


Fig. 3878.—Part of the Thoracic Duct and Intercostal Lymphatics. (Sappey, Atlas.) *A*, Vertebral column opposite the first lumbar vertebra: *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*, fifth to the twelfth ribs inclusive; *K*, superficial intercostal muscles between the ribs; the deep or internal intercostals have been removed to show the intercostal lymphatic plexus; 1, the thoracic duct near the cisterna chyli; it extends along the vertebral column nearly on the meson; 2, 2, trunks arising in the intercostal spaces; 3, 3, 3, lymphatic nodes in the course of the vessels; 4, 4, large trunk conveying the lymph from the three or four intercostal spaces into the abdomen and then pouring it into the cisterna chyli; 5, 5, similar trunk on the left side; 6, 6, and 7, trunks on the right and left, from the intercostal spaces to the thoracic duct.

In man the thoracic duct is formed in the abdomen opposite the first, second, or third lumbar vertebra by the union of the trunks of the lumbar and mesenteric lymphatic plexuses. The caudal end is formed by the union of the right and left lumbar trunk (*truncus lymphaticus lumbalis dexter et sinister*). The large trunk thus formed is then increased by the addition of the unpaired or azygous trunk (*truncus intestinalis*) from the stomach and intestines, part of the liver, the spleen and pancreas, and the right and left trunk from the intercostal plexuses (Figs. 3876, 3877). At the beginning of the duct where all these confluents unite there is usually a marked dilatation, the chyle receptacle, or cistern of Pecquet (*receptaculum chyli, s. cisterna chyli*). (Figs. 3876, 3878). This is sometimes absent in man as the confluents form a kind of network instead of one large trunk (Fig. 3877). In this case the thoracic duct is formed by the union of the network without there being present a special enlargement. This condition is said by Owen to be normal in the marsupials examined by him, but in the dog, cat, rabbit, and most of the higher animals there is usually a very well-marked cisterna. From this reservoir the thoracic duct traverses the diaphragm with the aorta, usually on the right side, and extends along the thorax mostly on the right and dorsal side of the aorta until opposite the sixth to the third thoracic vertebra it gradually inclines to the left, passes dorsad of the arch of the aorta, reaches the left side of the esophagus which it follows for a short distance, passing on with it along the dorsal side of the great blood-vessels until opposite the seventh cervical vertebra when it forms an arch something like the arch of the aorta, curving ventrad and to the left between the vertebral blood-vessels and the jugular vein to terminate at the junction of the left internal jugular and the subclavian vein (Fig. 3876). The opening is guarded by a double valve, so that reversal of the direction of the stream is avoided.

The thoracic duct differs in length with the length of the trunk. The average in an adult is about forty centimeters and its diameter is about two to three millimeters it being greater near its origin than near its termination. It in many cases divides into two or more parallel and anastomosing vessels, which finally unite to enter the vein together (Fig. 3877). The cisterna chyli is from forty to fifty millimeters long and six to eight millimeters in diameter, and in the arch near the termination there is sometimes, if not regularly, found a dilatation something like that shown in the dog and the rabbit (Figs. 3883 and 3885). The thoracic duct receives confluent branches throughout its entire course, and near the termination enter the important trunks from the arm, lungs, and head and neck (the jugular, subclavian, and broncho-mediastinal trunks). The entrance of each of these vessels is usually guarded by a paired valve.

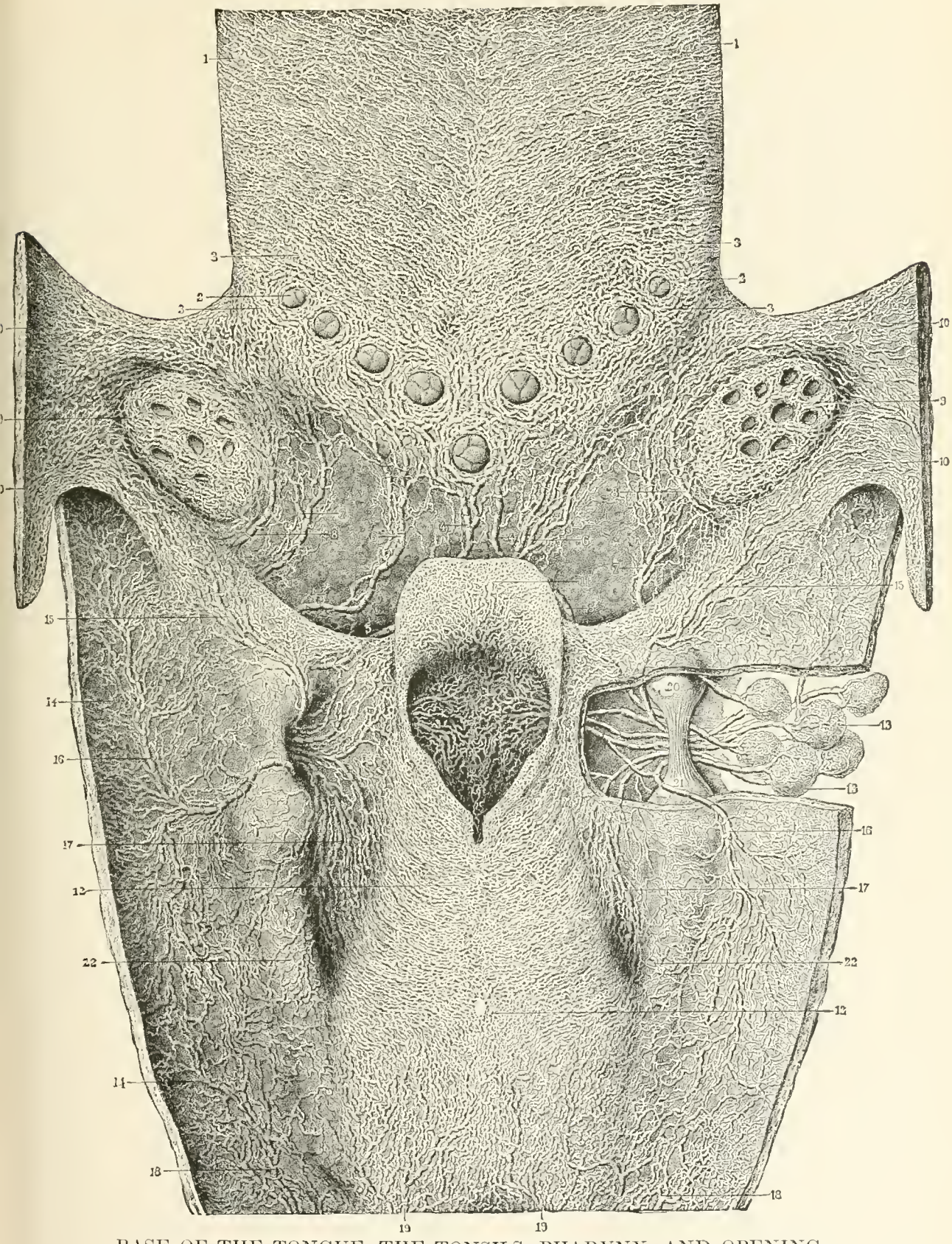
Varieties.—There are sometimes two ducts—one opening into the right, and one into the left veins of

EXPLANATION OF
PLATE XLV.

EXPLANATION OF PLATE XLV.

Which Represents the Base of the Tongue, the Tonsils, the Pharynx, and the Opening of the Larynx of Man. The Pharynx was Divided on the Dorsal Side, and the Walls were Reflected. (Sappey, "Atlas.")

1, 1, Lymphatic network on the dorsum of the tongue, the general direction of the vessels is obliquely toward the raphe (meson) and the base of the tongue; 2, 2, circumvallate papillæ in the form of a V; 3, 3, 3, 3, vessels surrounding these papillæ and soon converging to form mesal and lateral trunks; 4, 4, lymphatic trunks extending along the meson from the middle circumvallate papilla; 5, 5, continuation of 4, one on each side of the middle glosso-glottic fold, and finally penetrating the lateral fold, they enter the lymphatic glands (13) of the ental cervical plexus near the lateral thyrohyoid ligament; 6, 6, other trunks farther from the meson, taking the same course; 7, 7, lateral trunks from the base of the tongue, tonsil, etc.; they penetrate the pharyngeal mucosa and terminate in the same group of glands, but cross the dorsal instead of the ventral surface of the great cornu of the hyoid; 8, 8, trunks coming from the anterior pillars of the fauces, skirting the edge of the tonsils, and finally entering the cephalic, ental (superior deep) cervical lymphatic glands; 9, 9, the tonsils, covered by a dense network of lymphatics; 10, 10, 10, 10, the reflected sides of the arch of the palate (just below the "10" on each side is the divided uvula); 11, dense lymphatic network covering the epiglottis and extending upon the aryteno-epiglottic folds; 12, 12, a similar very dense and fine network of lymphatics upon the pharyngeal mucosa covering the larynx; 13, 13, several lymphatic glands belonging to the cephalic, ental (superior deep) cervical lymphatic glands, situated at the level of the thyrohyoid ligament; as is evident from the plate, they receive the trunks from the base of the tongue, part of the palatine arch, the tonsils, the larynx, and a great part of the pharynx; 14, lymphatics arising from the ventral and lateral part of the pharynx; 15, 15, lymphatics from the posterior pillars of the fauces, they wind round the ventral edge of the great cornu of the hyoid and enter the deep cervical glands at 13, 13; 16, 16, lymphatics arising from the dorsal and lateral aspect of the pharynx and extending to the cervical glands at 13, 13; 17, 17, lymphatic trunks on each side of the larynx to the ental cervical glands at 13, 13; 18, 18, lymphatics from the dorsal and lateral wall of the pharynx next the esophagus, they extend toward the thorax and enter the chain of ental cervical glands along the trachea and esophagus; 19, 19, lymphatics from the ventral part of the pharynx, and extending to the chain of ental cervical glands in company with 18; 20, summit of the great cornu of the hyoid exposed by the removal of the pharyngeal wall; 21, end of the major horn of the thyroid, connected with the hyoid by the thyrohyoid ligament; 22, 22, dorsal border of the thyroid cartilage showing through the pharyngeal wall.



BASE OF THE TONGUE, THE TONSILS, PHARYNX, AND OPENING OF THE LARYNX OF MAN

(Sappey, Atlas)

the neck. Sometimes a single duct divides, sending one branch to the right and one to the left, as shown in the figure of the cat and rabbit (Figs. 3880 and 8885). Rarely there is a transposition, the left thoracic duct opening on the right. It has been pointed out by Davis that variations of the above type are comprehensible on the assumption of a potentially bilaterally symmetrical arrangement of the lymphatics in the human embryo as in the lower forms—periaortic network and right and left trunks or ducts. (Cf. Figs. 3877, 3879, 3881, and 3902). In some instances the thoracic duct has been seen to terminate in the vena azygos. It has recently been shown by Silvester that in the New World Monkeys (seven genera examined), the mesenteric and lumbar lymphatics open into the renal veins or inferior vena cava near the renal veins by two to nine taps, and not by way of the thoracic duct into the veins at the base of the neck. (Compare under Development.) Multiple openings into the veins are not uncommon (cf. Fig. 3885).

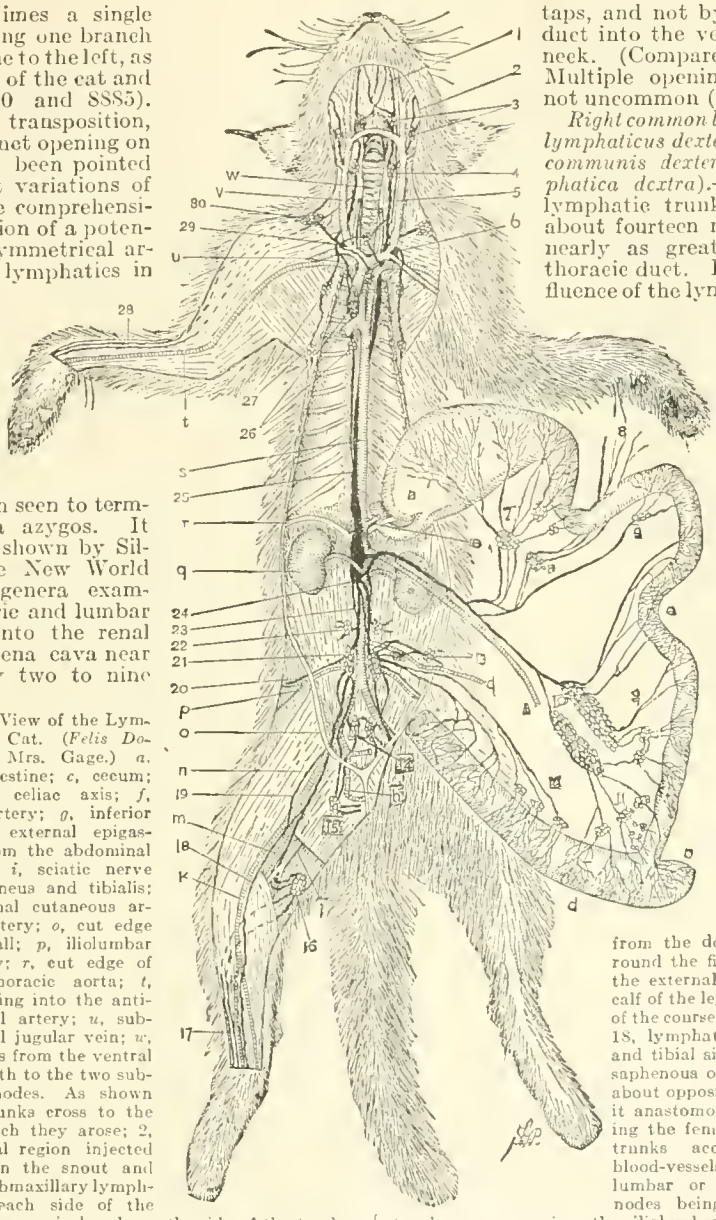


Fig. 3879.—General View of the Lymphatic System of the Cat. (*Felis Domestica.*) (Drawn by Mrs. Gage.) *a*, Stomach; *b*, small intestine; *c*, cecum; *d*, large intestine; *e*, celiac axis; *f*, superior mesenteric artery; *g*, inferior mesenteric artery; *h*, external epigastric artery reflected from the abdominal wall upon the thigh; *i*, sciatic nerve dividing into the peroneus and tibialis; *k*, saphenous or internal cutaneous artery; *m*, *n*, femoral artery; *o*, cut edge of the abdominal wall; *p*, iliolumbar artery; *q*, right kidney; *r*, cut edge of the diaphragm; *s*, thoracic aorta; *t*, brachial artery, extending into the antibrachium as the radial artery; *u*, subclavian vein; *v*, external jugular vein; *w*, trachea. 1, Lymphatics from the ventral lip and floor of the mouth to the two submaxillary lymphatic nodes. As shown in the figure, these trunks cross to the opposite side from which they arose; 2, trunks from the facial region injected from the bare spot on the snout and dorsal lip; 3, the two submaxillary lymphatic nodes, one on each side of the facial vein; 4, single deep cervical node on the side of the trachea and next the carotid artery; into this enter most of the efferent trunks from the submaxillary lymphatic nodes; 5, *truncus lymphaticus jugularis* from the deep cervical nodes to the thoracic duct on the left, and the right common lymphatic trunk on the right; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins; 7 lymphatics from the stomach to the celiac nodes; 8, lymphatics from the liver to a celiac node; 9, node near the duodenum into which many of the duodenal lymphatics enter; 10, the two enormous mesenteric nodes near the cecum, often called the nodes or pancreas of Asellius, into which most of the lymphatics of the small intestine, cecum, and part of the colon empty. From these nodes extends the great *truncus lymphaticus intestinalis* to the cisterna chyli, receiving the trunks from the duodenum, liver, and stomach on its way; in the cat, as shown in the figure, the truncus intestinalis is very long and usually single, making it very easy to insert a cannula for a starch or plaster injection; 11, trunks and nodes in the cecal region; 12, lymphatics from the colon, there are usually several small nodes near the attachment of the mesentery; 13, nodes in the mesocolon around the inferior mesenteric blood-vessels; 14, hypogastric lymphatic nodes; 15, node at the side of the external epigastric blood-vessels. It receives the lymphatics from the abdominal wall, part of the mammary gland and the external genitalia, its efferent vessels go partly to the hypogastric and partly to the aortic or lumbar lymphatic nodes; the node has been reflected from the abdominal wall with the external epigastric artery to the muscles of the thigh, it may represent the superficial inguinal group of man; 16, popliteal node in a mass of fat in the popliteal space. It receives most of the lymphatics of the foot and crus, and sends its efferent trunks between the two great branches of the sciatic nerve to follow the femoral artery; 17, trunks from the dorsum of the foot, winding round the fibular side of the crus with the external saphenous vein across the calf of the leg to the popliteal node, part of the course is indicated by broken lines; 18, lymphatic trunk from the dorsum and tibial side of the foot following the saphenous or internal cutaneous artery, about opposite to the middle of the thigh it anastomoses freely with those following the femoral vessels; 19, lymphatic trunks accompanying the femoral blood-vessels and finally entering the lumbar or aortic nodes, no inguinal nodes being present; 20, lymphatic trunk accompanying the iliolumbar blood-vessels and entering the lumbar or aortic lymphatic nodes; 21, lumbar or aortic lymphatic nodes; 22, lumbar or aortic nodes into which pass the lymphatic trunks from the internal genitalia, these are frequently merged with the preceding; 23, *truncus lymphaticus lumbalis*, there is one on each side, but frequently the trunks are multiple, and the branches of the two sides anastomose, they form principal constituents of the cisterna chyli; 24, cisterna chyli formed by the junction of the intestinal and lumbar trunks; 25, thoracic duct, a small branch is indicated as going to the right side of the body; 26, lymphatic nodes in the thorax, near the arch of the aorta and bronchi; 27, pectoral lymphatic nodes in course of the long thoracic blood-vessels; 28, lymphatics from the dorsum of the manus following the radial nerve and cephalic vein, and finally terminating in the prescapular node. The course in the brachium, where not visible in this view, is indicated by broken lines; occasionally one or more branches turn at the elbow to follow the brachial vessels into the axilla; in this case they enter the pectoral node opposite the third rib, true axillary nodes appearing to be absent; 29, termination of the right common lymphatic trunk at the junction of the subclavian and external jugular vein; 30, prescapular node receiving the lymphatics of the arm and shoulder, and usually an anastomosing branch from the jugular trunk, its efferent vessels join the jugular trunk.

Right common lymphatic trunk (*ductus lymphaticus dexter; truncus lymphaticus communis dexter, s. minor; vena lymphatica dextra*).—The right common lymphatic trunk (Fig. 3876) is only about fourteen millimeters long, but is nearly as great in diameter as the thoracic duct. It is formed by the confluence of the lymphatics from the right side of the head (*truncus lymphaticus jugularis dexter*), those from the right arm, shoulder, and breast (*truncus lymphaticus subclavius*), the efferent trunks from the right half of the sternal, and anterior mediastinal and

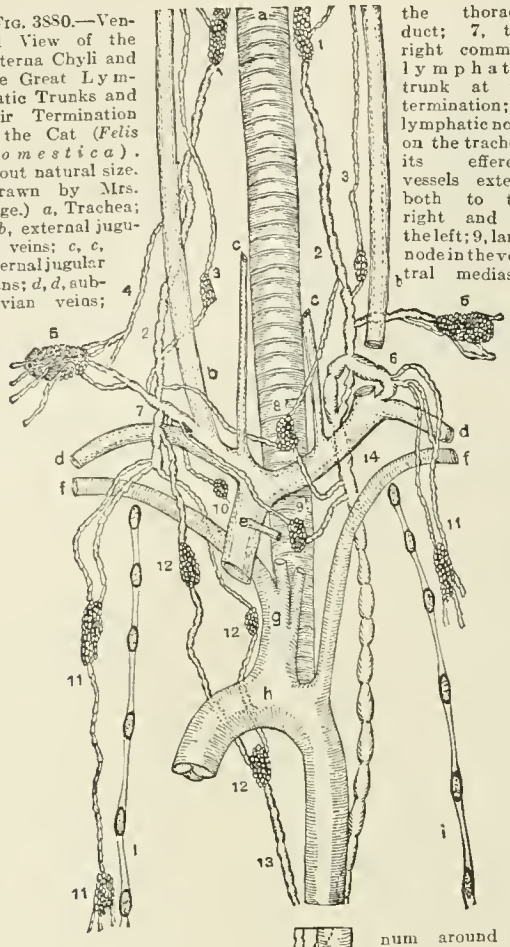
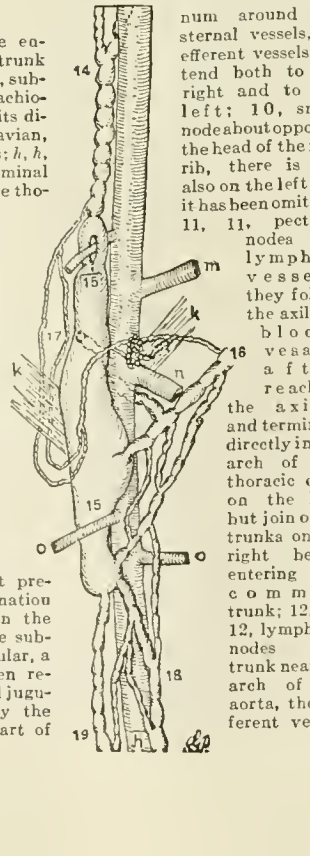


Fig. 3880.—Ventral View of the Cisterna Chyli and the Great Lymphatic Trunks and their Termination in the Cat (*Felis Domestica*). About natural size. (Drawn by Mrs. Gage.) *a*, Trachea; *b*, *b*, external jugular veins; *c*, *c*, internal jugular veins; *d*, *d*, subclavian veins; *e*, precava, opposite the entrance of the common trunk of the sternal veins; *f*, *f*, subclavian arteries; *g*, brachiocephalic artery opposite its division into the right subclavian, the right and left carotids; *h*, *h*, arch of the aorta and abdominal aorta; *i*, *i*, cut edges of the thoracic walls and the ends of the ribs; *k*, *k*, pillars of the diaphragm; *m*, celiac axis; *n*, superior mesenteric artery; *o*, *o*, the renal arteries. 1, Deep cervical node; 2, *truncus lymphaticus jugularis;* 3, 3, trunk and node along the external jugular vein, the trunk is one of the efferent vessels from the lateral of the two submaxillary lymphatic nodes (cf. Fig. 3879); 4, anastomosing branches between the jugular trunk and the efferents from the prescapular node; 5, 5, the right and left prescapular node; 6, termination of the thoracic duct in the veins at the angle of the subclavian and external jugular, a short segment has been removed from the external jugular to show more clearly the arch of the terminal part of the thoracic duct; 7, the right common lymphatic trunk at its termination; 8, lymphatic node on the trachea, its efferent vessels extend both to the right and to the left; 9, large node in the ventral mediastinum around the sternal vessels, its efferent vessels extend both to the right and to the left; 10, small node about opposite the head of the first rib, there is one also on the left but it has been omitted; 11, 11, pectoral nodes and lymphatic vessels, they follow the axillary blood-vessels after reaching the axilla and terminate directly in the arch of the thoracic duct on the left, but join other trunks on the right before entering the common trunk; 12, 12, 12, lymphatic nodes and trunk near the arch of the aorta, the efferent vessels form prominent constituents of the right lymphatic trunk; 13, branch of the thoracic duct turning to the right and finally terminating in the right lymphatic trunk; 14, 14, thoracic duct. As indicated by the constrictions the valves are considerably farther apart in the cephalic half; 15, 15, cisterna chyli on the right side of the aorta and extending for a considerable distance into the thorax; 16, *truncus intestinalis*, the common trunk from the stomach, liver, and intestines (cf. Fig. 3879). Before terminating in the cisterna chyli it divides into several branches, one of which winds round the left side of the aorta, one sends a branch to a small node near the origin of the superior mesenteric artery and from this node the efferent trunk passes laterad of the pillar of the diaphragm, enters the thorax with the splanchnic nerves and terminates in the thoracic duct just beyond the cisterna chyli; still another branch anastomosea with the lumbar trunks; the lymphatics form a perfect maze in thia region, so that it is no wonder Eustachius was bewildered in his first investigation of them; 17, lymphatic vessels from the abdomen to enter the thoracic duct in the thorax; this seems like an exact reversal of the condition in man where some of the lymphatics of the thorax (intercostal plexus) enter the abdomen to assist in forming the cisterna chyli (cf. Fig. 3878); 18, left and 19, right anastomosing trunks from the aortic (lumbar) nodes.



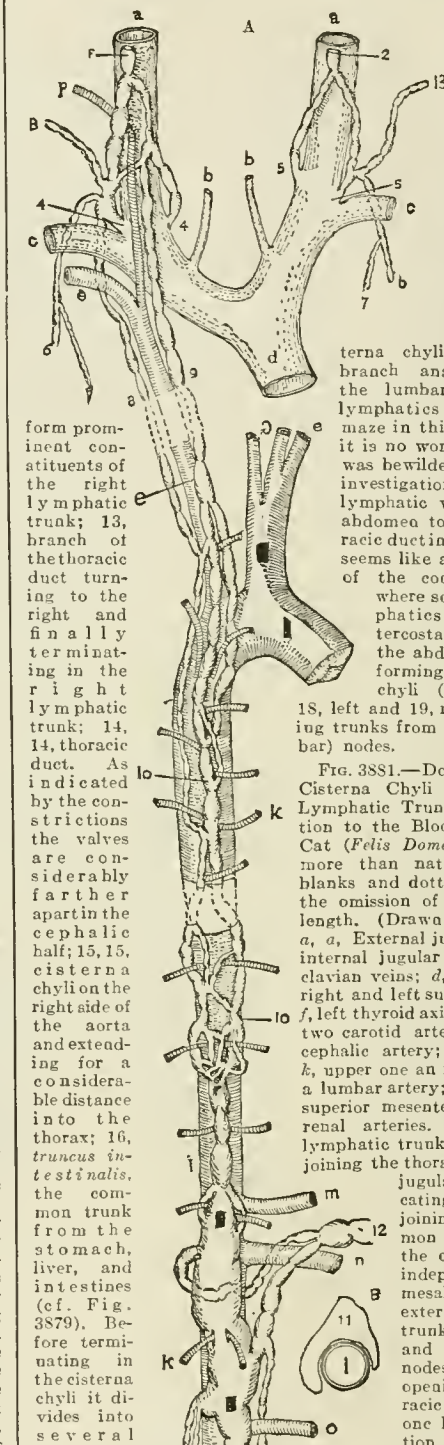


Fig. 3881.—Dorsal View of the Cisterna Chyli and the Great Lymphatic Trunks in their Relation to the Blood-vessels of the Cat (*Felis Domestica*). Slightly more than natural size. The blanks and dotted lines indicate the omission of a part of the length. (Drawn by Mrs. Gage.) *a*, *a*, External jugular veins; *b*, *b*, internal jugular veins; *c*, *c*, subclavian veins; *d*, precava; *e*, the right and left subclavian arteries; *f*, left thyroid axis; *g*, between the two carotid arteries; *h*, brachiocephalic artery; *i*, *i*, *i*, aorta; *k*, *k*, upper one an intercostal, lower a lumbar artery; *m*, celiac axis; *n*, superior mesenteric artery; *o*, *o*, renal arteries. 1, Left jugular lymphatic trunk, bifurcating and joining the thoracic duct; 2, right jugular trunk, bifurcating and one branch joining the right common lymphatic trunk, the other terminating independently in the mesal aspect of the external jugular; 3, 3, trunks from the right and left prescapular nodes; 4, 4, the two openings of the thoracic duct, the lateral one being at the junction of the subclavian and external jugular, the mesal one into the external jugular about opposite; 5, 5, the two openings of the right lymphatic trunks—they are similar in position to the openings of the thoracic duct; 6, 6, pectoral lymphatics; 7, 7, thoracic lymphaties (cf. 11 and 12 of Fig. 3880); 8, branch of the thoracic

duct on the ventral side of the great subclavian vessels, sometimes the entire duct is on the ventral side; 9, branch of the thoracic duct on the dorsal side of the subclavian blood-vessels—this is the position of the entire duct in about three-fourths of the numerous specimens examined; 10, 10, greatly divided thoracic duct. The thoracic duct is never simple in the cat throughout its whole course, but this one is more than commonly divided; 11, 11, 11, cisterna chyli. On the right is drawn a section at this point to show that the cisterna chyli nearly embraces the aorta; 12, intestinal lymphatic trunk sending a large branch on both sides of the aorta to enter the cisterna chyli; 13, left lumbar trunk greatly divided; 14, right lumbar lymphatic trunk anastomosing with the left and with a branch from the intestinal trunk.

Fig. 3882.—General View of the Lymphatic System of the Dog (Scotch Terrier). (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, cecum; *d*, large intestine; *e*, celiac axis; *f*, superior mesenteric artery; *g*, inferior mesenteric artery; *h*, epigastric artery displaced from the abdominal wall to the muscles of the thigh; *i*, sciatic nerve and other popliteal structures brought into view by removing a segment of the thigh muscles; *k*, saphenous or internal cutaneous artery; *m*, *n*, the femoral artery; *o*, cut edge of the abdominal wall; *p*, iliolumbar artery; *q*, right kidney; *r*, cut edge of the diaphragm; *s*, aorta; *t*, brachial artery and its continuation as the radial artery in the antibrachium; *u*, subclavian vein; *v*,

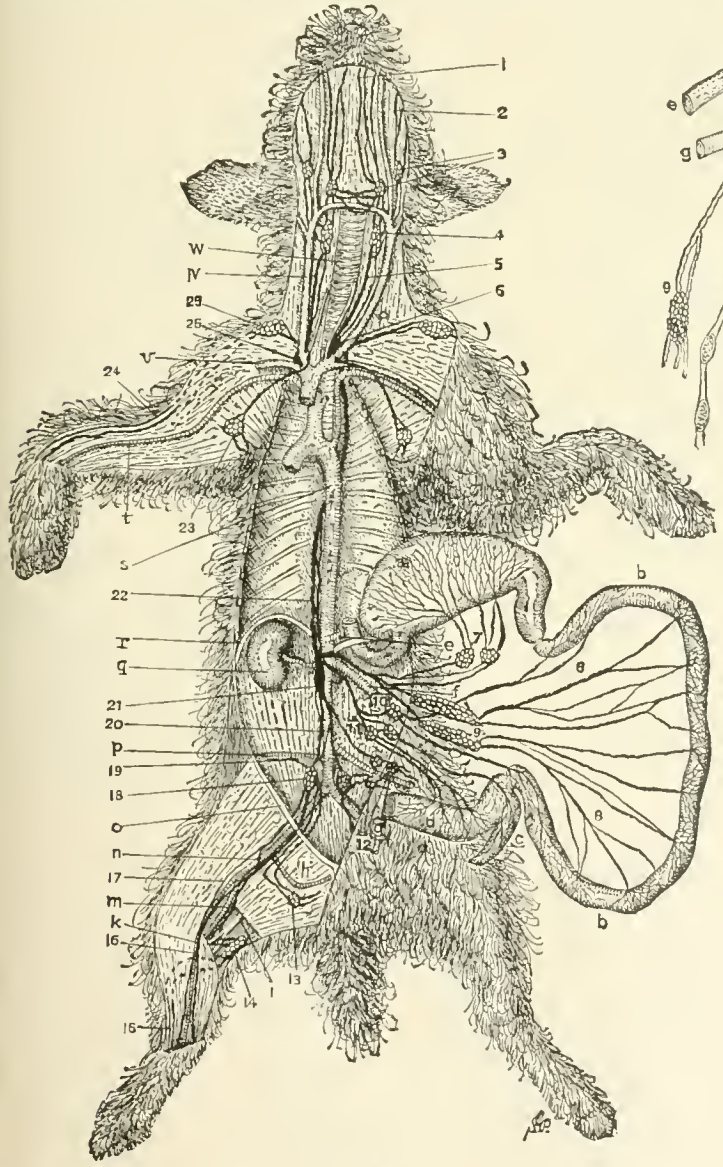
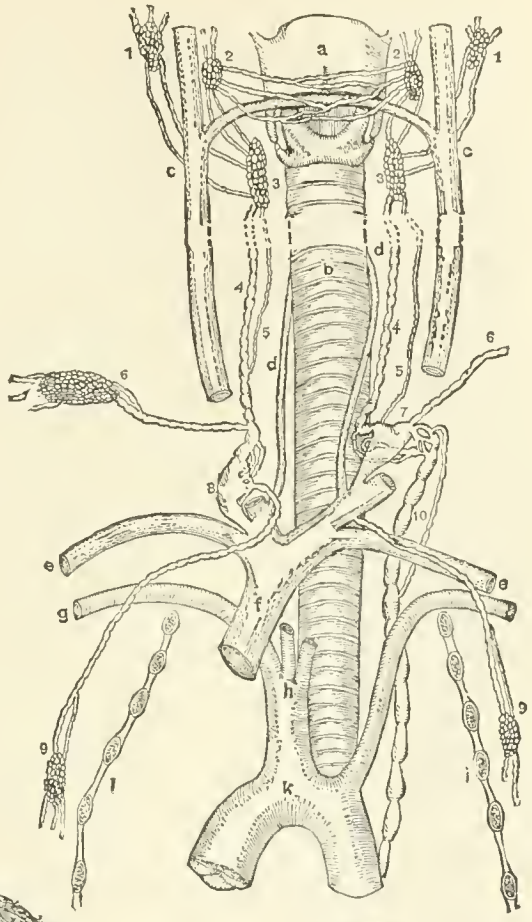


Fig. 3882.



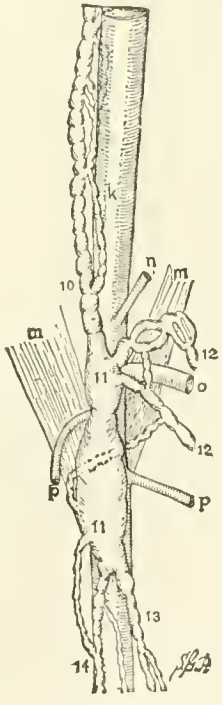


Fig. 3883.

external jugular vein; *w*, trachea. 1, Lymphatic trunks from the ventral lip to the mesal of the two submaxillary lymphatic nodes; 2, lymphatic trunks from the face and nose, and dorsal lip, injected from the snout; 3, the two submaxillary lymphatic nodes with the facial vein between them—the mesal nodes of the two sides are connected by several transverse vessels; 4, deep cervical node; 5, jugular lymphatic trunk finally joining the thoracic duct on the left, the right lymphatic trunk on the right; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins; 7, celiac nodes receiving the lymphatics of the stomach, and sending efferent trunks to the intestinal trunk; 8, lymphatic or lacteal trunks from the small intestine; 9, two large mesenteric nodes (so-called nodes of Asellius or pancreas Asellii; from these originates the intestinal lymphatic trunk, which is quite short in the dog and much more difficult to inject than in the cat; 10, node receiving trunks from the duodenum, ileum, and large intestine near the cecum; 11, nodes receiving the lymphatics from the cecum, and part of the large intestine; 12, nodes in the mesocolon along the inferior mesenteric artery; they receive vessels from the large intestine, and the efferent vessels go to the cisterna chyli and to the lumbar nodes; 13, node on the abdomen beside the external epigastric artery; 14, popliteal node; 15, lymphatics from the foot, following the external or short saphenous vein around the calf of the leg into the popliteal node; the parts of the vessels that would be hidden in this view are indicated by broken lines; 16, lymphatic trunk following the saphenous artery. The saphenous trunk freely anastomoses with the trunk following the femoral artery, and with it passes to the aortic (lumbar) nodes; 18, aortic (lumbar) lymphatic nodes; 19, lymphatic trunk, accompanying the iliolumbar artery, and terminating in the aortic (lumbar) nodes; 20, lumbar lymphatic trunks; 21, cisterna chyli; 22, thoracic duct, double for a considerable distance; 23, pectoral lymphatic node and vessels; 24, lymphatic trunks following the cephalic vein, and terminating in the prescapular node. The course along the brachium is indicated by broken lines, as the vessels would not appear in this view; 25, termination of the right lymphatic trunk; 26, prescapular lymphatic node of the right side.

Fig. 3883.—Ventral View of the Cisterna Chyli and the Great Lymphatic Trunks in their Relation to the Principal Blood-vessels of the Dog (Scotch Terrier). The blanks with dotted lines in the cervical region, and the blank in the thorax, indicate that part of the length has been omitted. About natural size. (Drawn by Mrs. Gage.) *a*, Larynx; *b*, trachea; *c*, *c*, the right and left external jugular veins, with segments removed; *d*, *d*, the two internal jugular veins; *e*, *e*, subclavian veins; *f*, precava; *g*, *g*, right and left subclavian arteries; *h*, brachiocephalic artery, near its division into the subclavian and the two carotids; *k*, *k*, aorta; *m*, *m*, pillars of the diaphragm; *n*, *n*, celiac axis; *o*, superior mesenteric artery; *p*, *p*, renal arteries. 1, 1, Right and left lateral submaxillary lymphatic nodes, receiving trunks from the face, nose and dorsal lip; 2, 2, mesal submaxillary lymphatic nodes, receiving trunks from the ventral lip; these two nodes are connected by numerous anastomosing and crossing trunks; 3, 3, deep cervical nodes, receiving the efferents from 1 and 2; 4, 5, 4, 5, jugular trunks from the deep cervical nodes to the thoracic duct and right common lymphatic trunk; 6, 6, trunks from the prescapular nodes, only the right node being shown; 7, termination of the thoracic duct on the mesal surface of the external jugular, near its junction with the internal jugular vein. The arch in the duct is on the dorsal side of the great subclavian vessels, and it arches toward the median line instead of laterad as with the cat, and before terminating enlarges considerably. Into the enlargement terminate the jugular trunks and the one from the prescapular node; the enlargement narrows markedly before entering the vein; 8, enlargement and termination of the right lymphatic trunk; 9, 9, pectoral nodes and trunks; the one on the left terminates independently in the lateral aspect of the external jugular, near its junction with the subclavian; 10, 10, thoracic duct; it is considerably divided just within the thorax, and then again just before enlarging near its termination; 11, 11, cisterna chyli on the ventral and right side of the aorta, and extending for a short distance into the thorax; 12, 12, intestinal lymphatic trunks; one branch winds round the left side of the aorta, and terminates finally on the right side of the cisterna chyli; 13, left lumbar lymphatic trunk; 14, right lumbar lymphatic trunk.

Fig. 3884.—General View of the Lymphatic System of a White Rabbit. (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, *c*, cecum; *d*, the so-called vermiform appendix; *e*, large intestine; *f*, celiac axis; *g*, superior mesenteric, and *h*, inferior mesenteric artery; *i*, external epigastric artery displaced from the abdominal wall to the muscles of the thigh; *k*, sciatic nerve and other popliteal structures exposed by removal of a segment of the thigh muscles; *m*, saphenous or internal cutaneous artery; *n*, *o*, femoral artery; *p*, cut edge of the abdominal wall; *q*, iliolumbar artery; *r*, right kidney; the left has been omitted, although the beginning of the renal artery is shown; *s*, cut edge of the diaphragm; *t*, aorta; *u*, brachial and ulnar artery; *v*, subclavian vein; *w*, external jugular vein; *x*, trachea. 1, Trunks from the ventral lip and sides of the mouth; 2, trunks from the snout; 3, the two submaxillary lymphatic nodes on either side of the facial vessels; 4, lymphatic nodes near the base of the ear; 5, deep cervical lymphatic node; 6, left jugular lymphatic trunk on its way to join the thoracic duct; 7, thoracic duct near its termination in the vein; 8, celiac nodes, receiving the lymphatics of the stomach; 9, 9, lacteals from the small intestine to 10, the great mesenteric node (node or pancreas of Asellius); it gives rise to two intestinal trunks, which are short, small, and difficult to inject with a coarse mass; 11, large mesenteric node receiving the vessels from the mass of lymphatic nodules at the termination of the ileum; 12, lymphatic tissue, *sacculus rotundus*, at the termination of the ileum; 13, node receiving the lymphatic trunks from the vermiform appendix; 14, nodes in the mesocolon along the inferior mesenteric vessels; the efferent vessels pass to the lumbar trunks; 15, hypogastric or sacral lymphatic node; 16, node on the abdomen by the external epigastric vessels—it has been displaced with the artery to the thigh muscles; 17, popliteal nodes receiving vessels from both sides of the crus, sending efferent branches between the peroneal and tibial nerves to follow the femoral artery, and another to accompany the ischiadic artery; 18, lymphatic trunks from the dorsum of the foot, winding round the tibial or outer side of the calf to join the popliteal node; 19, lymphatic following the saphenous artery; it usually divides near the knee, sending one branch to the popliteal node; 20, lymphatic trunk extending along with the femoral artery; it is formed by the intimate anastomosis of those accompanying the saphenous and deep femoral arteries; 21, aortic (lumbar lymphatic nodes; 22, subcutaneous lymphatic node near the iliolumbar blood-vessels,

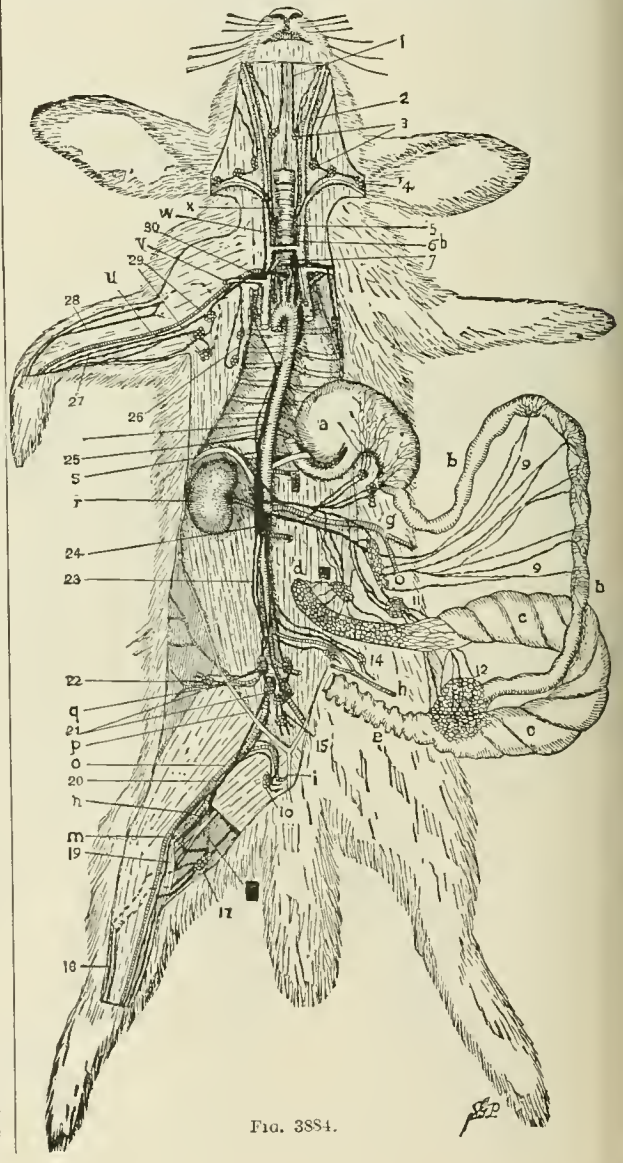


Fig. 3884.

just at the lateral margin of the sartorius muscle; the efferent lymphatics follow the iliolumbar vessels and enter the aortic (lumbar) nodes; 23, lumbar lymphatic trunks; the right one is much more divided than the left; 24, cisterna chyli; 25, thoracic duct; this is almost invariably more or less divided and sends out a considerable branch to the right lymphatic trunk; 26, pectoral lymphatic nodes; 27, anastomosing trunks following the radial and brachial artery to the axillary nodes; 28, trunk following the radial nerve, winding round the brachium to terminate in the axillary nodes also; the broken line indicates that the trunk would be out of sight in this view; 29, axillary lymphatic nodes; these are not very closely connected with the axillary vessels; 30, termination of the right lymphatic trunk.

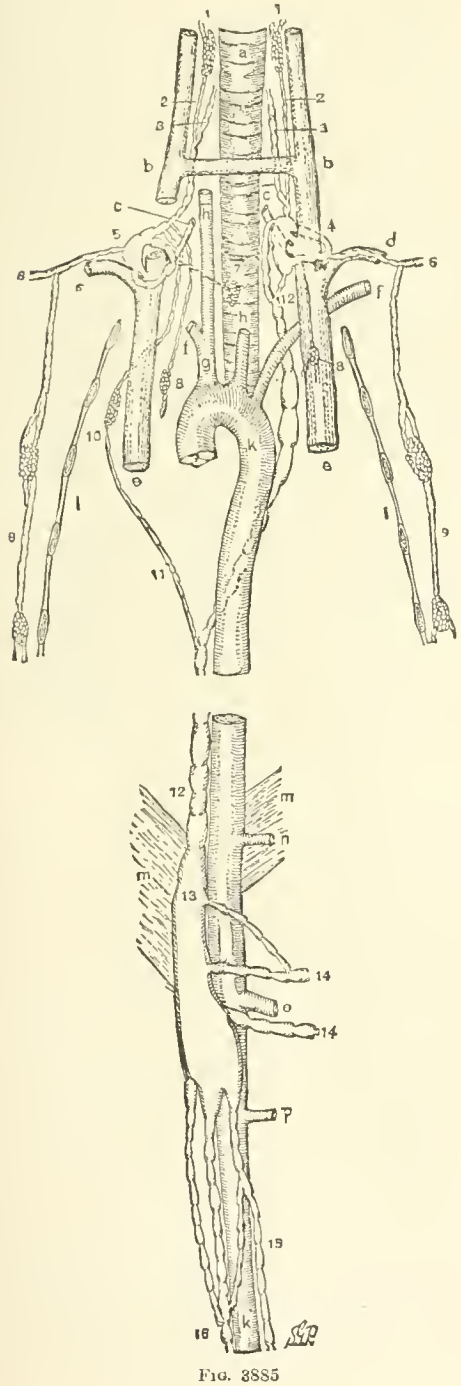


Fig. 3885

bronchial plexuses (*truncus broncho-mediastinalis dexter*). As stated above, a part of the lymphatics of the right costal region open into the left thoracic duct (Fig. 3878). As on the left side there is a tendency for the trunk to terminate by a multiple instead of a single opening. Not infrequently, there is no true common trunk formed, but the great trunks from the different regions open separately.

The great lymphatic trunks in the higher mammals conform quite closely to those of man, but the termination varies somewhat. When the internal jugular is small it is generally near the junction of the subclavian and external jugular (Figs. 3880 and 3885), in the horse this duct terminates in the precava, and in the ox usually at the junction of the left jugular and the precava. In the ox also it usually traverses a special opening in the diaphragm. In the horse the duct is dilated at its termination, as it is also in the dog and rabbit (Figs. 3883, 3885); in all the animals both trunks tend to open by two or more mouths (Fig. 3881), and in all the thoracic duct shows a strong tendency to conform to the lymphatics in general and break up into a kind of network instead of remaining of considerable size. Sometimes this network encloses the aorta, but more frequently it assumes the condition shown in Fig. 3881. (Compare with Fig. 3877, and the remarks under Varieties, above.) In the rabbit almost constantly, and very frequently in the cat, there is a branch of the thoracic duct extending to the right (Figs. 3880 and 3885).

The cisterna chyli is large in the dog, cat, and rabbit, and in many other animals, and there is a strong tendency for its component trunks (intestinal and lumbar) to divide before entering it, so that it is formed by the union of a coarse network rather than by a few simple vessels (Figs. 3880, 3881, 3885).

Fig. 3885.—Ventral View of the Cisterna Chyli and the Principal Lymphatic Trunks in their Relation to the Great Blood-vessels in the White Rabbit. (Drawn by Mrs. Gage.) *a*, Trachea; *b*, *b*, external jugular veins connected by a transverse vessel; *c*, *c*, internal jugular veins; on the right a segment is removed from the jugular better to show the branches forming the right lymphatic trunk; *c*, *c*, the two internal jugular veins; *d*, *d*, the subclavian veins; *e*, *e*, the right and left precavæ; *f*, *f*, the two subclavian arteries; *g*, brachiocephalic artery dividing into the right subclavian and the right carotid; *h*, *h*, carotid arteries, the left arises from the arch of the aorta; *i*, *i*, cut thoracic wall and ends of five of the ribs; *k*, *k*, aorta; *m*, *m*, pillars of the diaphragm; *n*, celiac axis; *o*, superior mesenteric artery; *p*, left renal artery, the right not being shown. 1, 1, Two deep cervical nodes; 2, 2, efferent trunks of the deep cervical nodes; 3, 3, superficial lymphatic trunks from the nodes near the ear; they follow the external jugular vein for a considerable distance, then penetrate the tissues to join the jugular trunk; 4, the termination of the thoracic duct; this is very complex, forming a ring around the jugular, and becoming ampulliform, it terminates by a narrowed neck at the junction of the external and internal jugular veins; the numerous trunks opening into the expanded end of the thoracic duct, have their mouths guarded by a paired valve; 5, termination of the right lymphatic trunk; it is expanded like the thoracic duct and receives many trunks. The external jugular vein is encircled as on the left. A segment of the vein has been removed, better to show the parts. The right trunk opens into the vein at the junction of the right subclavian and external jugular, as is the usual method on both sides in the dog and cat; 6, 6, right and left trunks from the axillary nodes; 7, tracheal node with trunk going to the right; there is probably one going to the left also, as with the cat; 8, 8, nodes in the thorax sending their efferent trunks to the corresponding common trunks; 9, 9, pectoral nodes, and trunks on the two sides; their efferent trunks unite with those from the axillary nodes to form the subclavian lymphatic trunk; 10, lymphatic node on the right, near the second rib, through which passes the branch from the thoracic duct to the right lymphatic trunk; 11, branch of the thoracic duct going to the right side; this right branch is a very frequent, if not a constant, feature in the rabbit; 12, 12, thoracic duct; it is frequently much more divided than is shown in this figure. The blank space near the middle indicates that a part of the length was omitted; 13, cisterna chyli; this is as in the dog and cat, inclined to the right side of the aorta, but it does not extend so far into the thorax; 14, intestinal lymphatic trunk; this is small, ususlly multiple, short, and difficult to inject with a coarse mass; 15, 16, the right and left lumbar trunks; they form a long-meshed network, and in this specimen terminate in the cisterna chyli by three trunks.

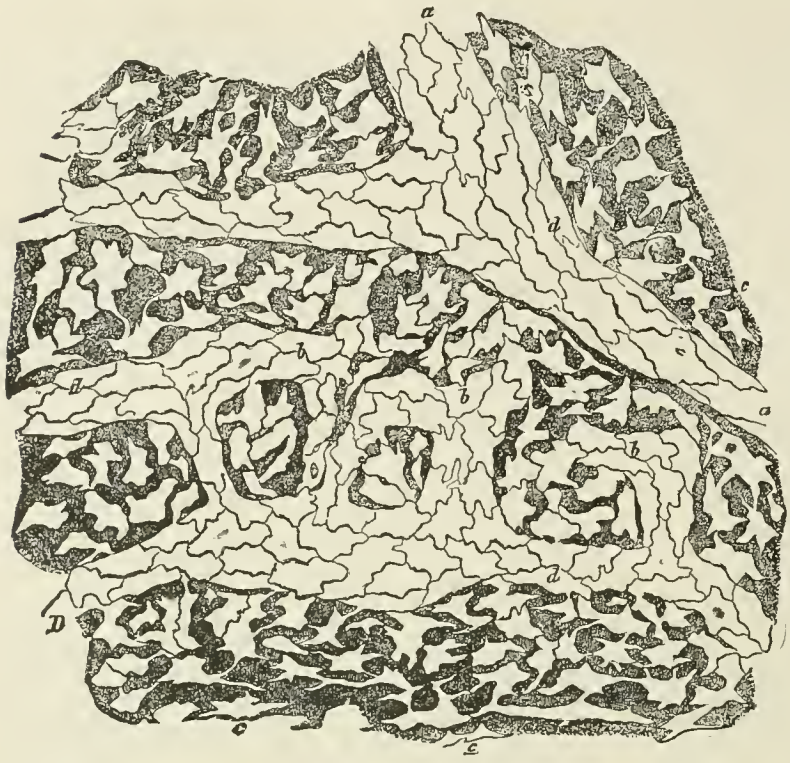


Fig. 3886.—Pencilled and Silver-stained Preparation of the Pleural Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Lymphatic Capillaries and their Relation with the Cell Spaces. (von Recklinghausen.[8]) Magnified 300 diameters. *b*, Beginning of the lymph capillaries by a continuity with the cell spaces; *c, c, c*, cell spaces surrounded by the dark ground substance. These spaces contain cells, lymph-canalicular cells, and the cell processes partly fill the white lines connecting the cell spaces). *d, d, d, d*, Lymphatic capillaries with the serrated endothelial cells. To illustrate the von Recklinghausen theory of the communication of tissue (pericellular) spaces and lymphatic capillaries.

In the non-mammalia, birds, reptiles, amphibia, and fishes, the great trunks are symmetrical, that is, nearly equal on the two sides. They open into the great veins near the heart. There is also a pair of vessels opening into the ischiadic or other pelvic veins, and in the frog and toad there is a lymph heart on each great trunk, near the opening. In the non-amphibian forms, where lymph hearts are present, they are confined to the pelvic region.

Origin and Structure of the Lymphatic Vessels.—There have been three rather distinct interpretations of the ultimate origin or beginnings of lymphatic vessels out in the tissues in their relation to blood-vessels and tissue elements: 1. That they are in direct communication with the blood-vessels at the periphery by means of connecting radicles (vasa serosa) so small that in normal conditions only the blood plasma can traverse them, and that under pathological conditions these connecting radicles may increase sufficiently in size to admit the passage of blood corpuscles. This was one of the earliest views (Boerhaave, Haller) and it was supported by the fact of the ready appearance of water or even colored gelatin in the lymphatics soon after the blood-vessels were injected. This was, and still is, a favorite method of demonstrating the lymphatics of an organ. In objection to the doctrine of the direct connection of the two systems of vessels, it was pointed out by Hunter that, when the coarser matters injected into the blood-vessels appeared in the lymphatics, it was due to a breakage somewhere in the wall of the blood-vessel; and further, that the filling of the lymphatics by injecting water or gelatin into the blood-vessels was but natural, as it is one of the properties of the blood-vessels to allow the contents to diffuse through their walls, and the lymphatics, from their office as a drainage system, take up the exuded liquid. This does not, however, show how the exuded liquid gets into the lymphatics. The pressure which forces the plasma through the walls of the blood-vessels would seem rather to collapse the lymphaties, as the pressure is on the outside. In a word, there appears to be no conclusive proof given that there is or is not a direct connection between blood-vessels and lymphatics. Such a connection is, however, entirely unlikely.

With the promulgation of the cell theory the vasa serosa were conceived to be hollow connective tissue cells which put the lymphatic radicles in communication with the blood channels (Schwann).

2. That there is a network of minute spaces in the tissues between and around the individual structural elements, through which the diffused plasma slowly moves, bathing all the cells and fibers, giving to them oxygen and the other nutritive elements, and taking in return carbon dioxide and the other products of waste. Part of this waste, especially the carbon dioxide, diffuses back into the blood capillaries. This system has been called *juice spaces and canals* by von Recklinghausen[8] and the *lymphcanalicular system* by Klein.[7] These minute channels and spaces are all interconnected and continuous with the blood-vas-

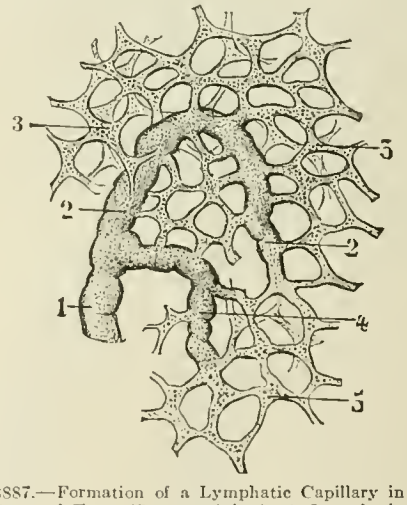


Fig. 3887.—Formation of a Lymphatic Capillary in the Skin of the External Ear. (Sappey, Atlas.) 1, Lymphatic capillary; 2 and 4, two minute branches uniting to form the larger capillary; 3, 3, 3, lacunes or dilatations formed by the union of the minutest lymphatic vessels, the capillicules. The union of a multitude of these lacunes forms a lymphatic capillary. This is shown best at the lower part of the figure. To illustrate Sappey's view of the origin of lymphatic capillaries in intercellular capillicules.

cular system through the intercellular cement and spaces, and with the lymphatic vessels in the same way (Fig. 3886), and further, these spaces frequently, if not constantly, contain branched cells, the cell body filling the larger spaces and the processes the connecting channels. These cell processes are often projected between the endothelial lining of the capillaries, thus forming the so-called pseudostomata, and therefore bring the lymphatics and blood-vessels really into continuity by the intervening cells and the spaces surrounding them.

Intermediate between this interpretation of von Recklinghausen, that the lymphatic radicles directly drain tissue spaces, and the third, next succeeding view, is that of Sappey, who has represented with marvellous clearness the entire lymphatic system from origin to termination. He believed, and thought he had proved by new and special means of research, that the lymphatic system at its origin is invariably composed of minute vessels (capillicules) from 1μ to 4μ in diameter (Fig. 3887), with structureless walls, which extend around and between all the structural elements. These capillicules are closed at the free

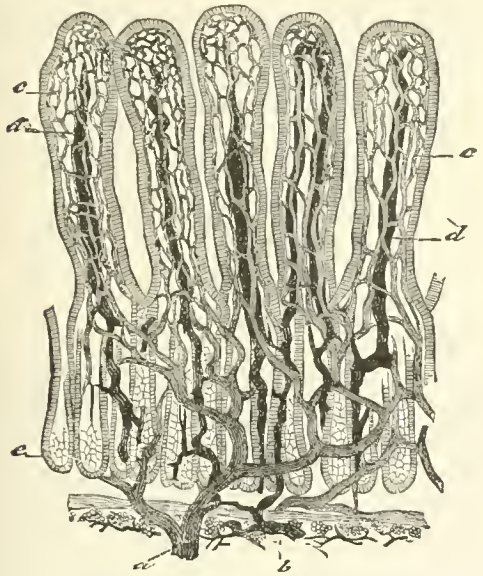


Fig. 3888.—Lacteals of the Intestinal Villi of the Dog. (Cadiat.) *a*, Artery extending into the villi to form a capillary network (light shading); *b*, lacteal extending from the villi into the submucosa (dark shading); *c*, *c*, blood capillaries in the villi; *d*, *d*, central lacteal of the villi. In one it forms a loop, in the other it ends blindly; *e*, crypts of Lieberkühn.

end, but join, in nearly the same way as do the canalicuili of bone, to form somewhat larger spaces, the lacunes, which vary from 2μ to 8μ in diameter, and like the capillicules have structureless walls. By the union of many lacunes the true lymphatic capillaries are formed, and in them first appears the endothelial lining. Further, although the capillicules around and between the structural elements have blind terminations, those connected with the blood-vessels extend into the lumen between the endothelial cells, and have open mouths into which the plasma of the blood can freely enter, and in some pathological conditions they may become so large that the blood corpuscles may pass through the capillicules to the lymphatic vessels. This view is in part a return to the original doctrine, and it also differs from the doctrine of the lymph-canalicular origin in excluding the cells from the spaces or lacunes, and in giving distinct but structureless walls to the capillicules and lacunes.

3. Most of the earlier workers conceived of the lymphatics as possessing free communications with the blood-vessels, with the tissue spaces, or even (William Hunter and the English school) with such body surfaces as the cutaneous, intestinal, pulmonary

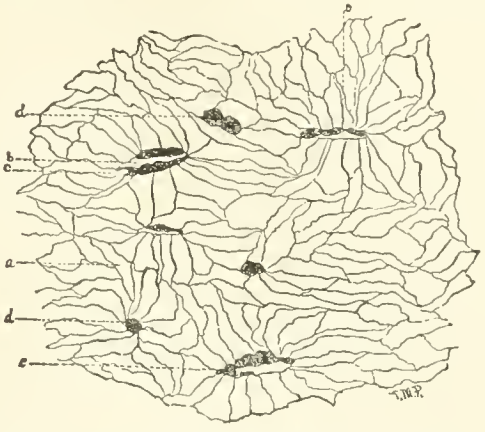


Fig. 3889.—Portion of the Cisterna Lymphatica Magna of the Frog, to show Endothelium and Stomata. (Prudden.) *a*, Ordinary endothelial cells, the nuclei not being shown; *b*, *b*, stomata leading from the peritoneal cavity into the dorsal lymph sac; *c*, *c*, germinating endothelium surrounding the stomata; *d*, germinating endothelia among the ordinary cells; these are frequently called pseudostomata.

as well; evidence or the last being presented as late as 1877.

Von Recklinghausen first clearly demonstrated the lymphatic endothelium when he founded his theory

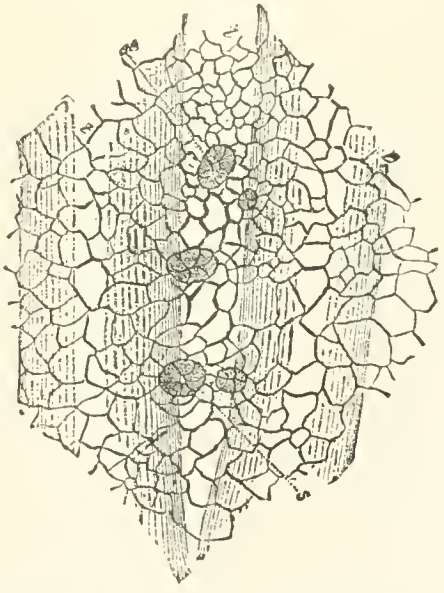


Fig. 3890.—Silver-stained Peritoneal Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Stomata. (Klein.[2]) *l*, Lymph channel between the tendon bundles; *s*, *s*, five stomata, surrounded by germinating endothelium and leading into the lymph channel between the two tendinous bundles. Part of the stomata are open and part closed; *t*, *t*, two bundles of the central tendon, between which is the lymph channel into which the stomata open. Over the tendinous bundles the endothelial covering is composed of markedly larger cells than over the lymph channel.

of the lymphatic tissue spaces. His in 1863 confirmed his (von Recklinghausen's) discovery but threw doubt upon the free communication of the lymphatic capillaries with tissue or other spaces, and many investi-

gators have come to consider the lymphatic system a closed system, like the blood-vascular system, the lymphatic endothelium forming a continuous unbroken layer even in the smallest channels, through which the lymph would pass to the interior of the capillary doubtless by the activity of the endothelial cells themselves. Lymphatic capillaries are not then, under this interpretation, in direct morphological communication with either blood capillaries or tissue spaces.

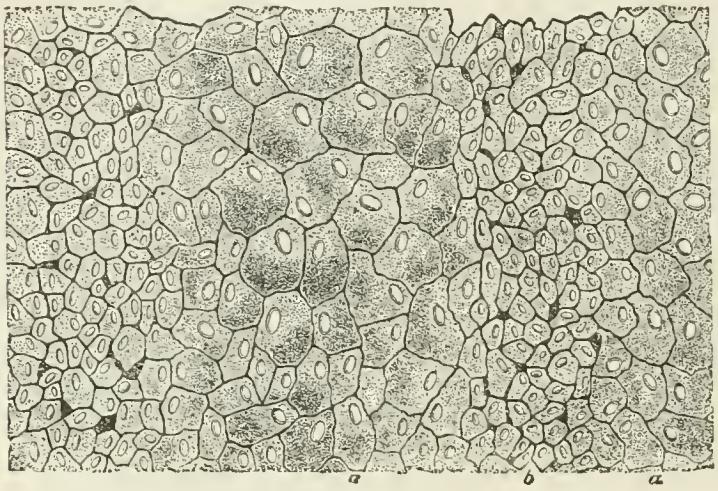


Fig. 3891.—Peritoneal Endothelium Mesothelium from the Central Tendon of the Rabbit's Diaphragm, to show the Difference in the Size of the Cells, and the Pseudostomata between them. (Klein.) *a*, *a*, Irregular rows of large nucleated endothelial cells, corresponding to underlying tendinous bundles; *b*, rows of smaller endothelial cells with numerous pseudostomata between them (the dark spots). The rows of small cells correspond to the lymph channels between the bundles (cf. Fig. 3890.)

Between the second and third interpretations at present no final decision can be made. The evidence strongly supports the third view; but perhaps neither is correct in its entirety, and for all regions and organs of the body. There seems to be no question but that lymphatics may be injected from unquestioned tissue spaces (*e.g.* cornea), and from the subdural space. There is also general agreement that the body cavities (serous spaces) may open directly into the lymphatic channels through stomata (Figs. 3889–3891). The distinction between tissue space and lymphatic space or channel may therefore not be as valid as some investigators believe, this applying particularly to perivascular spaces and perivascular lymphatic channels. The interpretation of the fundamental plan of development is involved (see below), the histological and embryological aspects of the problem being closely related.

The readily demonstrated or apparent origin of the lymphatic vessels is in a plexiform network of valveless capillaries of varying sizes (Plates XLIV., XLV., and XLVI., and Figs. 3892 and 3893). From this capillary network extend collecting trunks with abundant valves (Fig. 3863). The serous cavities are likewise directly connected with the lymphatic vessels through the stomata or pseudostomata (Figs. 3889–3891). Bnt the pleuro-peritoneal cavities are probably not primarily connected with the lymphatic system, but come to be so connected later.

A distinct capillary network of origin has been

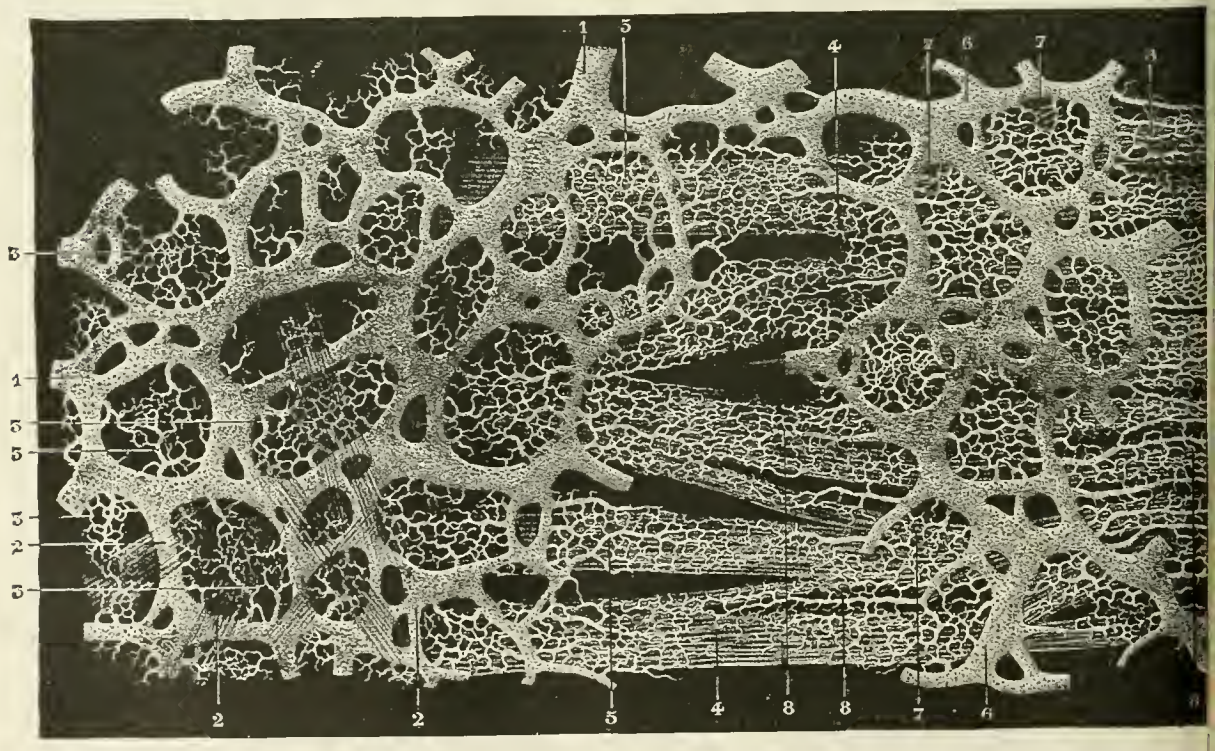


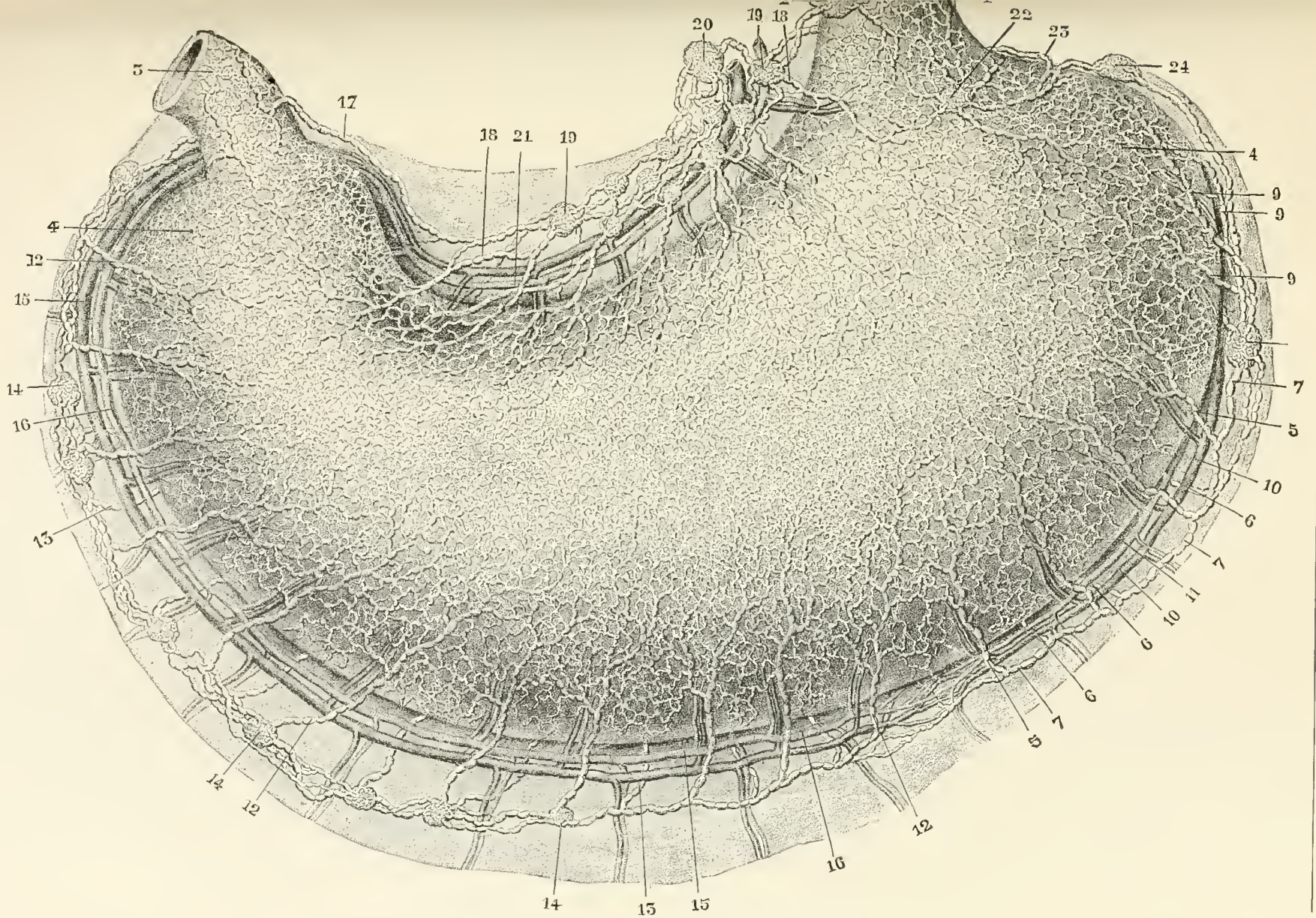
Fig. 3892.—Finer and Coarser Lymphatic Network of the Muscularis of the Small Intestine of a Child at Birth. (Sappey, Atlas.) Magnified 200 diameters and reduced about one-third. 1, 2, and 6, Coarse network of lymphatics resting upon the longitudinal muscles; 3, 4, 5, 7, and 8, finest lymphatic network around the muscular fibers, and uniting to form the larger network.

EXPLANATION OF
PLATE XLVI.

EXPLANATION OF PLATE XLVI.

Which Represents the Lymphatics of the Human Stomach. (Sappey, "Atlas.")

1, Gastric end of the esophagus; 2, lymphatic gland receiving part of the esophageal lymphatics; its efferent vessels extend to the glands around the coronary blood-vessels and there join those from the stomach; 3, the beginning of the duodenum; 4, 4, fine network of lymphatic vessels in the muscularis; from this fine network arise all the collecting trunks of the muscular coat; 5, 5, lymphatic trunks on the left part of the great curvature; 6, 6, 6, lymphatic vessels from the dorsal and ventral surfaces of the left third of the great curvature; 7, 7, 7, the principal trunk encircling the left half of the great curvature of the stomach; it receives the branches from the stomach and extends toward the left to enter a large gland (8) situated near the tail of the pancreas and the hilus of the spleen; 8, gland at the left of the stomach near the hilus of the spleen; it receives trunks from both directions, also some from the spleen; 9, 9, 9, trunks from the extreme left of the stomach to the gland marked 8; 10, 10, vena gastro-epiploica sinistra; 11, arteria gastro-epiploica sinistra; 12, 12, 12, and 13, 13, trunks from the dorsal and ventral aspect of the pyloric region; 14, 14, 14, the chain of glands on the right along the great curvature; through these pass all the lymphatics from the half next the greater curvature. The efferent trunks from these glands finally extend to the glands at the head of the pancreas; all the glands in the chain around the great curvature are sometimes designated as the *glandulæ lymphaticæ gastro-epiploicæ inferiores*; they lie in the great omentum, and form part of the celiac lymphatic plexus; 15, 15, 16, 16, vasa gastro-epiploica dextra; 17, trunk from the duodenum and the pylorus to the glands along the lesser curvature; 18, 18, trunks extending to the lesser curvature; 19, 19, the lymphatic glands along the gastric coronary vessels in the lesser curvature (*glandulæ lymphaticæ gastro-epiploicæ superiores*); they receive all the so-called ascending trunks from the stomach and some of the trunks from the esophagus; they form part of the celiac lymphatic plexus; 20, the large celiac gland to which the efferent vessels from 19 extend; 21, vasa coronaria gastrica; 22, gland, often double, on the ventral aspect of the cardia; 23, large trunk winding round the cardia and joining the trunk to 22 and 24; 24, gland, sometimes double, at the extreme left of the great curvature.



LYMPHATICS OF THE HUMAN STOMACH

(Sappey, Atlas)

PLATE XLVI.

satisfactorily demonstrated in all the tissues and organs except the following, and in some of these, as the cornea, the lymph is known to circulate, although not in an independent network of vessels.

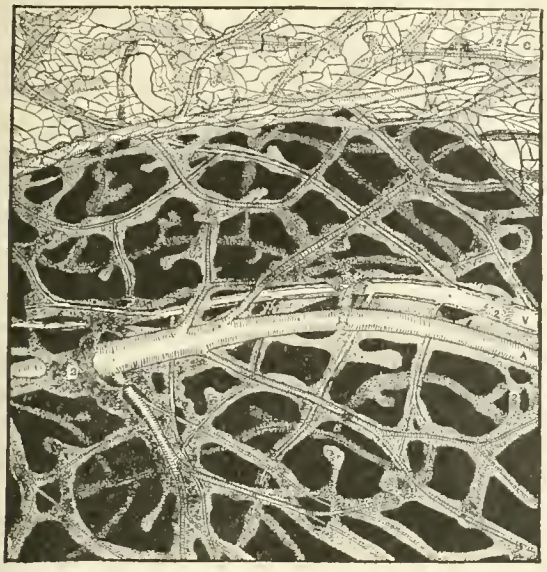


Fig. 3893.—Surface View of the Lymphatic Network in the Submucosa of the Rabbit's Cecum, showing the Form of the Network and the Relation of the Lymphatics and Blood-vessels. Magnified 55 diameters. (Drawn by Mrs. Gage.) *A*, *A*, Small arteries; *V*, small vein; *C*, the blood capillaries in the upper part of the figure; 2, 2, 2, 2, lymphatic vessels. (cf. Fig. 3884.) Throughout the entire figure is shown the tendency of the lymphatics to follow the blood-vessels and partly to surround them. The preparation was made by injecting Hoyer's chrome yellow mass into the appendix vermiformis, when it extended into the submucosa of the adjoining part of the cecum (see Fig. 3884). The blood-vessels were then injected with fine red gelatin mass from the superior mesenteric artery. After the gelatin had cooled the cecum was distended with alcohol, and the preparation finally mounted in Canada balsam.

1. The central and peripheral nervous system, the eye and internal ear. The lymph in these situations is either in perivascular spaces, in perineural spaces, or larger special spaces.

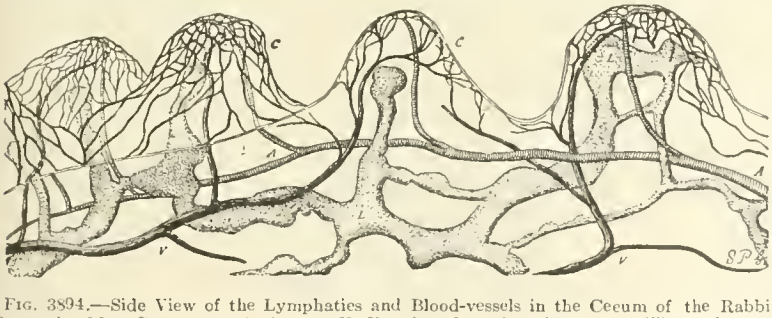


Fig. 3894.—Side View of the Lymphatics and Blood-vessels in the Cecum of the Rabbit. (Drawn by Mrs. Gage.) *A*, *A*, Artery, *V*, *V*, veins; *L*, *L*, lymphatics; *C*, villi. This figure shows the villus-like elevations persisting in the cecum of the rabbit (Hilton[12]) with the vascular and lymph vessels. It will be noted that the artery for each villus extends to the summit and breaks up into a network of capillaries which form a kind of mantle or tent. The lymphatics show the usual appearance, but with a kind of network in the villus at the right. On the left the whole villus is present at the top; on the right the part toward the observer has been removed from the two villi.

2. A lymphatic network has not been satisfactorily made out for cartilage. In bone perivascular lymphatics accompany the blood-vessels; they are absent from the osseous tissue proper. This appears true likewise of dentine and enamel.

3. All forms of epithelia, including hair and nails.

4. Cornea and sclera and possibly some other dense connective tissue structures (dura mater, etc.). The loose connective tissue of the body (areolar tissue, reticular tissue) forms the pathway for the lymphatic as for the blood-vessels.

Fig. 3895.—Endothelial Cells from a Small Lymphatic Capillary of the Central Tendon of the Rabbit. This figure shows well the characteristic sinuous outlines and the nuclei of the endothelial cells. (Prudden.)

The ducts of some glands (as the pancreas) have never yet been shown to contain lymphatics, although in the ducts of other glands, as the liver, lymphatics have been shown in great numbers.

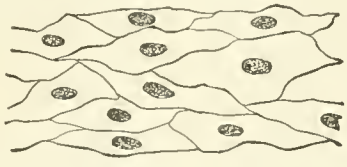


Fig. 3896.—Nucleated Endothelial Cells from One of the Larger Lymph Channels of the Central Tendon of the Rabbit's Diaphragm, to show the Elongated Form of the Cells in the Larger Vessels. (Cf. Fig. 3895.) (Prudden.)

The lymphatic capillary networks within the mucosa of the urinary bladder and of the uterus have not been adequately demonstrated.

These networks or plexuses of origin show considerable variety in different parts of the body. As a rule, the lymph capillaries are considerably larger than the blood capillaries (Figs. 3893, 3894), and there is a great tendency to form blind, often ampulliform enlargements (Fig. 3894). In the villi of elongated narrow form, the origin by a blind central vessel is normal, or there may be a simple loop instead. In man, where the villi are mostly short and broad, there is a complicated network something like the blood capillaries, except that the lacteal capillaries are much larger. The simple blind end and loop are also seen in some of the more elongated villi. The presence of ampulliform enlargements, or even blind endings, in a vessel is not enough to determine whether it is a blood-vessel or a lymphatic, for some blood-vessels in muscle (Ranvier) and in the dura of the brain (Key and Retzius) have the form which is usually considered so characteristic of lymphatic vessels. The final test must be the connections of the

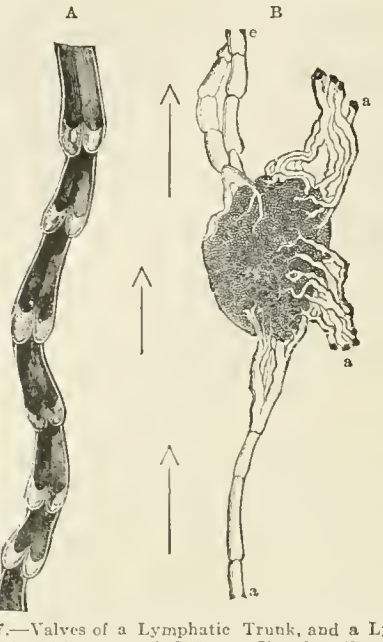


Fig. 3897.—Valves of a Lymphatic Trunk, and a Lymphatic Node with its Afferent and Efferent Vessels. (Sappey.) *A*, Lymphatic trunk slit lengthwise and opened to show that the valves are in pairs—they are close together and they are at the level of the enlargements; further, that the intervalvular segments are in general of a conical shape, the apex of the cone pointing in the direction of the current, up in this figure. *B*, Lymphatic node; *a*, *a*, *a*, the numerous afferent lymphatic vessels; *e*, the two voluminous efferent lymphatics.

vessel with a lymphatic node or with an undoubted blood-vessel.

Structure of Lymphatic Vessels.—Beginning with the lymph capillaries the wall is composed only of endothelial cells arranged mostly in the form of a tube. They may, however, be more like flattened clefts, the walls of which are in apposition except when containing lymph. The lining cells have sinuous edges (Fig. 3895). On the larger vessels the lining endothelium has more elongated cell outlines (Fig. 3896), and there progressively appear coats like those of the blood-vessels, except that they are thinner. The adventitia is easily separated from the vessel, is composed of a network of fine elastic fibers and a few longitudinally arranged plane muscle cells. The middle coat has, besides the fine elastic tissue, many circularly arranged plane muscle cells. This circular arrangement is not strictly adhered to, especially in the thoracic duct. Finally the inner layer has its elastic fibers mostly in a longitudinal direction, and the endothelium covers the internal surface. In the thoracic duct there is usually a considerable addition of white fibrous tissue to the middle layer, and, as stated above, many of the muscular fibers of this layer may be oblique or even longitudinal. In general, then, the lymphatic vessels agree with the veins quite closely in structure. The amount and the fineness of the elastic tissue present is supposed to exert a marked influence in causing the speedy return of the vessel to its normal caliber after its distention by the lymph.

Like the veins, the lymphatics are distinguished by the presence of valves; but they are much more abundant, there being, for example, sixty to eighty double valves from the hand to the axilla (Fig. 3897). In examining a well-injected preparation, it is very easy to determine the direction of the lymph stream as the segments of the vessel are approximately conical, the apex of the cone pointing in the direction of the stream (Fig. 3897). This is more marked in the smaller than in the larger vessels.

Valves are not found in the lymphatics of fishes, and are much less numerous in the other groups than in mammals.

Lymphatic Nodes or Glands and Lymphoid or Lymphatic Tissue.—The lymphatic nodes, glands or ganglia or conglobate glands, lymphoglandulæ, are rounded or flattened bodies placed in the course of the lymphatic vessels. These structures were known to Hippocrates, but were regarded by him as forming a part of the general glandular system. Naturally their true nature was discovered only after the discovery of the lymphatic vessels. In the higher mammals it is believed that no lymphatic vessel reaches one of the common terminal trunks without first traversing one or more of these nodes. They first appear in the birds, or perhaps some of the highest reptiles, but lymphatic tissue appears to be present in all the vertebrate forms; and as the nodes are practically concentrations of this tissue their absence is not so important as might at first appear. The nodes are sometimes solitary but usually are in groups or chains; they are mostly near blood-vessels, and so placed and loosely attached that they readily move aside to avoid pressure. In the limbs pressure is further avoided by position in the flexures of the joints. The nodes vary greatly in number and size in the different mammals. In man they reach the highest number (500 to 600) and vary from a few millimeters to two or more centimeters in diameter.

Afferent and Efferent Vessels.—The vessel approaching a node is said to be afferent or inferrent; the one leaving the node is called efferent. On approaching a node the afferent usually breaks up into several smaller vessels which enter the node (Figs. 3897 and

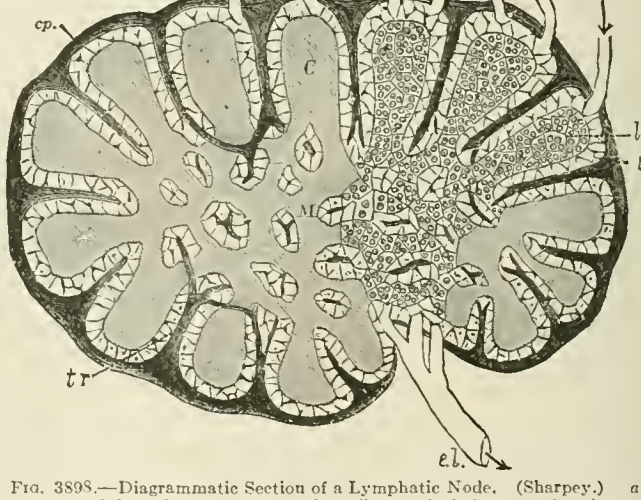


Fig. 3898.—Diagrammatic Section of a Lymphatic Node. (Sharpey.) *a*, *l*, Afferent trunk breaking up into several smaller trunks before entering the node; *e*, *l*, efferent lymphatic trunk formed by the union of several smaller trunks emerging from the node (the arrows indicate the direction of the current); *C*, cortical glandular substance; *cp.*, capsule sending septa into the node; *l.h.*, reticulated cords of medullary substance (it is shown in only a small part of the figure; the entire area shaded with lines possesses similar structure); *l.s.*, lymph sinus or channel; *M*, central or medullary part of the node (it is directly continuous with the cortical substance); *tr.*, trabeculæ or fibrous substance continuous with the capsule and forming a coarse meshwork in the node (in this mesh is the lymphatic tissue).

3898). After traversing the node the vessels leaving the surface unite usually in larger trunks than the afferent vessels, and continue to the next node, where the process is repeated, or the vessel may terminate in one of the common trunks.

Fig. 3899.—Section through Entire Human Lymphatic Node, Including Hilum. ×15. Dark zone, cortex; light central area, medulla. *a*, Lymphatic nodule of cortex; *b*, germinal centers; *c*, trabeculæ containing blood-vessels; *d*, capsule; *e*, hilum; *f*, lymph sinus of medulla; *g*, lymphatic cords of medulla; *h*, lymph sinuses of medulla and cortex. (From Bailey, Text-book of Histology.)

The structure of the lymphatic nodes was long enigmatical. It was held by many, and is still so held, that the node was really a kind of fine capillary network, like a renal glomerulus, or a rete mirabile, of blood-vessels; but it is now quite generally agreed that a lymphatic node consists of the following parts: (1) A fibrous framework forming an enclosing capsule and sending into the interior a multitude of anastomosing trabeculæ. The capsule and larger trabeculæ may also contain plane muscle cells. (2) Embedded in the meshes of this fibrous network is the proper glandular substance, which consists of lymphatic tissue; that is, a fine network of branching and anastomosing cells and fibers containing in their meshes lymph corpuscles or young lymphocytes. Near the surface of the node the lymphatic tissue is arranged in quite regular masses (cortical lobes or aveoli) by the projecting trabeculæ (Fig. 3898). In these, in young individuals, centers of cell proliferation (germinal centers; nodules) occur (Fig. 3899). This is the so-called cortical portion, while in the central part (medullary portion) the lymphatic tissue is in more cylindrical masses (the medullary cylinders or lymphatic cords), but the tissue in the two parts is directly continuous. (3) The lymph sinus or channel. This is the path taken by the lymph in passing through the node from the afferent to the efferent vessels. It is a narrow space filled with rather coarse reticular tissue, between the proper cellular substance and the fibrous framework (Fig. 3893, *l.c.*; 3894, *h*). The relations of this space may be clearly understood by comparing the fibrous framework to a mould and the proper lymphatic tissue to the material poured into the mould and which, upon cooling, had shrunken evenly from the mould throughout the entire node, thus leaving a narrow space which would represent the lymph channel. The afferent lymph vessel penetrates the sheath or capsule of the node and pours its contents into the lymph sinus. The lymph then slowly moves along the labyrinthine channels until it reaches the efferent vessels, when it enters them and continues toward the common lymph trunk. In passing through the sinus the lymph bathes the lymphatic tissue and probably soaks into it. Along the edge of the channel the newly developed lymphocytes enter the lymph stream and are carried along to the efferent vessel.

Blood-vessels are very abundant in the lymphatic nodes and are found almost exclusively in the lymphatic tissue. These blood-vessels are also accompanied by nerves. In some nodes the efferent vessels and the blood-vessels are found mostly in a small depression which, in analogy with the kidney, has been called the hilus. This is not a marked feature and is absent in many cases.

In infancy and youth the nodes near the surface are grayish in color while those in the interior of the body are pinkish. In adult and advanced life the nodes are usually somewhat atrophied and darker in color, and those of the bronchial plexus are often dark brown or even black.

Lymphatic, lymphoid or adenoid tissue, which is the characteristic structure of the lymphatic node, consists of a fine network of branching and anastomosing cells or fibers (reticular connective tissue) with the meshes crowded with lymphatic cells (Fig. 3900). Sometimes this tissue is quite sharply defined, when it is called a follicle or simple lymphatic node in other situations it is diffuse. The tissue is sparingly supplied with blood-vessels, and the lymphatic vessels are mostly on its surface as a perinodular network (Fig. 3901). The diffuse and follicular form of the tissue is found in great abundance in the alimentary canal of man and the lower animals and in the mucous membranes of the respiratory passages. In the palatine tonsils,

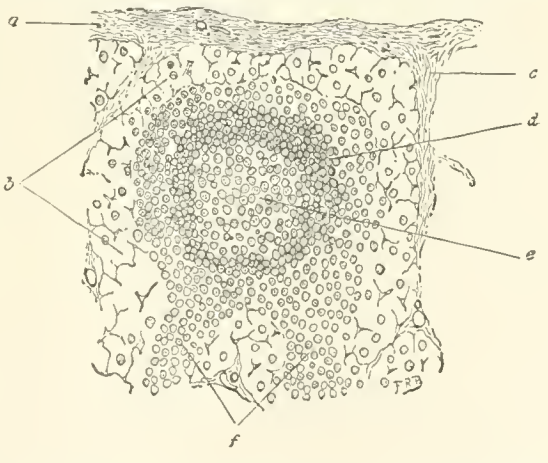


Fig. 3900.—Section through Cortex and Portion of Medulla of Human Lymphatic Node. *a*, Capsule; *b*, lymph sinus; *c*, trabecula; *d*, closely packed cells at outer border of lymphatic nodule; *e*, germinal center; *f*, lymphatic cords in medulla. (From Badey, Text-book of Histology.)

the lingual tonsil, and the pharyngeal tonsil it is aggregated in considerable masses; so also in the Peyerian patches, which are simply an aggregation of lymph nodules, follicles, or solitary nodes. The mucosa of the vermiform appendix of the rabbit (Fig.

3884) and man is almost entirely occupied by a great Peyer's patch; and the so-called solitary nodes (Fig. 3901) are lymphatic nodules or follicles with a dense meshwork containing blood capillaries and filled with lymph corpuscles. They are surrounded by a capillary network which helps to separate them somewhat from the surrounding less condensed lymphatic tissue (Fig. 3901).

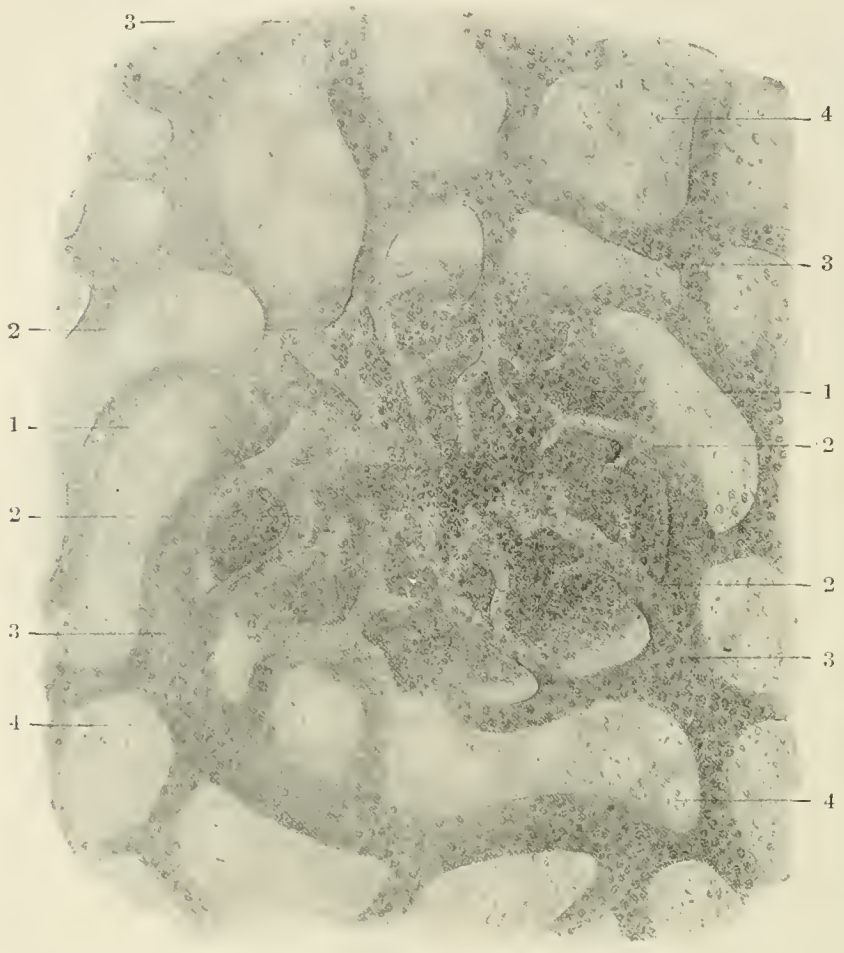


Fig. 3901.—Lymphatic Vessels arising from a Lymph Follicle or Solitary Nodule of the Large Intestine of Man. (Sappey, Atlas.) Magnified 100 diameters and reduced about one-fourth. 1, Lymph follicle seen from the submucosa; 2, 2, 2, 2, lymphatic radicles arising in the depth of the follicle and appearing on the surface; 3, 3, 3, trunklets formed by the union of the smallest radicles; 4, 4, base of the crypts of Lieberkühn.

Hemolymph Glands.—Deep red or chocolate-colored bodies from one to twenty millimeters in diameter with the general structure of lymph nodes but with the sinuses filled with blood instead of lymph.

In structure the parenchyma of these nodes resembles spleen or red marrow (splenolymph or marrow-lymph nodes). The nodes resembling spleen are most common. Intermediate or transition forms between hemolymph nodes and the ordinary lymph nodes occur.

Hemolymph nodes have been reported in the following animals: Hen, turkey, rat, dog, sheep, goat, ox, pig, horse, and in man. They occur most frequently along the great blood-vessels, especially those of the abdomen. They are most easily found in the root of the mesentery, and in the neighborhood of the renal and adrenal vessels. In the cervical region they are commonly near the parathyroids (Warthin[9] and vol. V. of this Handbook). Their nature and significance is not yet determined.

Development of the Lymphatic System.—While in the past, and up to the present hour, much serious study has been given to the development of the lymphatic system in the embryo, the matter remains in a far from satisfactory condition. From the time when this system was discovered and worked out, in the adult it has been known that it is an appendage of the venous system. It has also been known for many years that the lymphatic system develops considerably later than the blood-vascular system. In both the blood- and lymph-vascular systems it is clear that the cellular lining or endothelium constitutes the fundamental structure and appears first in development, whatever there is being added to it from the embryonic connective tissue surrounding it. Thus the problem of the ontogenesis of the lymphatic system is that of its endothelial lining. It should also be stated that, once formed, the vascular epithelium, or endothelium —both in the blood- and lymph-vascular systems— possesses a marked power of *growth*, showing itself in the extension of channels, regeneration after destruction of definite areas, and pathologically (endotheliomata). The difficulty therefore that attends an understanding of the development of the lymphatic system lies in the interpretation of the first appearance of the endothelium. Disregarding the older views of the mode of origin and development of the lymphatic system in the embryo, at the present time interest centers on two interpretations seemingly mutually irreconcilable.

I. The one is that the lymphatics of the body develop as mesodermal (mesenchymal) spaces—that is, spaces in the embryonic connective tissue—which by confluence form the lymphatic channels. These spaces are in part perivascular (perivenous; perintimal), in part formed independently of the venous pathways, although usually accompanying embryonic venous channels. These primary lymphatic spaces are not derived from the veins (or arteries) in the embryo and their lining endothelium is developed out of the mesenchymal cells bordering the space at its first appearance. Junction with the veins (as at the angulus venosus) is accomplished through intermediation of a venous element with which the lymphatic channels connect up. This view is particularly supported by Huntington[23] and by McClure as a result of extensive studies, particularly on the development of the lymphatics of the cat. Fig. 3902 gives Huntington's diagram of the plan of develop-

ment of the great lymphatic trunks (thoracic duct, right common duct), in which the middle section, the azygous segment, was formed by the union of mesenchymal spaces, largely periintimal, constituting an extensive network. (Compare, above, the section

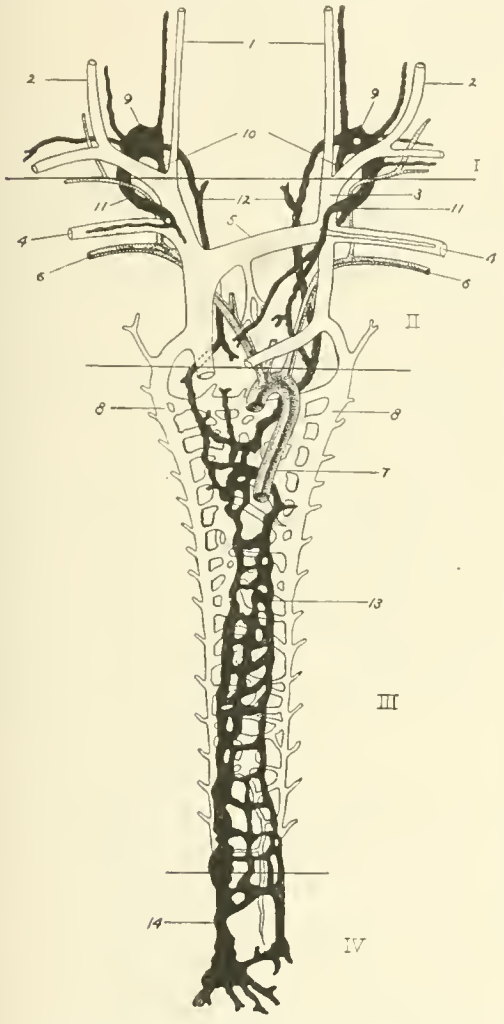


Fig. 3902.—Schema, from Huntington,[23] to show the Developmental Relations and Segments of the Thoracic Duct in the Cat According to Huntington, particularly the network of the "azygous segment" interpreted by him as arising from the confluence of extravenous (azygous) mesenchymal spaces. The general boundaries of the segments are represented by cross lines, they are: I, The jugular lymph sac; II, the preazygous segment; III, the azygous segment; IV, the postazygous segment. The lymphatics are shown in black, the arteries are shaded, while the veins are in outline only—unshaded. 1, Internal jugular vein; 2, external jugular vein; 3, common jugular vein; 4, subclavian vein; 5, left innominate vein; 6, subclavian artery; 7, aorta; 8, right and left azygous veins; 9, jugular lymph sac; 10, 11, jugular and subclavian taps or lymphatic-venous junctions, respectively—as in the cat the lymphatics frequently connect with the veins at the base of the neck, in two places; 12, thoracic duct, preazygous segment; 13, thoracic duct, azygous segment; 14, postazygous segment of the thoracic duct.

dealing with the relations and variations of the thoracic duct.)

II. Vigorously defended, particularly by Sabin,[22] is the view that the lymphatic system is derived entirely as a series of outgrowths from the veins at certain definite localities, namely; (*a*) from the jugular lymph sac, developed from the anterior cardinal vein on either side, and marking the place where the great trunks will empty into the veins at the angulus venosus. From these sacs grow out (Fig. 3903) the lymphatics of the cephalic portion of the body, including a part of the thoracic duct; (*b*) from the retroperitoneal preaortic) lymph sac (or sacs?), derived from mesonephric veins and furnishing the lymphatics for all the abdominal viscera with the exception of the kidney; (*c*) from the iliac sacs* coming as paired outgrowths also from mesonephric veins. From them develop the remaining lymphatics of the lower portion of the body (abdominal wall, kidney, legs), and the cisterna chyli. The thoracic duct is thus formed by the union of venous outgrowths from two localities. According to this interpretation the lymphatic endothelium is genetically derived from the venous endothelium, the lymphatic channels are from the beginning

Fig. 3903.—Injection of the Right Jugular Lymph Sac in Fetal Pig Measuring 3.5 Centimeters. Magnified about ten times. (After A. H. Clark.) The preparation was cleared by the Spalteholz method so that it shows the relation of the superficial lymph vessels to the jugular sac. It shows a complete injection of the suprascapular and occipital plexuses, but an incomplete injection of the superficial cervical plexus. *S.s* = the stalk of the sac showing faintly through the shoulder; *V.l.f.* = vena linguofacialis. In illustration of the interpretation that the lymphatics are developed as outgrowths from the veins; in this locality from the jugular lymph sac, itself a derivative of the venous system. (Sabin.[22])

continuously connected with the veins from which they sprouted, the peripheral or growing ends being from the beginning blind tubes (Figs. 3904 and 3905). A fundamental distinction exists between lymphatic spaces and tissue spaces; to the latter the lymphatic capillaries bear the same relation as do the blood capillaries. Mesenchymal spaces are but embryonic

* The lymphatic sacs above mentioned are generally homologized with lymph hearts of lower forms. See Sabin[22] and also Huntington.[23]

connective-tissue spaces; to the latter, the lymphatic capillaries bear the same relation as do the blood capillaries.

Lewis, F. T., in 1906, from conditions found by him in rabbit embryos, described the lymphatic vessels as appearing first along the course of veins and apparently derived from the veins by budding—not in a limited number of definite places but in many. His observations (not interpretations) might be brought forward in support of either view.

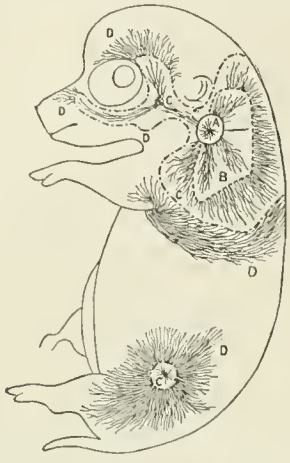


Fig. 3904.—Composite Picture of the Spreading of the Superficial Lymphatics in the Embryo Pig. (Sabin.) *A*, Area of lymphatics in a pig eighteen millimeters long; *B*, area in a pig twenty millimeters; *C*, area in a pig thirty millimeters long; *D*, area in a pig forty millimeters long. In the stages shown there are no lymphatics beyond the outlines indicated. In illustration of the view that the lymphatics are developed by centrifugal growth from the veins in two regions.

Between these two interpretations a final decision is impossible. The problem of the ontogenesis of the lymphatic system is but part of that of the entire vascular system. Two views exist as to the origin of the blood-vascular epithelium; one, that the cells are of mesenchymal (embryonic connective tissue) origin, the other that they come from an embryonic tissue early set apart in development as the parent tissue for all vascular endothelium, both in the blood and in the lymph vascular systems, the *Angioblast.*

Quite the same divergent views exist as to the origin of lymphatic or lymphoid tissue, and the problem is but a part of that of the blood cells in general. One doctrine is that all blood cells including the cells of lymphatic tissue are descendants of cells early differentiated in development (mesameboid cells). Certain of these cells find their way into the mesenchyme there subsequently by proliferation to give rise to the cells of lymphatic tissue as well as various forms of blood cells. The angioblast is believed to be the source of such primitive blood cells as well as the vascular endothelium. The alternative view is that the mesoderm (mesenchyme) is the source of the lymphatic tissue and the blood cells particularly at certain foci and in partienlar organs.

The lymphatic glands are developed from a network of lymph vessels by an ingrowth of lymphoid tissue and by the formation of a connective-tissue capsule around the outside.

Methods.—The lymphatic vessels are so thin that unless they contain some liquid or solid they are not visible. One of the first ways of making the general lymphatics visible was to inject water or colored gelatin into the arteries of an organ. The mass exudes and fills the lymph vessels; this is especially successful if the vein is tied. The lacteals are made evident by feeding the animal some fatty food, like milk, an hour or two before death.

Vessels of sufficient size may be injected centrad with starch or plaster-of-Paris. It is not necessary to tie the cannula in place; simply pressing upon it with the fingers is sufficient. The insertion of the cannula is greatly facilitated by first inserting a beaded bristle into the lymphatic, then by raising the bristle the cut in the vessel may be seen. Where the vessels are too small to be seen, very successful injections may be made by the puncture method. That is, a hypodermic cannula is connected with a syringe or a constant-pressure apparatus, and inserted where lymphatics are supposed to be. The cannula is forced in as in ordinary hypodermic injections, and the mass allowed to flow or it is forced in. If the attempt is successful, the fine network and collecting trunks of a limited area will be injected. The toes and the finger-tips of man are favorite places for injection. In animals the pads of the feet and the bare spot on the snout are good. A lymphatic gland is always easy to inject. For an injecting mass mercury was much used by the older anatomists. Colored gelatin was also used and is now much more employed than mercury as it flows readily through the lymph glands. An excellent gelatin mass is Hoyer's chrome yellow: dry gelatin, fifteen grams; water, 75 c.c. After the gelatin is softened it is melted over a water-bath and heated to 80° C., then 75 c.c. of a cold saturated solution of bichromate of potash, heated to 80° C., is added to the gelatin; finally, 75 c.c. of a cold saturated solution of acetate of lead is heated to 80° C. and added with constant stirring. Berlin blue in gelatin is preferable for microscopic specimens (Plate XLIV, and Fig. 3894). India ink in water isa lso of great service, especially in embryos.[10]

An injection mass employed by a number of recent workers is the oil paint mass of Gerota (consult Bartels[15] for formulæ, etc.). Different colors may be used (blue, green, black). The following formula illustrates the technique: Prussian blue oil paint, two

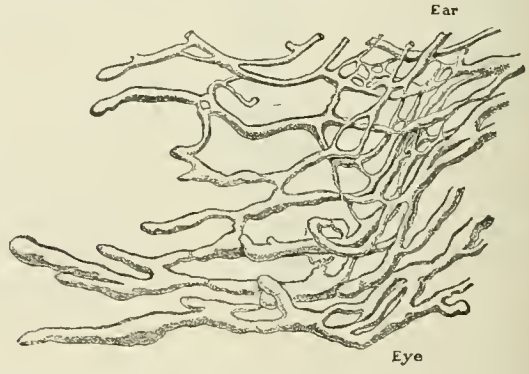


Fig. 3905.—Terminal Lymphatics of the Skin between the Eye and Ear in a Pig Fifty Millimeters Long. ×11. (Sabin.) To illustrate the view of the centrifugal growth of the buds in lymphatics as growing from the veins.

grams, is thoroughly rubbed up with three grams pure oil of turpentine and fifteen grams ether, in a mortar, and then strained through several layers of fine muslin or chamois skin wet with turpentine. In injecting the puncture method is employed. The percentages giving best results will vary somewhat with the kind of paint and its density.

The puncture method was used by Hunter, Mascagni, and Cruikshank. Cruikshank, in his "Anatomy of the Absorbing Vessels" (1790), p. 44, says: "I have sometimes injected the lacteals from punctures made by the side of the veins where I knew they must be, though they were then invisible to the naked eye." He also injected the lymphatic glands by puncture.

Young animals are best for studying the lymphatics, and the leaner the animal the better. For

investigating the embryology of the lymphatics, embryos in which the heart is still beating are best. After the embryos are cold they cannot be satisfactorily injected (Sabin[10]). In man lymphatics have been demonstrated in organs in the fetus when they could not be in the adult. Mature animals are better for the lymphatics of the reproductive organs; and, for the pancreas, an old man or animal is to be chosen.

SIMON HENRY GAGE.
Revised by B. F. KINGSBURY.

BIBLIOGRAPHY.

The writer wishes to express his great indebtedness to Professor Wilder for generous supplies of material for investigations in the comparative anatomy of the lymphatic system, for aid in purchasing costly works, and for hearty encouragement; to the library of the Surgeon-General's Office for the loan of rare and valuable works of reference, and, finally, to the editor for encouragement and suggestions.

In preparing the article free use has been made of the larger works on physiology: Flint's treatise, Landois and Stirling; Milne-Edwards, Leçons, etc. In human anatomy, Allen, Gray, and Quain in English; Sappey in French; Henle, Krause, Gegenbauer, and Hoffmann in German. The clinical remarks are especially complete and satisfactory in Allen; many very suggestive remarks are also made in Sappey's Atlas. In comparative anatomy the works of Owen, Gegenbaur, and Parker's translation of Wiedersheim, in English, and Milne-Edwards' Leçons, in French, are the most satisfactory. For the bibliography of the subject Mascagni, Milne-Edwards, Hoffmann, and Robin (see[5] below) are especially commendable, as is also the Index Catalogue of the Surgeon-General's library.

Specific references have been made to the following:

For the more recent bibliography of the lymphatic system, the reader is referred to Bartels, Sabin (Nos. 15 and 22).

1. Sappey, Ph. C.: Description et Iconographie desVaisseaux lymphatiques considérés chez l'Homme et les Vertébrés, folio, p. 156, 48 plates, Paris, 1886. Also Traité d'Anatomie, descriptive, third edition, Paris, 1876.

2. Key and Retzius: Studien in der Anatomie des Nervensystems und des Bindegewebes, two folio vols., 75 plates, Stockholm, 1875 and 1876.

3. Alexander, A.: Ueber die Lymphcapillaren der Chorioidea. Arch. f. Anat. und Phys., Anat. Abth., p. 117, 1889.

4. Breschet, G.: Le système lymphatique consideré sous les rapports anatomique, physiologique, et pathologique, Paris, 1836, 304 pp., 4 Pl.

5. Robin, Ch.: On the Perivascular Lymphatics of the Central Nervous System, in Journal de la Physiologie de l'Homme et des Animaux, vol. ii., pp. 537–548, 1859; Journal de l'Anatomie et de la Physiologie Normale et Path., vol. iv., pp. 1–34, 1867; Article, Système Lymphatique, in Dechambre's Dictionnaire des Sciences médicales, pp. 386–474, 1870. At the end of this article are over seven pages of bibliography.

6. Krause: Handbuch der menschlichen Anatomie, third edition, 1879.

7. Klein, E.: The Anatomy of the Lymphatic System, 2 vol., 16 plates.

8. Recklinghausen, F.: The Lymphatic System, in Stricker's Histology.

9. Warthin, A. S.: The Normal Histology of the Human Hemolymph Glands. Amer. Jour. Anat., vol. i., No. 1, pp. 63–79. See also article on Hemolymph Glands in vol. v. of this HANDBOOK.

10. Sabin, Florence R., M.D.: On the Origin of the Lymphatic System from the Veins, and the Development of the Lymph Hearts and Thoracic Duct in the Pig. American Journal of Anatomy, vol. i., pp. 367–389, 1902.

11. Waldeyer, W.: Mikroskopische Anatomie der Cornea, Sklera, Lider und Conjunctiva. Graefe-Sämischs Handb. d. Augenheilk., 1874, vol. i., p. 169.

12. Hilton, W. A.: The Morphology and Development of Intestinal Folds and Villi in Vertebrates. Amer. Journ. Anat., vol. i., No. 4, 1902.

13. Mascagni, Paulo: Vasorum lymphaticorum corporis humaoi Historia et ichnographia, folio, mdcclxxxvii, (1787).

14. Gutman, G.: Ueber die Lymphbahnen der Cornea. Arch. f. mikr. Anat., vol. xxxii, 1888, pp. 593–602.

15. Bartels, P.: Das Lymphgefässsystem. in Handbuch der Anatomie des Menschen., vol. iii., Pt. 4, Jena, 1909. von Bardeleben, Editor. See his bibliography.

16. Most, P.: Ueber den Lymphapparat von Nase und Rachen. Arch. f. Anat. u. Physiol. Anat. Abt., 1901, pp. 74–94. For other papers, see Bartels.

17. Schwalbe, G.: Der Arachnoidalraum ein Lymphraum und sein Zusammenhang mit dem perichorioidealraum. Centralbl. f. d. med. Wiss., 1869, pp. 465–467.

18. Cuneo, B. et Andre, Marc: Relations des espaces perimeningées avec les lymphatiques des fosses nasales. Bull. Soc. Anat. Paris, 1905, vol. lxxx., pp. 58–63. See also Delamere, Poirier, et Cuneo.

19. Sakata, K.: Ueber die Lymphgefässe des Esophagus und über seine regionären Lymphdrüsen mit Berücksichtigung der Vorbereitung des Carcinoms. Mitt. aus d. Grenzgebiet d. Med. u. Chirurg., vol. ii., 1903, pp. 634–656.

20. Davis, H. K.: A Statistical Study of the Thoracic Duct in Man. Amer. Journ. of Anat., vol. xvii., 1915.

21. Delamere, G., Poirier, P., and Cuneo, B.: The Lymphatics. Translation by C. H. Leaf. Chicago, W. T. Keener & Co. 1904. 301 pp., 117 Figs.

22. Sabin, Florence R.: The Origin and Development of the Lymphatic System. The Johns Hopkins Hospital Reports. Monographs, N. S., No. V, 1913, 9 4 pp., 19 Figs. See also other papers in bibliography contained. Also: in Merkel u. Bonnet; Ergeb. d. Anat. u. Entwgesch., vol. xxi., 1914 (covering the same ground as the above paper).

23. Huntington, G. S.: The Anatomy and Development of the Systemic Lymphatic Vessels in the Domestic Cat. Memoirs of the Wistar Institute of Anatomy and Biology. No. 2, 1911, p. 175, Fig. 275. For other titles by himself and by McClure, consult the above.

Lysidin.—Ethylene-acetamidine—($NCH_2.NHCH_2.CCH_3$)—is freely soluble in water and alcohol, and is insoluble in ether. The drug, on account of its hygroscopic nature, is marketed only in fifty-per-cent. aqueous solution, a pale-yellow liquid with soapy feel.

Lysidin is a near relative of piperazine and, like the latter, has a noteworthy value in gouty conditions. The dose is 2 to 10 c.c. (5 ss.–iiss.) of the solution daily, given with large quantities of water.

W. A. BASTEDO.
R. J. E. SCOTT.

Lysin.—Lysins are antibodies of Ehrlich's third order and are conceived of as possessing two haptophore groups, one for union with the molecule of the cell, the other which combines with complement and allows it to exert its action on the cell. Since in many instances the cell does not undergo complete lysis or solution a better term for these antibodies is cytotoxin (*q.v.*). An exception to this rule is seen when the antigen is an erythrocyte when the resultant hemolysis brings about complete destruction of the red cells. Some of the bacteria also undergo lysis so that it has been suggested that the antibodies of the third order be divided into hemolysins, bacteriolysins and cytotoxins. So far as our knowledge goes these substances are identical except that they are called forth by the injection of different antigens.

RALPH G. STILLMAN.

Lysine.—α-ε-diaminocaproic acid,

$$\begin{array}{l} NH_2 \qquad\qquad NH_2 \\ | \qquad\qquad\quad | \\ CH_2.CH_2.CH_2.CH_2.CH—COOH, \end{array}$$

one of the so-called "hexone bases" is a basic body produced from various proteins by hydrolytic cleavage. In some of the vegetable proteins as zein and gluten it is absent. Upon putrefaction it yields cadaverine. See *Ptomaines*.

F. P. U.

Lysoform is a liquid containing lysol and formaldehyde, and in five per cent. solution is said to possess powerful bactericidal qualities. As it is, moreover, cheap and inodorous, it is a popular disinfectant.

R. J. E. SCOTT.

Lysol.—This is a proprietary preparation of cresol introduced to supersede creolin, the best-known solution of this valuable disinfectant. The advantages claimed for lysol over the other cresol compounds are that it forms a clear solution when mixed with water and contains a greater amount of cresol. It is prepared by dissolving the cresols in fatty matter

and subsequently saponifying by the addition of alcohol. It is a brown, oily-looking, clear liquid, with a feeble, aromatic, creosote-like odor. It is said to contain fifty per cent. of cresol. Its solution forms a soapy, frothing fluid, which becomes turbid only when mixed with hard water, the extent depending upon the quantity of lime salt present; this turbidity increases upon standing for some time. Lysol mixes freely with alcohol, glycerin, chloroform, and benzene.

For disinfecting the hands, a five-per-cent. solution is used.

On mucous surfaces, when used in stronger solution than two per cent., it causes a burning and painful sensation which lasts for some time, but otherwise is perfectly unirritating. BEAUMONT SMALL.

Lytton Seltzer Springs.—Sonoma County, California.

POST-OFFICE.—Lytton. Hotel and cottages.

These excellent seltzer and soda springs are located about four miles north of Healdsburg, on the line of the San Francisco and Northern Pacific Railroad. Some of the waters are used commercially. The water is slightly acid when first drawn, but by exposure it loses its carbonic anhydride and becomes alkaline. The following comparative analysis of the soda, seltzer and Carlsbad springs has been made:

	Grains per Gallon		
	Soda	Seltzer	Carlsbad
Sodium chloride	8.93	79.34	44.06
Sodium bicarbonate	21.16	6.29	7.30
Sodium carbonate	4.97	72.73	.....
Potassium carbonate	trace	3.60	.....
Magnesium bicarbonate	9.03	13.90	.....
Potassium sulphate	.....	.....	4.11
Sodium sulphate	2.60	.....	29.22
Sodium borate	.....	.....	9.10
Calcium bicarbonate	.....	14.05	.....
Calcium carbonate	4.90	.....	6.70
Calcium sulphate	.....	5.03	.....
Magnesium sulphate	1.14	6.75	.....
Lithium carbonate	.....	.....	0.12
Barium carbonate	.....	.....	0.30
Strontium carbonate	.....	.....	0.04
Calcium phosphate	.....	.....	0.38
Ferrous carbonate	2.09	2.14	.....
Alumina	.....	6.81	traces
Magnesium carbonate	.....	.....	26.04
Iron carbonate	.....	.....	2.60
Silicia	3.75	8.09	4.80
Magnesia carbonate	.....	.....	0.08
Borates	.....	4.43	.....
Lithium	.....	trace	.....
Ammonia	.....	0.33	.....
Organic matter	traces	traces	traces
Total solids	58.57	223.49	134.85

A previous analysis showed 228.69 grains in solids and 383.75 grains in carbonic anhydride to the United States gallon The temperature of the water is 62° F. It is much used as an antacid in dyspepsia, and in uric-acid states. The water has aperient and diuretic properties. EMMA E. WALKER.

MacClellan, George.—Born at Woodstock, Connecticut, Dec. 23, 1796. He studied medicine at the University of Pennsylvania, in Philadelphia, and received the degree of Doctor of Medicine from that institution in 1819. He was elected resident physician to the hospital of the Philadelphia Almshouse in 1818, one year before he graduated. He settled in Philadelphia, and already during the first year of his practice he had performed many of the most important operations in surgery. "He opened a dissecting room and gave private courses of lectures, both on anatomy and on surgery, displaying that same vivacity of manner which characterized him through life, and he became an attraction to medical students. His attentive class consequently became very soon so numerous as to require for their accommodation a larger room. His more public career as a lecturer began in 1826, when he founded the Jefferson Medical College. . . . During the latter part of Dr. MacClellan's life, he obtained one of the largest

FIG. 3906.—George MacClellan.

practices known in the country; his name had extended to the Old World, and on this continent he attracted patients from all parts of our Union, and the West Indies and South America. Few men in private practice have operated so frequently. . . . In ophthalmic surgery he was particularly eminent. . . . The extirpation of the parotid gland, so long a mooted point and source of serious contention among surgeons, was performed by him several times, most of which were successful" (Stone). He died in Philadelphia, May 9, 1847.

MacClellan's "Principles of Surgery" is the only large treatise which he appears to have written.

A. H. B.

MacCormac, Sir William.—Born in Belfast, Ireland, January 17, 1836. He studied medicine in Dublin, London, Paris, and Berlin, and became a member of the Royal College of Surgeons of England in 1857. He began the practice of his profession in Belfast in 1861, and during the Franco-Prussian War (1870–1871) he was Surgeon-in-Chief of the Anglo-American Ambulance at Sedan. He afterward published an account of this experience under the title: "Notes and Recollections of an Ambulance Surgeon," 1871. In 1876 he again saw active service as a surgeon in the war between Turkey and Servia. In 1881 he was made a baronet. He was consulting Surgeon and Emeritus Professor of Surgery in St. Thomas' Hospital. He died at Bath, Dec. 4, 1901.

Of the various writings published by Sir William MacCormac the following deserve to receive special mention: "Antiseptic Surgery, its Principles and Practice," 1880; and "Abdominal Surgery." He also contributed articles on hernia, on injuries of joints, and on amputation of the thigh (more especially as compared with excision of the knee) to the Dublin Quarterly Journal, and on subastragaloid dislocation of the foot, on some cases of bleeders, and on excision of the scapula to the St. Thomas's Hospital Reports. A. H. B.

MacDaniel, Edward Davies.—Born in Chester County, South Carolina, July 7, 1822. In 1855 he began the study of medicine at the Medical

College of the State of South Carolina, at Charleston, and received the degree of Doctor of Medicine, from that institution in 1857. After graduation he settled in Camden, Wilcox County Alabama, and very soon built up a large practice. Early in the seventies the University of Alabama, conferred on him the honorary degree of LL. D. In 1887 he removed from Camden to Mobile, and very soon afterward was elected Professor of Materia Medica, Therapeutics and Clinical Medicine in the Medical College of Alabama. He died of pneumonia at Denver, Colorado, in June, 1898.

Dr. MacDaniel's most important contributions to medical literature are the following: "On Irritation of the Urinary Organs, Produced by Santonica and Santonine," *New Orleans Med. and Surgical Journal*, 1869; "On Hemorrhagic Malarial Fever in Alabama," Trans. of Alabama State Medical Association, 1874; and "On a New Method of Artificial Respiration and the Care of New-born Babies," Trans. of the American Medical Association (for 1869). A. H. B.

MacDowell, Ephraim.—Born in Rockbridge County, Va., November 11, 1771. Dr. MacDowell's early medical studies were prosecuted at the University of Edinburgh, under the guidance of John Bell. After a residence of two years abroad, MacDowell returned in 1795 to his home in Kentucky. He had acquired a great stock of anatomical and surgical knowledge, and his ambition to put this

Fig. 3907.—Ephraim MacDowell.

knowledge to practical use had received a powerful stimulus. Very soon after he had established himself in practice he began to manifest his great aptitude for surgical work. In a little while—to quote the words of Dr. Gross—"he commanded all the surgical operations of importance for hundreds of miles around him, and this continued till some years later when Dudley returned from Europe to share with him the empire in surgery. . . . In 1809 he performed his first ovariotomy." He did not realize at the time the very great importance of what he had accomplished; and it was not until 1817 that he published, largely from memory, a very incomplete account of the facts. These, according to the authority just quoted, are as follows: "In the autumn of 1809 Dr. MacDowell was consulted by Mrs. Crawford, the subject of a large ovarian tumor, whose case, from its novelty and the attendant circumstances, must forever remain memorable in the annals of our profession. After a most thorough and critical examination, Dr. MacDowell informed his patient, a woman of unusual courage and strength of mind, that the only chance for her relief was excision of the diseased mass. He explained to her with great clearness and fidelity the nature and hazard of the operation; he told her that he had never performed it, but that he was ready, if she were willing, to undertake it, and to risk his reputation upon the issue, adding that it was an experiment, but an experiment well worthy of trial. Mrs. Crawford listened to the surgeon with great patience and coolness, and, at the close of the interview, promptly assured him that she was not only willing but ready to submit to his decision; asserting that any mode of death, suicide excepted, was preferable to the ceaseless agony which she was enduring, and that she would hazard anything that held out even the most remote prospect of relief. The (entirely successful) result has been long before the profession. Mrs. Crawford submitted to the operation, and thus became the first subject of ovariotomy, of whom we have any knowledge." Dr. MacDowell's skill was exhibited equally in other capital operations—for example, in lithotomy, in operations for strangulated hernia, etc. His death occurred June 25, 1830. A. H. B.

Macis.—*Mace. Banda Mace.* The arillode of the seed of *Myristica fragrans* Houttuyn (fam. *Myristicaceæ*).

The origin and preparation of mace are fully explained under *Myristica*. It occurs in narrow bands, 2.5 centimeters (one inch) or more long, somewhat branched and lobed above, united into broader bands below; orange brown, exuding fat when scratched or pressed; odor fragrant; taste warm and aromatic. In the ground condition, mace has been grossly adulterated, especially with the wild or Bombay mace, from *Myristica malabarica*. This is longer and more slender, of much darker color, softer, weaker, and more flexible and contains very little volatile oil, but a good deal of resin, by means of which its powder is readily distinguished. Curcuma, ginger, and similar substances are also considerably used in the adulteration of mace, and are readily distinguished by a similar resinous nature, as well as by their starches.

A good mace contains eight per cent. or more of volatile oil, a large amount of fat, very little resin, a little sugar, and other ordinary vegetable constituents. It is free from starch. The ash should not exceed two per cent. and in a clean article is considerably less.

The volatile oil of mace is slightly heavier than that of nutmeg and is soluble in three parts of alcohol. It is of complex composition, being identical in this respect with oil of nutmeg, except that its content of terpene is somewhat smaller. Owing to this practical identity of the two oils and the greater cheapness of oil of nutmeg, it happens that commercial "oil of mace" is almost without exception oil of nutmeg.

The action, uses, and dosage of mace are those of nutmeg. Henry H. Rusby.

McGuire, Hunter Holmes.—Born in Winchester, Va., October 11, 1835. He received the degree of M. D. from the Winchester Medical College, in 1855. From 1856 to 1858 he held the Chair of Anatomy in the same institution. Throughout the Civil War he rendered valuable services, first as Brigade Surgeon under "Stonewall" Jackson (1861–1862) and afterward as Medical Director of the Second Corps, Army of Northern Virginia (1862–1865). At the close of the war he was elected Professor of Surgery in Virginia Medical College, Richmond, and he held this position until 1880. In June, 1892, Dr. McGuire was elected President of the American Medical Association. His death occurred September 19, 1900.

Among his numerous contributions to medical literature the following deserve to receive special mention: "Gunshot Wounds of Joints;" "Gunshot

and Other Wounds of the Peritoneum," "Ligation of Subclavian;" and "Injecting Male Bladder without the Use of a Catheter, and some of its Advantages."
A. H. B.

Mackenzie, Sir Morell.—Born in Leytonstone, Essex, England, July 7, 1837. He was a pupil of the London Hospital, and in addition he studied in Vienna, Budapest (under Czermak), and Paris. In 1862 he received the degree of Doctor of Medicine from the University of London, and soon afterward began practice as a throat specialist in London. He was one of the first in England to employ the laryngoscope. In 1863 he established the Hospital for Diseases of the Throat, an institution which before 1900 had received over 100,000 patients, and which served as the model for other similar hospitals in England and America. In 1888 he was made a baronet by Queen Victoria in recognition of the services which he had rendered to the Crown Prince of Prussia (subsequently Emperor Frederic III.). He died February 3, 1892.
A. H. B.

Macleod, Sir George Husband Baird.—Born in Campsie, Scotland, in 1828. He studied medicine in Glasgow, London, Paris, Berlin, and Vienna, and received his doctor's degree from the University of Glasgow in 1853. He was a surgeon in the British Army during the Crimean War, and had charge of the General Hospital in the camp in front of Sebastopol. In 1858 he published an account of his experience in this campaign, under the title: "Notes on the Surgery of War" (London, 1858; Phila., 1862). From 1859 to 1869 he was Professor of Surgery in Anderson's College in Glasgow, and subsequently he was chosen Regius Professor of Surgery in the University of Glasgow. At the same time he was made Surgeon-in-Ordinary to the Queen in Scotland, and the title of baronet was conferred on him. He died August 31, 1892.

Sir George Macleod is reported to have been a brilliant teacher. Of his published writings the following deserve to receive special mention: "Outlines of Surgical Diagnosis," 1864; "Surgical Affections of the Esophagus, Larynx and Pharynx," "Wounds of the Thorax," "Tracheotomy," "Ulceration," "Varix," and "Wounds"—all of these six articles in *Cooper's Surgical Dictionary;* and "Surgical Affections of the Neck" in the *International Encyclopedia of Surgery.*
A. H. B.

Macrobdella.—A genus of leeches with jaws which lack sensory papillæ. *M. decora* is the American medicinal leech. It is widely distributed in quiet water through the northern United States and Canada. See *Hirudinea.*
A. S. P.

Madder.—*Rubia.* The root of *Rubia tinctoria* L. (fam. *Rubiaceæ*). Rubia is a perennial herb, native of the Orient and extensively cultivated there. The dried root is cylindrical, elongated, 0.3 to 1 centimeter (⅛ to ⅜ inch) in diameter, externally dark reddish brown, internally somewhat lighter to pink. It is of soft texture, slight odor, and a sweetish, slightly astringent and bitter taste, tinging the saliva red. It is of complex composition, the source of its coloring matter being one or more glucosides which are decomposed by various processes employed in forming it. The drug has entirely lost its place as a medicinal agent and is now exclusively used for dyeing. Even this use has largely declined under the influence of the aniline dyes.
Henry H. Rusby.

Madeira.—The island of Madeira, the largest of the group of islands bearing that name, lies off the Morocco coast of Africa at a distance of about 360 miles, and about 300 miles to the north of the Canaries. It is one of the best types of the warm moist climates, and some fifty or more years ago was considered by the English the ideal climate for pulmonary tuberculosis and other lung diseases; much in the same way as Florida in this country was formerly regarded as the Mecca for consumptives. The extent of the island is about thirty miles from east to west, and thirteen miles wide. Extending from one end to the other is a range of mountains averaging 4,000 feet in height, with a maximum of 6,100 feet (Pico Ruivo, in the center of the island). The side ridges of this central chain extend to the coast in every direction, usually terminating in lofty headlands. The north coast is more precipitous and wilder than the south. The soil is fertile, and on the mountain slopes are gardens with luxuriant semi-tropical vegetation and vineyards.

Madeira belongs to Portugal and "the inhabitants are of Portuguese descent, with some admixture of Moorish and negro" (Solly). The population of the two inhabited islands, Madeira and Porto Santo, is about 134,000. Funchal, the capital and largest town of Madeira (population 22,000), lies upon the south coast, and is built around the curving shore of a bay, extending up the encircling hillside to a height of 350 feet or more above sea-level. It is sheltered from the northerly winds which are prevalent, by the mountain chain, and is the usual place of residence selected by invalids resorting to the island during the season which extends from September to May, though one can spend the summer comfortably on the island by going up into the mountains. The scenery is very attractive and varied. The roads are very steep, so that wheeled vehicles are rarely used, but in their place palanquins, sledges, and portable hammocks. The sanitation and water are good. The accommodations are excellent, there being several English hotels and furnished villas called "quintas" for rent situated at various elevations. There are also English and Scotch churches, and an English club and library. There are good fishing and sea-bathing all the year round, the temperature of the water in winter being from 60° to 70° F.

Madeira is reached by steam from Liverpool, London, Southampton, and Plymouth, and from various other ports on the Continent, and is also frequently a point of call by steamers from Boston and New York taking the southern route.

As has been said, the climate of Madeira is a mild, moist, marine one, and is consequently a very equable one, not only in the daily but also in the yearly range. The average mean daily range for the year is 9.2° F. and the mean nychthemeral range during the six months, November to April, is only 10° F. The mean monthly range of temperature for each of the five months—November to March—is as follows:

November, 16°; December, 16.9°; January, 16.9°; February, 18.7°; March, 18.9°. The mean annual temperature is 66.2°, and for the winter 61.6°. The extreme range of temperature is from 90.8° to 46.22° F., for eight years of observation.

At Funchal frost and snow are wholly unknown, but snow falls on the mountains once or twice during the winter, very seldom, however, below the altitude of 2,000 feet. The mean annual relative humidity is given as from seventy to seventy-five per cent., and for the five months from November to March, seventy-one per cent., according to Kisch. During spring and autumn the relative humidity is least. The mean annual rainfall is twenty-nine inches of which sixty-six per cent. falls in the four months, November to February. In the winter six months there are on an average fifty rainy days. Lombard

Annual Averages.

	Latitude.	Temperature. (Degrees Fahrenheit.) Mean for January.	Mean for July.	Mean Annual.	Relative Humidity.	Rainfall.	Cloudy Days.
Madeira	32° 30′ N.	60.4°	71.1°	66 2°	70.75%	29 00	110.0
Jupiter, Fla	26° 57′ N.	63.4	80.5	73.4	82.0	62 10	79.8
Key West	24° 34′ N.	70.3	84.0	77.5	73.9	40.80	59.1
Jacksouville	30° 20′ N.	55.8	82.5	69 2	72.0	54.60	85.1
Santa Barbara	34° 28′ N.	51.2	66.8	60.7	73.0	17.60	71.0
San Diego	32° 43′ N.	53.6	67.1	60.4	72.9	9.49	87.2
Bermuda	32° 15′ N.	62.5	79.8	70.8	80.0	62.54	83.0
Nassau	25° 5′ N.	69.0	87.0 Summer.	78.7	79.0	56.00 Oct. to May.	.....
Mentone	43° 46′ N.	49.3	73.0	60.0	72.0	25.61	80.0
Cairo	30° 3′ N.	53.6	77.9	70.2	58.4	1 22	40.0
Aiken	33° 32′ N.	44.15	78.8	61.61	59.55	48.00	.....

gives the number of cloudy days per annum as 110, and of fair and clear days as 189. The prevailing winds are from the north, northeast, and northwest. Generally there are no high winds at Funchal, but occasionally it is visited by the "leste," a hot dry wind blowing from the Morocco coast, chiefly in the spring and autumn.

In the above table the climate of Madeira is compared with various other warm marine climates and with the dry climates of Cairo and Aiken.

The climate of Madeira is not suited, in the writer's opinion, for pulmonary tuberculosis generally, although occasionally individual cases may do well, as in almost any climate. No warm, moist marine climate can be considered favorable for the arrest or cure of this disease, and experience, especially that at Madeira, confirms the statement. For cases of chronic laryngitis with scanty expectoration, chronic bronchitis and emphysema, however, such a climate is favorable, as well as for that large class of cases characterized by debility. "The feeble, flickering lamp burns longer there than in a more stimulating and tonic air, and now and then it seems to gather renewed power, and burns up again with some of its old luster." For delicate scrofulous children such a mild marine climate is of value. Kisch regards rheumatism and gout, and also a tendency to diarrhea and to albuminuria, as contraindicating the Madeira climate. One can reach Madeira from New York or Boston in about seven or eight days and the voyage is generally a calm one. Edward O. Otis.

Madura foot.—See *Mycetoma*.

Magendie, François.—Born at Bordeaux, France, October 6, 1783. He studied medicine in Paris, and received the degree of Doctor of Medicine in 1808, the subject of his graduating thesis being "Sur les usages du voile du palais, et la fracture des côtes." Shortly afterward he was made Prosector of the Medical Faculty of Paris, and in this capacity he was permitted for some time to give lectures on anatomy and physiology. From 1816 onward he devoted himself exclusively to physiological experiments upon living animals. In 1826 he was appointed adjunct physician at the Salpêtrière Hospital; in 1836 he succeeded Récamier as Professor of Physiology and General Pathology at the *Collège de France;* and at the same time he was made an attending physician at Hôtel-Dieu. He died October 7, 1855, at Sannois, near Paris.

According to Pagel, Magendie was one of the principal originators of the modern tendency to submit all questions, not merely those of a physiological but also those of a pathological and of a pharmacological nature, to the test of actual experiment. It was his belief that there was only one trustworthy source of knowledge—viz., experiment. Magendie's contributions to our knowledge of physiology were simply invaluable, and they relate to almost every department of that branch of medical science—particularly, however, to absorption, to the action of the heart, to animal heat, to digestion, to physiology of the nerves, etc. It was to him also that we are indebted for much of our knowledge with respect to the alkaloids, many of which were first introduced by him into medical practice.

Fig. 3908.—François Magendie.

The summary of his work on the alkaloids is preserved to us by the solution of morphine for hypodermic use known as Magendie's solution, and that of his work as a physiologist by the terms Magendie's foramen, M.'s spaces, and M.'s law.

Magendie's contributions to medical literature are very numerous, and not a few of his writings deal with events which occurred to him in the course of his career as a medical practitioner. A. H. B.

Magnesium.—I. General Medicinal Properties of Compounds of Magnesium.—Medicinally, magnesium is notable among metals for its inertness, its compounds exhibiting absolutely no specific effect individual to their basic radical. As a class, the magnesium salts tend to be of low diffusion power and purgative, and, as compared with salts of potassium or of sodium with the same acid radicals, are less obnoxious to the taste and are generally milder in action.

II. The Compounds of Magnesium used in Medicine.—The compounds of magnesium entering into preparations of the United States Pharmacopœia are

the *oxide* ("magnesia"), *hydroxide, carbonate, citrate,* and *sulphate.*

Magnesium Oxide, MgO.—Magnesium oxide, the *magnesia* or *calcined magnesia* of common parlance, is easily obtained by exposing to a low red heat the so-called magnesium carbonate of pharmacy. According to special circumstances in the making, magnesia may be comparatively light or comparatively heavy. Two grades of magnesia thus occur in the markets, both of which are recognized by the United States Pharmacopœia. The *light* variety is officially entitled, simply *Magnesii oxidum, Magnesia,* Magnesia, while the heavy grade is distinctively styled *Magnesii oxidum pondersum,* Heavy Magnesia.

Both varieties of the substance are in the form of an exceedingly fine white powder, very light in the case of the simple "magnesia," but dense in the case of the "heavy" article. In both cases the powder is odorless, but with an earthy, though not saline taste; is almost insoluble in water, and quite so in alcohol. In the case of the light variety, one part of magnesia mixed with fifteen parts of water and allowed to stand for half an hour will form a gelatinous magma of magnesium hydroxide. Heavy magnesia, on the contrary, does not readily react in this way. Magnesia slowly absorbs carbon dioxide from the atmosphere, and hence is directed by the Pharmacopœia to be kept in well-closed vessels.

Magnesia is strongly alkaline in respect of power of saturating acids, but, from its feeble solubility, shows scarcely a trace of the physiological properties exhibited by the soluble alkalies potassa and soda. Locally, magnesia has only the negative properties of a light, smooth, insoluble powder, but taken internally it neutralizes acids in the primæ viæ, and in the condition of a soluble magnesium salt thus resulting proves mildly laxative. As an internal medicine, in short, magnesia combines the properties of an antacid and a laxative, and is used exclusively for obtaining the effects of such virtues, either singly or together. Thus it may be prescribed as a simple laxative in constipation, a simple antacid in "sour stomach," or as a medicine of both virtues when, in the case of irritation of the intestines from the products of sour fermentation of the food, both an alkaline and a laxative effect are needed. When given as a simple laxative, it may be necessary to follow the dose of magnesia with a draught of lemonade to secure the necessary acid for the solution of the magnesia. As an antacid, magnesia is given in doses of gr. x.–xxx. (0.65–2.0) and as a laxative gr. xxx.–lx. (2.0–4.0). It is administered rubbed to a smooth cream with water or milk, and, in general, "heavy" magnesias are preferable to the "light" variety, by reason of their being more readily miscible with fluids. A mixture of magnesia, with water, if not weaker than one part to fifteen, slowly gelatinizes on standing as stated above by formation of magnesium hydroxide, and if kept for a day or two may cake into lumps. And such concretions have been found, postmortem, in the human stomach, after habitual full dosing with magnesia.

Magnesium Hydroxide, $Mg(OH)_2$.—Magnesium hydroxide, or *hydrate of magnesia,* is not official under its own form, but is an integral part of the composite so-called *carbonate* of the United States Pharmacopœia, and is what forms on allowing an aqueous mixture of magnesium oxide to stand, as above described. Magnesium hydroxide also occurs as a bulky gelatinous precipitate on decomposing, by caustic soda, magnesium sulphate (Epsom salt) in solution. Such a precipitate, washed and diffused in enough water to make the mixture of creamy consistence, constitutes a preparation that is exceedingly convenient as a means of administering magnesia, and which, if the hydroxide have been thoroughly washed and if the water employed for the dilution be perfectly pure, has a mild taste only, resembling that of milk, and will keep without change. A tablespoonful of such preparation is a full antacid dose for an adult, and two tablespoonfuls a laxative. This preparation is listed in the National Formulary under the title *Magma Magnesii,* and various makes are known in the market as *milk of magnesia.*

Magnesium Carbonate, approximately $(MgCO_3)_4$-$Mg(OH)_2 + 5H_2O$.—The normal magnesium carbonate is not used in medicine, but under the title *Magnesii Carbonas,* Magnesium Carbonate, the United States Pharmacopœia makes official the well-known *magnesia alba* of the shops, a composite salt, which may be regarded as a compound, in variable proportions, of normal magnesium carbonate and magnesium hydroxide. The United States Pharmacopœia recognizes the composition represented by the formula $(MgCO_3)_4$, $Mg(OH)_2 + 5H_2O$. This compound forms as a white precipitate on mixing solutions of magnesium sulphate (Epsom salt) and sodium carbonate. Collected, washed, and dried, it then appears as light, white, friable masses, or a light, white powder, odorless and tasteless, insoluble in alcohol, and almost insoluble in water, to which, however, it imparts a feebly alkaline reaction. When strongly heated, it loses water and carbonic acid gas, and is converted into magnesia. It is soluble in dilute acids with copious effervescence. Magnesia alba is made in two grades of density, technically known, respectively, as the *light* and *heavy.* The difference is said to be determined by the strength of the solutions used for the precipitation, concentrated solutions producing a heavy, and weak a light, product. The United States Pharmacopœia does not contradistinguish the grades of density nor direct the process of manufacture, and, as a matter of fact, much of the commercial carbonate is prepared from dolomite.

Magnesia alba is practically identical in medicinal properties with magnesia, and may be used for the same purposes as that compound. The former is, however, the inferior remedy, first, because in its uniting with acids in the primæ viæ it necessarily evolves gas—an unpleasant circumstance; and secondly, because it needs to be given in double the doses of magnesia. Magnesia alba is administered, like magnesia, rubbed to a cream with water or milk, an operation which is greatly facilitated by first rubbing the powder with a little undiluted syrup.

Magnesium Citrate ($MgHC_6H_5O_7$).—This salt is official in the United States Pharmacopœia only in composite pharmaceutical preparations, as follows: *Liquor Magnesii Citratis,* Solution of Magnesium Citrate. The salt is formed in solution by adding the pharmacopœial carbonate to a solution of citric acid; the solution is flavored with syrup of citric acid, and the mixture being put into a twelve-ounce bottle, a small charge of acid potassium carbonate ("bicarbonate") is finally added, and the bottle instantly, thereupon, securely corked, the cork being fixed in place by twine. Reaction now takes place between an excess of citric acid present in the mixture and the potassium carbonate, whereby potassium citrate forms and carbon dioxide gas is evolved. But the bottle being stoppered, the gas is retained and remains in solution under pressure. Thus there is obtained an acidulous, sweetened, and actively effervescing aqueous solution of magnesium citrate, with a little potassium citrate. For the making, the quantity of 15 grams of magnesium carbonate is ordered for each twelve-ounce bottleful.

Magnesium citrate is a simple saline purgative, mild in character, not disagreeable to taste, and generally very well borne by the stomach. The agreeable flavoring and effervescent property of the pharmaceutical representatives of the salt make the medicine an especially appropriate one for children, or for use in fevered states requiring the action of a purge. The official solution, it will be observed, comes only in twelve-ounce bottles. One bottleful

is a purgative dose for an adult, but it is generally given only in wineglassful doses, sipped during the day, so that half a bottleful or more is consumed in the twenty-four hours. The fluid should be ice-cold, and the bottle should instantly be recorked after the drawing off of each dose, and kept, set upside down, in a cool place. But after once opening a bottle, the solution is not good for longer than a day. The granulated salt is to be given in doses of from one to three teaspoonfuls, dissolved, at the time of taking, in iced water, and the solution drunk during effervescence.

Magnesium Sulphate ($MgSO_4+7H_2O$).—Magnesium Sulphate—the well-known *Epsom Salt*—is official in the United States Pharmacopœia as *Magnesii Sulphas*, Magnesium Sulphate. It is a widely distributed salt, being an ingredient of sea-water, and of the water of some saline springs, and occurring also native. It is prepared for commerce in a number of ways. Magnesium Sulphate occurs in small, colorless, right-rhombic prisms, or circular needles, slowly efflorescent in dry air, odorless, having a cooling, saline, bitter and disagreeable taste, and a neutral reaction. It dissolves in one and a half parts of cold water and very freely in boiling water. It is insoluble in alcohol.

Magnesium sulphate is a typical saline purge, and, although of very disagreeable taste, is usually well borne by the stomach. In excessive dose, however, it induces nausea and vomiting in addition to profuse purging. In small, repeated doses the salt may prove slightly diuretic, and often in such doses it makes an excellent corrective in ordinary gastric derangement. A full purgative dose for an adult is ʒi(30.0), but if taken, as preferably it should be, immediately upon rising in the morning, on an empty stomach, one-fourth of such amount may be sufficient for a purge. As a corrective, gr. v. (0.3) may be given at a dose, repeated a number of times daily. The salt is best given dissolved in ice-cold lemon soda. Magnesium sulphate is by far the most commonly used saline purgative, and hence the non-distinctive phrase, a *dose of salts*, is commonly held to mean a dose of this particular salt. *Bitter purging salt*, and, simply *bitter salt*, are also common names for the sulphate. Epsom salt is an ingredient of the pharmacopœial *compound infusion of senna*.

Based on the investigations of Meltzer and Auer, magnesium sulphate has been used as an anesthetic (see *Anesthesia, Spinal*, in vol. i.); used intraspinally it is of service in eclampsia, and convulsions due to tetanus or strychnine. A twenty-five per cent. solution applied to a nerve trunk blocks both motor and sensory impulses. It has been used also, with some success, in toxemias occurring during the puerperium.

EDWARD CURTIS.
R. J. E. SCOTT.

Magnoliaceæ.—(*The Magnolia Family.*) This is a small family of trees and shrubs, mostly of warm temperate regions, many of them highly esteemed for their ornamental and fragrant properties. Some valuable timbers are yielded by the larger trees. The bark and herbage are generally permeated by volatile oil and amaroids, so that many of them have been rather extensively used as aromatic bitters. This is especially true of the bark of several species of *Magnolia*, containing *magnolin*, and *Liriodendron*, containing *liriodendrin*. Under the title of "*Magnolia*," *M. virginiana* L., *M. tripetala* L., and *M. acuminata* L., all of the Southern United States, were long official. Their bark is given in doses of ʒ ss.–i. (2.0–4.0).

HENRY H. RUSBY.

Maimonides.—Abu Amram Musa ben Maimun, usually known by the shorter name which heads this sketch, was born of a Jewish family of high class in Cordova, Spain, in 1135. Fleeing from religious persecution by the Mohammedans, his family wandered through many countries, living for several years in Fez and finally settling in Cairo. Here he made a living by trading in precious stones and rare coins, at the same time studying philosophy and medicine. In 1179 he was appointed physician to El Fadel Abdul Rahim, who became the successor of Saladin, who gave him a large sum of money which enabled him to abandon trade and devote himself exclusively to scientific study and the practice of medicine. At the same time he was chief rabbi of Cairo. He died in Fostat (old Cairo) on December 13, 1204.

In his philosophy Maimonides was ranked among the Neo-Platonists, and his freedom of thought brought down upon him the condemnation of the French Jews as well as of the Inquisition. The eastern Jews, however, venerated him as the greatest of their race, and toward the end of his life his learning and character won for him honors from many of the universities of Europe. The most important of his medical writings were: "Tractatus de regimine sanitatis," a "Treatise on Poisons," and "De Causis et Indiciis Morborum," a collection of aphorisms from Greek and Arabic authors.

T. L. S.

Maisonneuve, Jacques Gilles.—Born at Nantes, France, November 10, 1809. He began his medical studies in the hospital of his native city, and then continued them at Paris, under the instruction of Dupuytren, Récamier, and other teachers of distinction. He received the degree of Doctor of Medicine in 1835, and in the same year, after a competitive examination, he was given the position of Prosector in Clamart's Anatomical School. While acting in this capacity he gave courses in operative surgery. During the immediately following years he held the position of attending surgeon successively in the Bicêtre, Cochin, and Pitié Hospitals. Finally from 1862 until the time of his retirement from active work, he was one of the regular surgeons of Hôtel-Dieu. He died April 9, 1897, at La Roche-Hervé.

Maisonneuve's name is preserved in the operation of intestinal anastomosis called after him, especially in France, and in the urethrotome known as the "maisonneuve."

A. H. B.

Malacocotylea.—An order of parasitic flukes that includes all human trematode parasites. There are never more than two suckers; hooklets are lacking. Development may be with alternation of generations (Digenea) or without (Metastatica). See *Trematoda*.

A. S. P.

Malaria.—Malaria is a general term used to designate a group of specific fevers, their complications and sequelæ, caused by a living animal parasite termed Plasmodium invading the red blood cells of man, and transmitted from man to man through the agency of mosquitos belonging to the subfamily Anophelinæ. It is characterized by the periodicity of the symptoms, production of anemia, enlargement of spleen, pigmentation of visceral organs and amenability to treatment with quinine.

PREVALENCE AND GEOGRAPHIC DISTRIBUTION.—*United States.*—The disease is reportable in few States, and owing to a lack of complete vital statistics accurate data regarding its prevalence are not available. It is known that the milder types exist in localities in the New England and Middle Atlantic States. The region of States covered by the Appalachian Mountains, and the North Central and Western States are almost free from malaria. We find that there is an

increase in severity and prevalence of malaria as the south is approached. Following the Atlantic coast, tertian and estivoautumnal types are to be found in the southeastern portion of Virginia, the eastern half of North Carolina, and in South Carolina, Georgia, and Florida to an increasing extent. In all portions of the States bordering the Gulf, Florida, Alabama, Mississippi, Louisiana, and Texas, and those bordering the Mississippi River, including the western parts of the States of Tennessee and Kentucky, parts of Missouri, and the State of Arkansas, the disease, in all its types, prevails to a great extent. Of the States on the coast, the tertian and estivoautumnal types are encountered in certain localities in California, and to a less degree in the States of Arizona, Utah, Washington, and Wyoming.

Where investigations have been made during the past two years in some of our Southern States, it has been found that its prevalence varies considerably within each State; in some portions being comparatively rare, and in others epidemic in character. In general it prevails mostly in regions bordering the rivers, and the tributaries and deltas of the rivers.

In Alabama, the reported deaths from malaria in 1913, were equal to 2 per cent. of the reported deaths from all causes, giving a rate of 20.3 per 100,000 population, while for the State of Mississippi in the same year, 5.93 per cent. reported deaths from all causes was due to malaria, a mortality rate of 70.3 per 100,000. It would appear also from available records that in the State of Alabama there were 200 or more cases of malaria for each death reported, and in Mississippi fifty-three cases were reported to one registered death from malaria. Statistics clearly confirm the general statement made that the disease is a rural one, there having been reported, in Mississippi, one death in the urban districts from this cause, as against 7.2 in the rural districts.

Other Countries.—It is generally stated that malaria prevails in countries lying within 60° north latitude and 35° south latitude. The best conditions are to be found in the regions of the equator, gradually diminishing as the extremes of latitude mentioned are reached.

In *Canada* it is said some malaria exists in the regions of the Great Lakes.

Malaria exists to a great extent in the *West Indies*, excepting the Islands of Antigua and Barbados, where it is said to be almost if not entirely absent. Also on the Atlantic coasts of Mexico and Central America, to a lesser degree on the Pacific coast, and on the northern and eastern coast of South America including Columbia, Venezuela, Guiana, and the greater part, and far into the interior of Brazil. On the Pacific side of South America, malaria exists in portions of Bolivia, Ecuador, Peru, and Chile, the southern limit being 35° south latitude.

Throughout *Africa*, to 30° south latitude, the disease is widespread, excepting in the extreme southern part including Cape of Good Hope, and German Southwest Africa, and the Orange River Colony. The most pernicious and severe types are commonly encountered on the Gold and West coasts and on the Mediterranean coast, and particularly in the valleys of the Nile and Congo Rivers.

It is widely prevalent in *Asia*, particularly in Arabia, Asia Minor, Persia, Afghanistan, Beloochistan, in the Bombay and Bengal, Presidencies of India, Siam, China, Indo-China, the Malay Peninsula, the foothills of the Himalayas, and among the islands along the coast including Ceylon, Philippine Islands, Formosa, Sumatra, and Java.

Malaria exists on the eastern and northern coasts of *Australia* to 20° south latitude, New Guinea, and Borneo of the East Indies, but in the larger number of Pacific islands the disease is not known.

In *Europe*, Italy, Greece, Sicily, and Turkey are the most heavily infected countries, where all types of malaria occur. To some extent it is also present in all the other countries, in the regions of the deltas and banks of the main rivers, excepting in Great Britain, Norway, and Sweden. The northern limit is 63 to 64° north latitude.

In some countries, as in Great Britain and in our own Western States where malaria prevailed to a great extent in former years, the disease has become extinct, due undoubtedly to modern sanitation and extensive cultivation and drainage of lands. On the other hand, in the course of an epidemic 1866–72, the two East African Islands, Mauritius and Reunion, which previously were free, became infected, and this was followed by an extensive spread of the disease.

History.—For many centuries there were theories as to the causation of malarial fever, of which the prevailing opinion was that it was due to "miasmata" resulting from putrefactive processes of vegetable matter most severe in swampy regions, and carried by air. The drinking of contaminated water has also been advanced as a cause.

The term "malaria" had its origin from this supposed relation, as the derivation of the word would indicate, from the Italian mal, meaning bad, and aria, air, and was first used by Torti in 1753 in a treatise on these fevers.

Hippocrates, fifth century, described these fevers and divided them into continued fever, daily fever, tertian fever, and quartan fever. Following the introduction of cinchona through the Viceroy Del Cinchon, and his physician-in-ordinary, Juan del Vego, in 1640, Morton (1697) and Torti (1712) distinguished the malarial fevers by their yielding to the administration of the drug.

The theory of the parasitic origin of the disease dates back to Varro (B.C. 116–37); it was subsequently revived by Lancisi (1717), Rasori, and other observers, and confirmed by the discovery in 1880 by Laveran of the parasite now recognized as the specific cause of malaria.

Prior to this, Meckel in 1847, first described pigment-bearing cells found in the blood and spleen of a patient who had died of malaria. Similar bodies which were seen by Virchow and Heschl (1847–50), and Planer (1854) who saw them in fresh blood, were undoubtedly malarial parasites, subseqnently seen and recognized by Laveran to be living organisms.

In 1885 Golgi discovered that the paroxysms which characterize malarial fevers coincided with the sporulation of a group of parasites; also that there were species of parasites distinguishable in the different forms or types of malaria.

With the discovery of the specific cause, much interest was aroused regarding its transmission from person to person. Mosquitos had, at different times, been associated with the spread of malaria. Varro (B.C.) and Columella and Vitruvius Lancisi (1717) mention the idea as prevailing among Italian peasants, Josiah Nott (1848) and Louis Daniel Beauperthuy (1854) connected mosquitos with the transmission of malarial fever and yellow fever; and King (1882) gave a number of reasons in support of the theory of mosquito transmission of malaria.

In 1894, and again in 1896, Manson formulated a definite hypothesis on the subject, and to him and Ross must be credited the demonstration and establishment of the fact.

Ross (1895–97) published in 1898 the result of his observations of the development and transmission of Hæmoproteus of birds, avian malaria, through culex mosquitos, which by analogy served for the further observations of A. Bignami, G. Bastianelli, and B. Grassi of the life cycle of malaria parasites in certain species of mosquitos belonging to the family of Anophelinæ.

MacCallum in 1898, also observed in Hæmoproteus of birds, the minute changes in the process of fertilization of the female organism by the flagellate body

derived from the male, and the further development into a motile organism.

The successful cultivation of the parasites outside of the human body, *in vitro*, was first done and described by C. C. Bass and F. M. Johns, 1912, who used human blood with dextrose for their medium.

Attempts to inoculate lower animals with the plasmodium of malaria have been made, but have proved futile. Inoculation experiments from man to man have proved that the different species of parasites are associated with a definite type of fever.

Practical experiments, proving the relation of mosquitos to malaria and excluding the possibility that the disease may be transmitted by water, air, or food, have been carried out.

Etiology.—As the continuance of malaria is dependent upon the three factors, the parasite, the mosquito, and man, in studying the etiology of the disease, all three must be considered, as well as the conditions influencing each.

The Malarial Parasite.—Various classifications have been advanced since the discovery of the parasite by Laveran. It is generally accepted that it belongs to the animal kingdom and to the division, Protozoa, class of Sporozoa, order Hæmosporidia, and genus Plasmodium, of which at least three species are known, namely, *P. vivax*, the parasite of tertian malaria; *P. malariæ*, the parasite of quartan malaria. *P. falciparum*, syn. *Laverania malariæ*, the parasite of subtertian malaria.

There are some authorities who recognize as many as three distinct species belonging to the last-named form, viz., a pigmented subtertian, a pigmented quotidian, and an unpigmented quotidian, but in the experience of many authorities only the three first given have been definitely differentiated, likewise by the writer in cases occurring in the United States and from Central and South America, Africa, and Europe.

These parasites exist in two separate stages or phases: (*a*) The human phase, also called the asexual cycle, schizogonic or endogenous cycle, where man acts as the intermediate (vertebrate) host and in whom, its development causes the symptoms of malaria. (*b*) The mosquito phase, also called the sexual cycle, sporogonic, or exogenous cycle where the mosquito acts as the definitive (invertebrate) host in which the parasite passes through a process of development required for the continuance of its existence, and through its bite may again be transferred to man.

Human Phase or Cycle.—The malarial parasites are found in the red blood cells of man, derive their nourishment from these cells, and multiply. The changes common to all species of parasites will first be described.

Upon the bite of the infective mosquito, there are injected into the blood, the minute, long, slender parasites composed of protoplasm, having a nucleus which may be shown to contain a chromatin particle, and are called sporozoites.

The sporozoite finds its way into a red blood cell, and through its ameboid movement, encloses a portion of the cell, and then appears as a round speck of protoplasm containing a vesicular-like nucleus, and is then termed a trophozoite.

The trophozoite grows at the expense of the hemoglobin, by the protrusion of pseudopodia enclosing portions of the cell for nutritive purposes. As a result of this process of development granules of black pigment appear, which is an excrementitious product, and to which the name hemozoin was given by Sambon. Upon reaching maturity its ameboid activity is decreased. It is then called a schizont, when it appears as a structureless protoplasmic rounded body occupying the greater portion of the cell, having a nucleus and nucleolus, with hemozoin, more or less in motion, scattered throughout. The hemozoin now groups itself into masses, placed centrally or radially, when division or sporulation of the nucleus and protoplasm into from four to thirty-two minute segments occurs. Each such segment is called a merozoite, while some of the protoplasm which does not enter into this segmentation is known as the "rest body" or "nucleus de reliquat."

Upon the rupture and destruction of the cell in the blood, the freed merozoite enters a red blood cell to start life over again, either as a trophozoite and to repeat the process of development just described, or as a gametocyte which becomes differentiated into male or female form. Some of the merozoites that fail to enter the red blood cells, as well as the residual protoplasm or "rest body" and hemozoin are phagocyted and thus disposed of.

In the process of sporulation a toxin is also developed and where a sufficient number of schizonts sporulate at the same time, the collective toxins freed in the blood give rise to the acute or chronic symptoms of the disease.

It has been noted that some of the merozoites do not become schizonts to undergo segmentation, and develop into sexual forms. The young merozoites destined for this development, appear as minute round bodies, but without a vesicular-like nucleus as found in a trophozoite. These develop into round- (in tertian and quartan infection) or crescentic- (in subtertian or estivoautumnal infection) shaped bodies called gametocytes, contain hemozoin, and become differentiated into male and female bodies that do not segment and consequently do not give rise to any symptoms, but are destined for a life outside of the human body, that is, in the mosquito. The male gametocyte is called a microgametocyte and is characterized by a hyaline protoplasm, which stains lightly; the female, the macrogametocyte has a more compact granular protoplasm, is therefore more resistant to outside influence and persists a longer time than the male form, and takes the basic stains more deeply.

The Mosquito Phase, Sporogony.—Reproduction by a sexual process from these gamete forms does not occur in the human body, but does take place, when they are taken up by a female mosquito, capable of becoming infected.

Upon being sucked up in the blood by the mosquito the parasites undergo certain changes in the cavity of the stomach. The crescent gametocyte becomes a round body, while those of the other two forms, tertian and quartan, are already round.

The female, or macrogametocyte, extrudes minute portions of its protoplasm called polar bodies, and is then known as a macrogamete ready for fertilization. The male, or microgametocyte, throws out thin long flagella knobbed at one end, four to six in number, each containing portions of the nucleus, free from hemozoin, and when these flagellate portions separate from the parent cell, they are known as microgametes.

The microgamete moves about freely, and is the element which fertilizes the female or macrogamete. After the fertilization the nuclei fuse together, the body called zygote or sporont becomes elongated and motile and is then known as the ookinete or vermicule. The ookinete enters the wall of the stomach of the mosquito, and lodging itself becomes encapsulated, where it develops and grows into a round body, forming a cyst-like projection called oocyst. In reaching maturity the nucleus and protoplasm divide forming the daughter cells called sporoblasts, which upon further division form the narrow thread-like bodies called sporozoites. The ripe oocyst now ruptures into the body cavity of the mosquito liberating numerous sporozoites. The sporozoites finally find their way to the salivary glands, when the mosquito is infective and upon

biting a person will injeet some of these bodies with its saliva into the blood, where the parasite finding its way into a red blood eell begins its asexual eyele again. During the period of development of the parasite in the mosquito, requiring eight or ten days or more, depending upon the temperature and other conditions, the mosquito is in its infected stage and is not eapable of transmitting the parasite until sporozoites have developed.

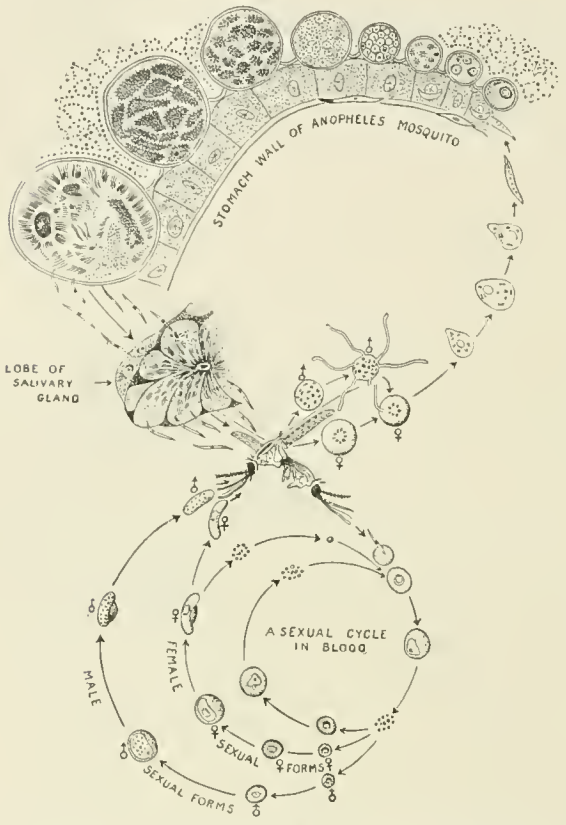


Fig. 3909.—Life Cycle of the Malarial Parasite in Human Blood and in the Body of the Mosquito. (U. S. Public Health Service.)

The blood taken up by the mosquito may contain many gametocytes, yet only a comparatively small number of oocysts may develop. It has been found that it sometimes requires several feedings of blood containing gametes, before the mosquito may become infected.

Another phase is deseribed by Schaudinn in which the female gametocyte or macrogametocyte, while in the body of man, reverts to the asexual or schizogonic eycle of development; this is termed parthenogenesis. The changes said to oecur in this process are a division of the nucleus, one pale and poor in chromatin elements around which hemozoin eollects, the other rich in ehromatin elements and with its surrounding protoplasm undergoes sporulation forming merozoites and thus repeats the proeess of schizogony.

To this parthenogenetie phase is ascribed the lateney and relapse of malarial fevers. There are other authorities who ascribe lateney and relapses to a eonjugation of two young asexual forms producing an organism resistant to quinine and other bodily influences; others believe the parasites become immune to quinine, or other influences, and eontinue an asexual existence; and others again believe the asexual forms eontinue their existence normally but reduced in numbers.

The terms employed to describe the various forms of the parasites, may be briefly given, as follows:

Sporozoite	—the youngest form enters the red blood cell and becomes
Trophozoite	—which grows at the expense of hemoglobin, becomes pigmented; reaching maturity develops into
Schizont	—the segmenting body, or rosette body, each segment forming
Merozoites	—entering new red blood cells, changes into either
Schizont	—which repeats segmentation or
Gametocyte	—the sexual forms which become differentiated into
Microgametocyte	—the male forms, hyaline sphere in tertian and quartan, and crescents in estivoautumnal;
Macrogametocyte	—the female form, granular protoplasmic spheres in tertian and quartan, crescents in estivo-autumnal.
Microgametocyte	—forms
Microgametes	—the knob-like flagellated body which impregnates
Macrogametocyte	—after casting off polar bodies when it is known as
Macrogsmete	—and after fertilization is called a
Sporont	—which changes into an oval elongated body, becomes motile, forms the
Ookinete	—which enters the wall of the stomach of the mosquito and becoming encysted is called
Oocyst	—divides into daughter cells, the
Sporoblasts	—are developed oocysts, dividing into the minute spindle formations of
Sporozoites	—ready for life in the red blood cells.
Parthenogenesis	—a sexual reproduction in which the macrogametocyte reverts to the schizogonic phase by formation of merozoites.

The three types of parasites present certain eharaeteristie differences in their elinieal manifestations as well as in their microscopieal appearances upon examination of the blood in fresh and stained preparations, which will warrant some deseription.

Plasmodium vivax, the tertian parasite, the parasite that causes the tertian type of malarial fevers. It requires forty-eight hours for its asexual or sehizogonic eycle. In the fresh blood specimen, the young form or trophozoite appears as a round body about one-fourth to one-fifth the size of a red blood cell, having a low index of refraction and therefore the border gradually shades off with the substanee of the red blood cells in whieh it is seen.

The effeet on the red blood eells is early notieed, for after a few hours the eell appears slightly enlarged and swollen.

The growing parasite, owing to a constant ameboid aetion, in which pseudopodia are projected and retracted, presents varied and grotesque appearing figures. In six hours, small, fine, light-brown pigments, particles, or hemozoin granules, appear, whieh increase with the growth, and owing to the aetivity of the parasite, have an active dancing motion.

The full size of a sehizont is reaehed in about thirty-six hours when it takes on the shape of the contained cell which appears as a rim around the parasite and about twice the size of a normal red blood eell. It now enters into the presporulating stage, when ameboid motion ceases, the pigment gradually eollects into masses, and segmentation of the eytoplasm and nueleus into fourteen to thirty young spores, or merozoites, oeeurs. These segmenting forms are described as resembling a "mulberry" "rosette," or "daisy," but may be likened in appearanee to a eireular group of a similar number of shot or beads plaeed on a flat surfaee.

The entire development from the trophozoite stage to complete segmentation requires forty-eight hours.

Upon a blood examination of an active ease, the parasites are usually seen to be in the same stage of development. There may be two generations matur-

ing on successive days, so that there may be twenty-four hours difference in the ages between the two groups. Such double infections give rise to daily paroxysms of fever.

In blood smears stained with a good polychrome methylene blue stain, such as any of the modification of the Romanowsky stains, the young parasite appears inside of the red blood cell as a distinct blue ring within which and close to its edge is a clear unstained zone, the nucleus, surrounding a deep red chromatin spot, the nucleolus.

In the older forms, the cytoplasm of the parasite predominates, taking on a blue stain, and showing pigment granules scattered over it. In these forms the chromatin becomes divided, so that in some of the more mature forms it may be indistinct, reappearing in the presegmenting stage, and with the formation of spores a corresponding chromatic mass in each.

bodies; the female or macrogametocyte, twice the size of a red blood cell, with a chromatin mass composed of minute chromatin granules placed eccentrically and the protoplasm stained deeply; the male or microgametocyte smaller, with pigment appearing in small rods, the chromatin mass placed centrally, and the protoplasm stained lighter shade of blue.

Plasmodium malariæ, the quartan parasite, is the parasite responsible for the quartan type of malaria fever, in which paroxysms occur every seventy-two hours, corresponding to the period required for the asexual or schizogonic cycle, *i.e.* from one sporulation to the next sporulation, of this parasite. In this, as in the tertian, there may be more than one generation, but each such generation will be seen to be about in the same stage of development.

There may be two generations segmenting on successive days causing paroxysms on those days with

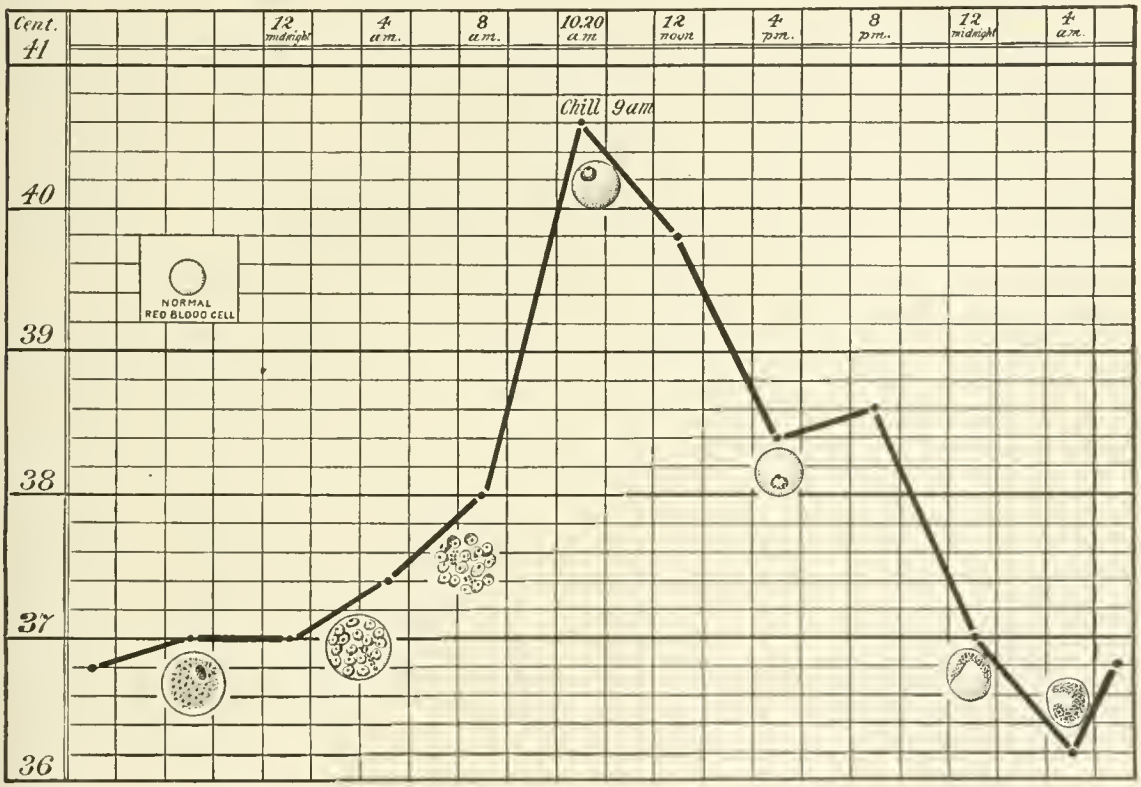


Fig. 3910.—Showing Relation of Development of the Parasite to the Symptoms in Tertian Malaria. (U. S. Public Health Service.)

A characteristic staining reaction of red blood cells in which there is a red stippling of the cells, known as "Schüffner's dots," occurs almost only in tertian infections; it has been reported as occurring very rarely in quartan infections. In a number of specimens prepared by the author, the staining reaction just described is not frequently obtained, nor has it been seen in several series of preparations of quartan infections.

In tertian infections, gametocytes appear early and are numerous. The flagellation or formation of microgametes from the adult male gametocyte, the microgametocyte, may be observed in from ten to thirty minutes in preparation of blood to which a little moisture has been added, as by breathing upon the slide, or exposing to moisture in a wet chamber made by cutting out an opening in a blotter moistened with water.

The stained gametocytes are large round blue

one day interval, and if three generations, segmentation may occur on successive days giving rise to daily paroxysms, or quotidian type of fever.

In fresh blood preparations the young form or trophozoite appears much like that of the tertian type, but is a little more distinct because of a higher index of refraction. Pigment granules are black and larger than in tertian infections, appear within a few hours, and give evidence of little movement.

The infected red blood cell remains normal in size, or may sometimes appear slightly contracted, somewhat greenish in color, contrasting with the effects of tertian infections where the cells become swollen and pale.

The parasite grows slowly, and in the more advanced stages of development may be seen as small round bodies, containing black pigment occupying the central portion of a cell, or sometimes as bands extending across the cell. When nearly full grown, it is

round, does not quite fill the cell and contains heavy black granules of pigment.

In the sporulating or segmenting form, the pigment is usually collected in the center as a small black mass, the spores, six to eight in number, being arranged quite regularly about the circumference much like the petals of a daisy, to which it has been compared.

In stained preparations, the young ring form greatly resembles the tertian trophozoite, but it appears to be slightly larger, and takes the blue stain better, so that the ring seems thicker and a darker blue. The band formations occur commonly in this type of infection, though occasionally such formations have been seen by me in some preparations of tertian infections.

Gametocytes are comparatively few, which may account for the relative infrequency of this form of infection. They are round in form and the sexes may be differentiated by size and the relative location of the chromatic mass, as in tertian forms, namely, large size and chromatin mass eccentrically in female, and smaller size centrally placed chromatin in male forms.

Plasmodium falciparum, Laverania malariæ, the estivoautumnal or subtertian parasite is the parasite concerned in the type of malarial fevers following an irregular course, often accompanied by complications, and spoken of as tropical, malignant, and pernicious malaria that may terminate fatally.

The asexual or schizogonic cycle takes place chiefly in the visceral circulation, spleen, bone marrow, or brain, so that in the peripheral circulation one will see almost exclusively the young ring, merozoite form, or trophozoite. This body is smaller than in the other two forms, about one-eighth to one-sixth the diameter of a red blood cell, and the occurrence of two, three, four, or five young parasites in a single cell is much more frequent in this form of infection.

In stained preparations the young ring appears a very delicate blue and thin, with a chromatin spot directly on the edge; frequently two chromatin spots are seen on the edges opposite one another, or the divided chromatin granules may be arranged close together on the circumference of the parasite. No pigments are seen in these forms, so that unlike the other forms of parasites, division of chromatin occurs before the appearance of pigment.

The young parasite may frequently be seen entering on the edge of the red blood cell. The infected cell remains either normal in size, or shrinks and becomes crenated. The older infected cells have a tendency to stick or agglutinate, and it is probably on this account that the more advanced stages are rarely seen in the peripheral circulation. To this property of adhesiveness is attributed the disturbance of circulation in the capillaries in the brain or other organs, producing a complication of symptoms.

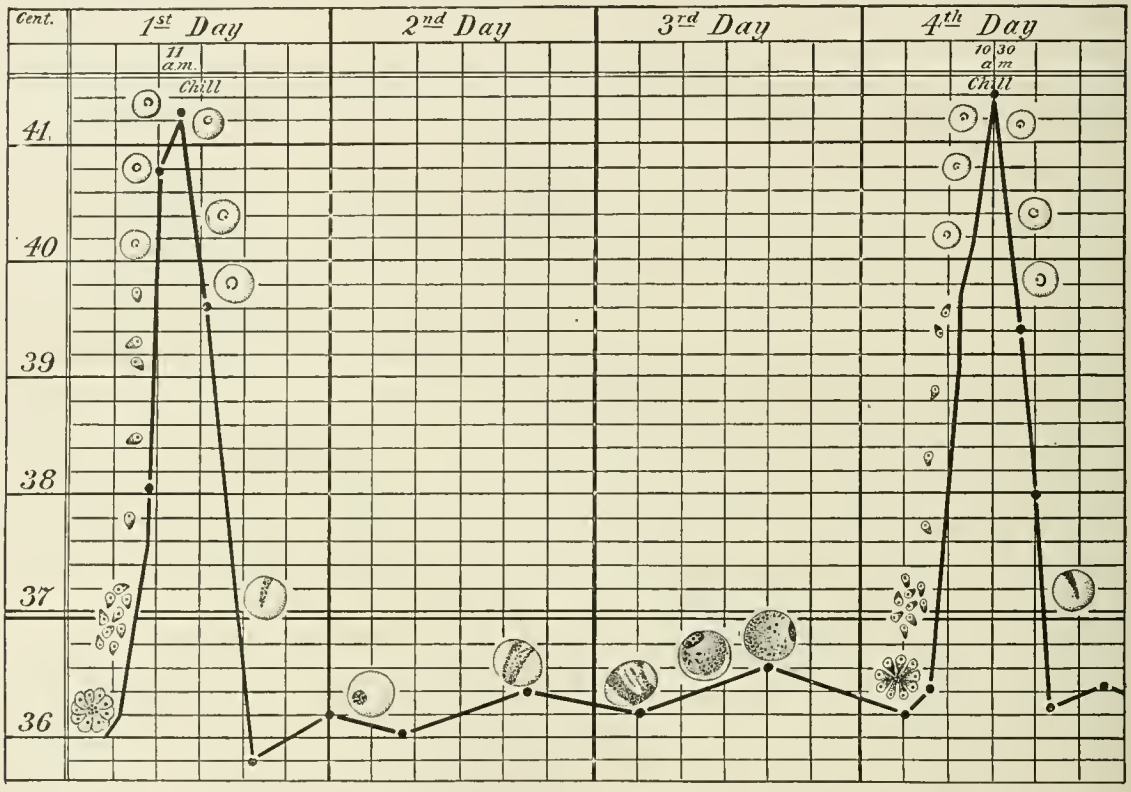


Fig. 3911.—Showing Relation of Development of the Parasite to the Symptoms in Quartan Malaria. (U. S. Public Health Service.)

Sporulation occurs in the visceral circulation of the internal organs, mainly in the spleen, bone marrow, and brain, and from five to sixteen or up to thirty spores are formed upon segmentation. The full grown schizont remains round and contains a very dark pigment.

The gametocytes are crescentic in shape, thus differing from that of the other types, and from the shape of schizonts in this type. The crescent bodies are also differentiated into males and females, the female appearing narrower and longer, the pigment being centrally located, and taking a deep blue stain, while the male crescent appears smaller and a little broader, with the pigment irregularly scattered in the protoplasm and staining less intensely. In stained preparations, the crescent may appear surrounded by a thin pale-pink border with a pink arch stretched across the ends of the crescent on the concave side. Often all traces of the red blood

cells are lost. Ovoid forms are also often found in the peripheral circulation.

The schizogonic cycle requires about thirty-six to forty-eight hours and in this type of infection sporulation of groups is not so regular and consequently the febrile attacks are much more protracted and remittent in type.

Epidemiology.—All epidemiological observations agree completely with the established fact of mosquito transmission of malaria, and exclude the possibility of transmission through air, water, and food.

Effectual measures directed on the basis of mosquito transmission have, in a number of instances, eradicated or controlled the disease. The explanation of the appearance and disappearance of malaria in various regions can be attributed to this fact only.

tian form is the prevailing type. In the United States, the season begins in June or July, increases in August and September, and subsides sharply in October. According to Hirsch, a mean temperature of 15° to 16° C. (59° to 60.8° F.) forms the regional limit at which malarial fevers can occur.

Meteorological conditions, temperature and rainfall, are of the greatest importance. A certain degree of temperature is necessary both for the activity of mosquitos, and the development of the parasite in them. According to Koch a temperature of 14° C. (57.2° F.) and upward is necessary to the development of the malaria parasite in the mosquito, which quite coincides with the regional limit placed by Hirsch.

Mosquitos do not bite, and are inactive when a temperature of 60° F. or less is reached. At this or

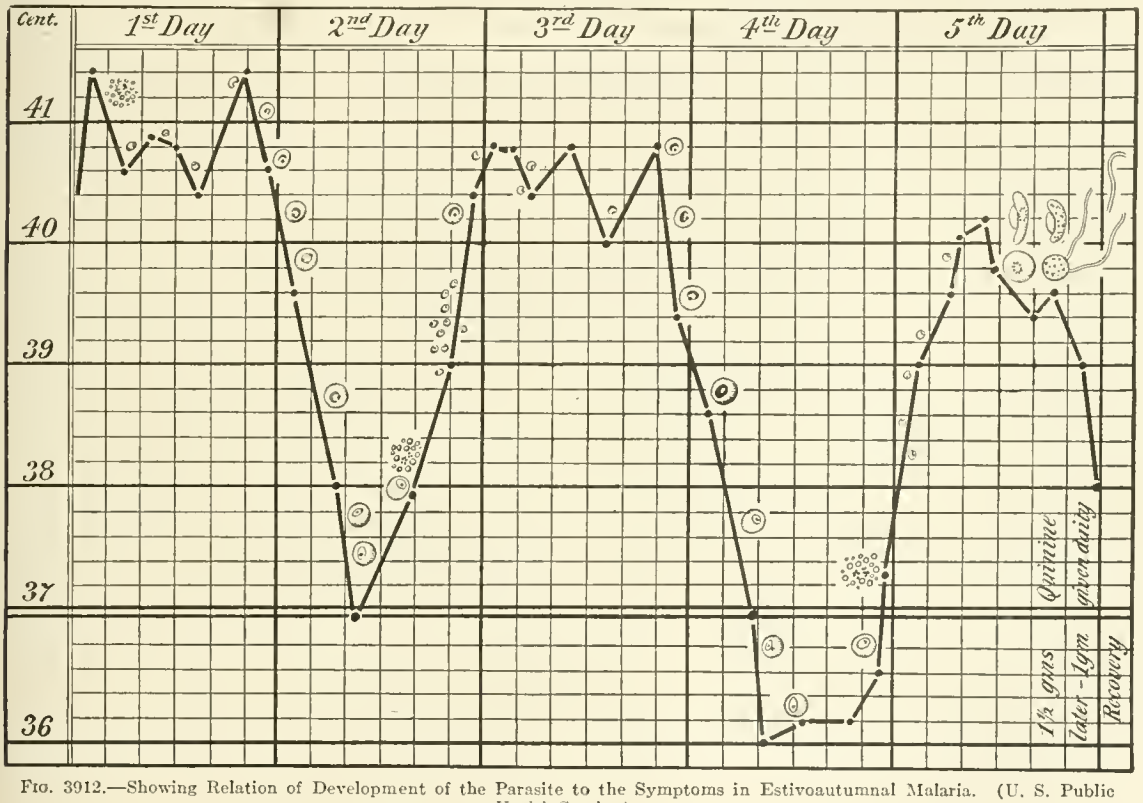


Fig. 3912.—Showing Relation of Development of the Parasite to the Symptoms in Estivoautumnal Malaria. (U. S. Public Health Service.)

Climatic and Seasonal Prevalence.—The geographic distribution naturally follows climatic and meteorological conditions, which in their turn influence the prevalence of mosquitos and the development of the parasite in them.

In the *tropics,* the disease prevails to the greatest extent after rains, and at the beginning of the rainy season. All types are encountered but the severest, or estivoautumnal forms, are most common.

In the *subtropics,* the height of the malarial season is reached at the end of summer and beginning of autumn. In the United States, this is in an increasing degree in the months of July, August, and September, subsiding in the months of October and November, increasing again about the month of April. In these regions the tertian type prevails, although the estivoautumnal is also quite prevalent. The quartan type follows in frequency but is comparatively rare.

In the *temperate zone* the season of prevalence is shorter, that is the latter part of summer. The ter-

lower temperature the mosquitos begin to hibernate, finding protection in garrets, under houses, in hollows of trees, etc., but if the weather should moderate and become quite warm, as happens in our southern States, the mosquitos may again become active; it is known that endemic outbreaks of malaria have occurred in the winter months, but whether due to infected hibernating mosquitos or to relapses is not known. It has not yet been definitely determined whether the infected hibernating mosquito carries over the infection from winter until spring.

In the winter months cases of malaria which occur are usually relapses from previous infection. The influence of cold, in these relapses, produces a lowering of the vitality in the individuals, and thus favors the renewed invasion of the parasite.

The prevalence of malaria varies also in certain years, being greater after a season of rain, and high flood waters. The year 1912 in the south was a "wet year" and generally conceded to have been a highly malarious year, while the years 1913 and 1914

were very much less so, the past year being remarkably dry and a general drought prevailed.

Upon the subsidence of flood waters many pools and ponds are left favorable for the breeding of mosquitos. It is then that malaria begins to increase, reaching epidemic proportions, as have occurred after the overflows of the Mississippi River, the Nile, Danube, and other rivers in different countries.

Under meteorological influence may be considered winds. It is supposed that winds carry mosquitos great distances, but the Anopheles do not ordinarily venture flight in strong winds. Sanitary Engineer J. A. A. Le Prince observed in Panama that Anopheline mosquitos will fly against the wind in one place (Pacific side) and at another will fly across the wind (Atlantic side). He has observed that Anopheline mosquitos will fly a long distance, one-half mile or more in search of blood in one place, and yet at another, the same species will not venture a quarter of a mile from its breeding place. There are undoubtedly some bionomical facts yet unsolved connected with the habits and life of Anopheles, all of which have an important epidemiological bearing on malaria.

Character and Topography of the Soil.—A porous soil, such as gravel or sandy soil, will drain or take up water rapidly, while a clay soil being more impervious favors the retention of pools of water on the surface.

Naturally where the topographical conditions favor rapid drainage no water will remain. Yet in creeks, branches, river beds, and the like having a steep fall, very frequently the beds are shallow, or flat lands exist where water may collect, or eddies form, which favor mosquito breeding. Lakes, ponds, pools, having shallow margins overgrown with vegetation, also form excellent places for Anophelines to breed. Regions where drainage is slight, such as in the lowlands, flats, or river deltas, have been notoriously malarial.

The artificial formation or changes made in the soil, such as borrow pits, ditches, earthworks and constructions including dams, and the building of roads, frequently favor the retention of water for sufficient time to serve as breeding places for mosquitos.

Altitude.—In the higher altitudes, malaria is usually unknown. This is due to the lower mean temperature which does not favor Anopheline breeding. There are some exceptions, such as the Peruvian Andes where malaria occurs at an altitude of 2,000 meters; in the Himalayas at 2,000 meters; in places in Africa at an altitude of 1,500 meters. In the United States the Rocky Mountains and Appalachian range are generally free, the reports of cases being those of relapses from original infections contracted at the sea coast. The disease is one of low lying countries, and it is there that malaria is most prevalent, as the geographical distribution of the disease would indicate.

People living in malarious sections often select the hills for their residences where they will remain free from the disease. A measure of protection may be secured by living in the upper stories of buildings instead of the lower floors; however Anophelines (*Anopheles quadrimaculatus*) will often find entrance into buildings through chimneys, and they have been found on the third floor of buildings, so that the statement that Anophelines will not fly many feet above ground is too indefinite. In observing their flight they apparently do not rise above twenty feet, but upon approaching a building they may rise to a greater height if entrance is barred, and their prey cannot be reached otherwise.

The Human Factor.—So far as is known, man is the only intermediate host for the plasmodium of malaria.

Malaria Carriers; Endemic Index of Malaria.—It has been shown by Koch, that in a malarious section a number of apparently healthy persons, chiefly children, harbor the sexual forms of plasmodium in the blood, and from them the Anopheline mosquitos may become infected. The percentage giving the relative number of such carriers was termed by Christophers and Stevens the "Endemic Index of Malaria." Two methods were used for determining this index: (1) Examination of persons for enlargement of the spleen; (2) microscopic examination of the blood for parasites.

The spleen test is undoubtedly the easiest and most rapid method. In highly malarious regions it would undoubtedly give valuable information, but in recent investigations in the United States this method was not employed. Other factors causing enlargement of the spleen must be considered, as in the Far East, where kala azar is common among children. In the United States this disease need not be considered, but the fact that quinine is commonly employed and used in the United States for the treatment of "chills and fever" has its influence in checking the active symptoms and consequently an effect in preventing enlargement of the spleen, and must therefore be considered in index work.

A parasite index is to be obtained by making microscopic examinations of the blood of apparently healthy persons, chiefly children. Such an index will vary as to season. If possible, it should be taken at the beginning of the season, before the Anopheline mosquito flight takes place. The result of an examination at that time would give a minimum percentage of carriers, excluding persons who had recovered spontaneously or by treatment during the winter months. Another index taken at the end of mosquito flight in the late fall will naturally give a larger percentage and will show the increase. If antimalarial measures have been carried out, the index should be taken at corresponding periods in different years.

The following table will give the parasite index obtained in various states in the United States, giving number and color examined and type of infection:

Summary of Result of Examinations Made by the United States Public Health Service, to Determine Endemic Index in Various States in the United States.

State.	Number of Places.	Year.	Number Examined.		Number Infected.		Types of Infection.			
			White.	Colored.	White.	Colored.	T.	Q.	E.A.	Mixed T. & E.A.
Alabama	7	1912–1915	1,348	283	151	36	139	....	48	.....
Arkansas	16	1913–1914	2,444	2,245	188	287	325	....	145	6
North Carolina	8	1913–1914	3,449	941	237	108	268	1	73	2
South Carolina	1	1913	14	53	1	7	5	....	3	.....
Mississippi	2	1914–1915	320	2,083	32	720	417	....	328	7*
Virginia	1	1914	318	2	29	1	27	....	3	.....
	35		7,893	5,607	638	1,159	1,181	1	600	15

Total number examined 13,500.
Total number infected 1,797, equal to 13.28 per cent.

* One tertian and quartan.

This gives 1,140 positive findings equal to 15.53 per cent. of 7,338 persons examined. The highest infection was obtained in Mississippi in a place in the Yazoo Valley. The ages of persons in whom parasites were found ranged between nine months and eighty-five years. To this list may be added the results obtained from a collection made by Dr. Byrd, examined by the State Board of Health of Florida.

Florida, ten places, number examined, 576
Number of positive findings 44 = 12.9 per cent.

No age is exempt, but the largest proportion of cases occurs in children and young adults. Authentic reports of cases occurring in the new born, would indicate that sometimes the parasites may be transmitted from the mother to the child.

Sex has apparently no influence.

The white and colored races in the United States are equally susceptible, but the pernicious types occur less frequently in the colored. Hemoglobinuria, which may be considered a complication of malaria, rarely occurs in the colored, while in the white race, living in the same regions, it may not be infrequent.

The native in whom immunity, to a certain degree occurs, is, as age advances, less susceptible to attacks than the newcomer. Such immunity applies only to the continued residence in the locality and to the type of malaria prevalent, as a change of residence, or a new infection of a different type, will often precipitate an attack.

Other Influences.—Persons occupied in the opening up of new lands or new construction works, also in occupations requiring them to be out at night, are more likely to contract malaria.

Relapses in malarial fevers are quite common, and conditions that lower the resistance of individuals who are carriers will often bring on an attack. The most common are chilling of the body, undue exposure to the sun, exhaustion, starvation, traumatism, parturition in women, surgical operations, change of residence, bathing, as at resorts, residence in unhygienic surroundings, digestive disorders, mental shock, insufficient treatment of previous attacks; in fact nearly any depressing mental or bodily influence may cause a renewed invasion and increase of the parasite from their latent phase.

So much depends upon the life and habits of the Anopheline mosquitos in the epidemiology of the disease, that its consideration is of greatest importance. The many and varied factors influencing the life history of Anophelines must therefore be considered in the etiology of the disease.

The Malaria-bearing Anopheles.—Mosquitos form the family Culicidæ, under the order of Diptera, which includes flies and gnats, which are two-winged insects. Mosquitos are distinguished by having a long suctorial proboscis, by the veins of their two wings being fringed with scales, and by their posture when resting in raising their hind legs, and by their many jointed antennæ.

The *classification* of mosquitos is very unsatisfactory. The subfamily of Anophelinæ to which the known malaria-bearing mosquitos belong, is divided by Theobold into eighteen genera which are distinguished by the shape and arrangement of scales. About 150 species of Anophelines have been determined, of which number forty are more or less definitely known to act as hosts for the plasmodium.

Knab gives a list of thirty-four species of American Anopheles, of which number eight have been definitely shown to serve as hosts for the malarial parasite. The American species of malaria-transmitting Anopheles, given by him are:

albimanus	quadrimaculatus
argyritarsis	pseudomaculipes
crucians	pseudopunctipennis
intermedium	tarsimaculata

The three most prevalent Anophelines found in the South of the United States, where malaria prevails to the greatest extent are *Anopheles quadrimaculatus*, *Anopheles crucians*, and *Anopheles punctipennis*. The last named is not considered to be a transmitter of malaria.

From experimental evidence it appears that all Anophelines cannot become infected, and that some species are susceptible to infection by certain species of plasmodium only. This serves to explain why malaria is absent in some regions, and why certain types of malaria prevail in certain localities.

It is held that *Anopheles crucians* is infectible by the estivoautumnal parasite, and not by the other types of parasite, and by some that *Anopheles quadrimaculatus* is infectible by the tertian and quartan and not by the estivoautumnal. While *Anopheles crucians* may be a transmitter, and undoubtedly is, in the epidemological observations made in a number of places, it makes its seasonal appearances rather late and is proportionately much fewer in number. In the winter months it has been found not only to equal but to exceed in numbers the *Anopheles quadrimaculatus*.

There may be topographical conditions to account for this variance. If *Anopheles crucians* is the chief carrier of the estivoautumnal type of infection in our Southern States, then it (*Anopheles crucians*) should be found to be much more numerous than it is, and should become proportionately numerous by the month of September, when the estivoautumnal type of malaria is quite common.

From a number of observations and collections made in different parts of the southern portion of the United States, it would appear that *Anopheles quadrimaculatus* is chiefly responsible for the spread of all forms of malaria.

Bigname (1898) succeeded in transmitting malignant parasite infection through *Anopheles maculipennis* (*quadrimaculatus*) which had been caught in an infected house, which proves its infectivity by the estivoautumnal parasite.

General Description.—Male mosquitos are recognized by the antennæ which are densely covered with long hairs; in the female the hairs of the antennæ are short and fewer. The female, only, bites. In the Anophelines, the palpi in both sexes are almost as long as the proboscis.

The Anophelines, as do all mosquitos, pass through the stages of egg or ovum, larva, pupa or nymph, imago or adult mosquito. Although the larval and pupal stages are passed in water, they are true air breathers.

Eggs.—The Anopheline eggs when first laid on water, sometimes on blades of grass, sticks, etc., close to the water, are white, and after a few hours appear black. They are laid erect, in small masses, but soon appear lying flat and singly on the water surface, forming symmetrical patterns, which are quite characteristic.

Hatching of the eggs is favored by warm weather and occurs in one or two days. The number of eggs deposited at one oviposition varies, and may reach a hundred or more. A single mosquito may deposit more than 2,000 eggs during the season.

Larva, Wiggler or Wriggler.—The Anopheline larva may be distinguished by the normal position assumed, which is flat or parallel to the water surface, and when disturbed it "scoots" over the water but sometimes dives downward, quickly rising to the top; by the head, which is narrower than the thorax, and turns a semicircle, so that it appears to be feeding on the water surface; and by a stump-like respiratory siphon on the eighth abdominal segment.

These larval forms are found only in water, and feed during this stage. In the course of development they shed their outer skin three times.

Anatomically, they have a head, thorax, and nine abdominal segments. The head is narrower than the

thorax, has eyes placed laterally, in front of which are the antennæ, and beyond these the mouth or rotary brushes, and under the latter the mandibles and maxillæ with the labium between them. The neck is very short and narrow. The thorax is oval shaped and has three rows of long hairs. There are nine abdominal segments, the first seven bearing hairs which are variously distributed in the different species. On the eighth segment is a short stubby projection comprising the breathing apparatus, having two tracheal openings. The last segment is small and bears a set of four anal gills with tufts of hairs.

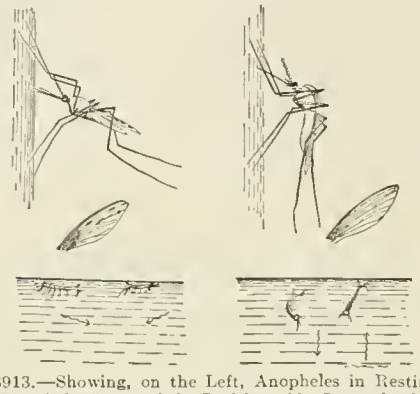


Fig. 3913.—Showing, on the Left, Anopheles in Resting Position, its Dappled Wing, and the Position of its Larvæ in the water; on the Right, Culex in Resting Position, its Plain Wing, and the Position of its Larvæ in the Water. The arrows indicate the direction taken by the larvæ when the water is disturbed. (Abbott, Hygiene of Transmissible Diseases, W. B. Saunders Co.)

The larvæ range in size from about one-sixteenth inch in length when young to nearly one-fourth inch when fully grown, which stage is reached in seven to nine days in summer. They may possess different colors such as green, brown, black, etc., depending upon the character and color of their food. They feed mainly on the slimes from leaves, algæ, or any other vegetable substance present, and are sometimes cannibalistic.

The pupa or nymph, also called tumbler, the next stage, is a comma-shaped body, which passes its existence in water. In this stage it is purely developmental and does not feed. There are two breathing tubes located on either side of the back of the thorax and attached about the middle or slightly anteriorly. These tubes are funnel shaped, larger anteroposteriorly, and narrow laterally, with the broad end pointed toward the surface when resting to breathe. At first the pupa is light in color, sometimes green, brown, etc., as that of its larval stage, and later will appear to be black when the head and wing parts of the mosquito are visible through the shell. When disturbed it darts about in the water, and rises and floats to the top without any effort.

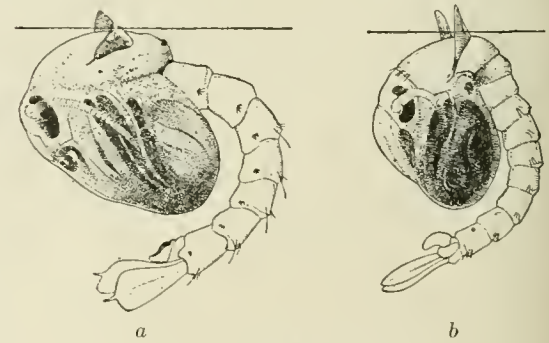
After a period usually of two days, longer in cold weather, the anterior portion of the pupal shell splits on the posterior aspect, when the imago or adult mosquito emerges, the head parts appearing first. It draws itself out of the water surface, and after the legs and wings are in position is ready for flight.

The Anopheline mosquito is recognized (1) by its palpi, being as long or nearly as long as the proboscis in both sexes; (2) by having dark spots on the wings; (3) when resting on a surface, it holds it entire body in one straight line forming an angle, or standing nearly vertical to the surface. In effect, therefore, the proboscis points toward the surface and the abdomen away from the surface on which the mosquito rests.

Anatomy.—The body consists of a head, thorax, and abdomen. The head is oval, and has two compound eyes, one on either side. Projecting from the head in front are five parts, in the middle the proboscis or biting part and lying to either side of this the palpi, and situated above and to the outer side of the proboscis the two antennæ. The proboscis or beak consists of seven parts:

The Labium, or sheath enclosing the piercing organs, composed of two mandibles or lancets fitted for cutting and bearing serrations on the outer side of the enlarged ends in the female; these organs are absent in the males. Two maxillæ or palpifers. One hypopharynx situated below, which is grooved and forms the gutter with the one epipharynx above, along which blood is taken up in the act of biting. In the gutter of the hypopharynx, but dorsal to the epipharynx, saliva is passed. In the male the hypopharynx is fused with the sheath so that structurally it is not adapted for biting, but is used for sucking of juices of plants on which it lives. The palpi on each side of the proboscis are jointed structures nearly as long as the proboscis in both male and female. The antennæ are jointed appendages having sixteen segments and covered with long dense hairs giving them a plumose appearance in the male, and of fifteen segments covered with short hairs in the female. The first joint of the antennæ is socket like. The part of the head above and behind the eyes, is called the occiput; it is covered by scales of different shapes used in the classification of species. The neck is short and connects the head with the thorax.

The thorax is divided into the prothorax, mesothorax and the metathorax. The mesothorax, which comprises the greater portion of the thorax, is covered by the scutum and behind this is the "scutellum" which is not trilobed. Laterally, on each side of the thorax, are placed two thoracic spiracles. Each segment of the thorax carries a pair of legs, one on either side, making therefore three pair of legs, each leg composed of nine segments, the coxa, trochanter, femur, tibia, metatarsus, and four tarsi; the last segment, tarsus, carries the two claws or ungues, each of which in the female terminates in a double hook; in the male the first leg terminates in a single claw. These parts are variously arranged in the different species. There is one pair of wings arising on either side of the mesothorax. By the arrangement of the



a *b*

Fig. 3914.—Pupæ, *a*, of *Anopheles maculipennis; b*, of *Culex fatigans.* (Greatly enlarged.)

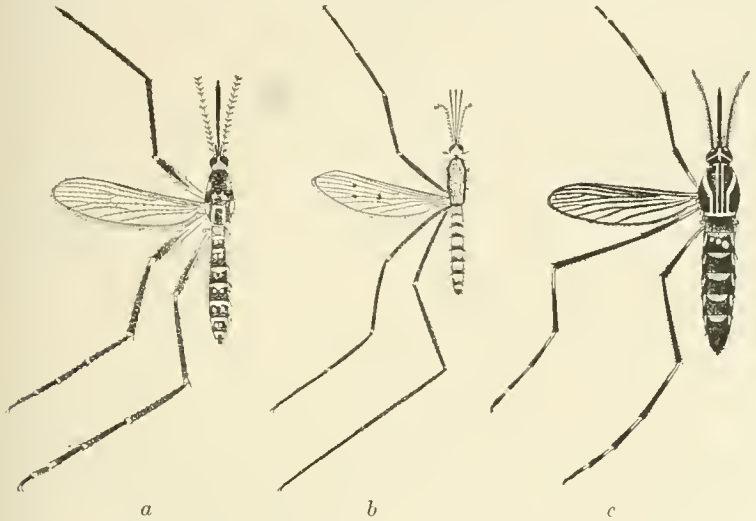
scales the wings appear spotted. These markings are used in the classification of species. The halters or rudimentary wings are knob-like structures arising from the metathorax.

The abdomen is composed of eight segments, the terminal segment bears external genital organs, the clasper in the male, and the flap-like ovipositor in the female. There are six to eight abdominal spiracles placed laterally on each side of the abdomen.

Internal Anatomy.—In the thorax are located a pair of salivary glands, one on each side of the thorax and each composed of three lobes. The ducts unite

to form a single duct which passes forward through the neck into the head. It unites with its fellow from the opposite side, forming a common duct ending in a salivary pump which is continuous with the salivary groove of the hypopharynx.

The alimentary canal consists briefly of: (1) Mouth comprised in the labium. (2) Buccal cavity or true mouth situated just behind the clypeus. (3) Pharynx extending from the buccal cavity to posterior end of head, where it ends in—(4) Esophagus which is short and runs to the esophageal valve ending on a level with the origin of first pair of legs. Three blind tubules or sacs diverge from the esophagus.



a *b* *c*

Fig. 3915.—Disease-bearing Mosquitos. *a*, Culex; *b*, Anopheles; *c*, Stegomyia.

(5) Esophageal valve, or preventriculus which acts as a valve. (6) The midgut or stomach, a straight tube terminating in a diverticulum, extends from the level of the first pair of legs to the sixth abdominal segment. (7) The hind-gut consisting of ileum, colon, rectum, and anus which opens on the last segment of the body. Malpighian tubules, five in number, arise at the juncture of the mid- and hind-gut, and are inserted in the pyloric end of the stomach.

The female organs consist of ovaries and accessory organs; the male, of testes and special organs.

In the act of biting, the labium or sheath is retracted, allowing the piercing parts enclosed to project and pierce the skin. It is during this act that Anophelines become infected and in turn infect man with the malarial parasites.

It is the midgut or stomach in which the oocysts of the plasmodium develop, and the salivary glands where the sporozoites find their way to the saliva.

Some Characteristics of Anophelines.—Breeding Places.—Anophelines prefer and select clean water where vegetation exists. The natural breeding places, or places of selection, are creeks, swamps, branches, shallow pools, pockets of streams, etc., where vegetation, such as grass, algæ, weeds, sticks, floating débris, logs, moss, etc., is present. Man is often responsible for making natural breeding places, as may be found in street gutters, ditches, grass plots, where waste water from various sources may collect. Artificial breeding places such as water contained in bottles, barrels, cans, etc., are sometimes sources of Anophelines, but these places are unusual. When selection of artificial breeding places is made, we have found that natural breeding places are close at hand or Anopheline mosquitos quite numerous.

Life of Anopheles.—This is not known but it is generally stated to be one to two months in summer. They may hibernate over winter or estivate over a long dry spell.

Time of Flight.—This occurs chiefly during the hours between sunset and sunrise. It does its biting or feeding during the same hours. It may bite earlier on dark days, or in shady places.

Biting Habits.—The Anophelines are light shy and do not bite when one is active and moving. They attack one quickly and directly, giving little if any warning. The sting is less irritating than that of other kinds of mosquitos. Blood food stimulates ovulation.

Flight.—Anophelines fly variable distances according to species, and sometimes this varies with the same species. It has been found by Sanitary Engineer J. A. A. Le Prince that *A. albimanus* will fly 6,200 feet. The author has found that *A. quadrimaculatus*, males and females, in great numbers, will fly at least 3,000 feet from the breeding place. Other observers (Craig, James) report flights of two to two and one-fourth miles.

Other Habits.—When in search for blood, Anophelines will use every effort to find access to a source of blood. At daybreak, they seek to leave a building and apparently go blindly for an opening to leave a house and reach some shady place among shrubbery, trees, grass, or other places of shelter. During the daytime they may often be found resting on walls behind furniture or other objects, in barns, outhouses, lofts, chicken-houses, stables, in the woods on the bark and in hollow trees. A spider web is a favorite resting place.

The singing note of Anopheles is distinctly lower than that of Culex or the common mosquito.

It is important that we study the habits of Anophelines in different places and under different conditions. Some of the conditions determining the prevalence of malaria bear directly upon those affecting the propagation of Anophelines.

Infected Anophelines.—From what has been said, the susceptibility to infection of Anophelines varies with the species, some do not become infected, others with some difficulty, and still others more readily so.

Under natural conditions, the percentage of infected mosquitos has been found to be small, though Craig found as high as thirty-five per cent. infected mosquitos in the Philippines during the height of the malarial season, and as low as one per cent. at other times; Stephens and Christopher found five to twenty per cent. infected at Freetown; A. Plehn found 2.2 per cent. of 860 examined in Cameroon, Africa; and Celli 2.5 per cent. in Italy.

The infectibility of Anophelines varies so that it may require several feedings before infection occurs. Daniels is mentioned by Deaderick as having investigated this subject, and gives the following summary of experimental work:

19 fed only once	5 had zygotes	26.0 per cent.
13 fed twice	6 had zygotes	46.0 per cent.
16 fed three times	10 had zygotes	62.0 per cent.
9 fed four times	6 had zygotes	66.6 per cent.

As sporozoites are the forms of the parasites to be found in the salivary glands, and the oocysts in the stomach walls, the examination of these organs is of especial interest.

Dissection of Infected Anopheles.—The removal of the organs, salivary glands and stomach, is quite simple, requiring only a little patience and practice.

The necessary apparatus consists of a glass plate, microscopic slides and cover-glasses, dissecting needles, physiological salt solution, and if permanent preparations are to be made, fixing and staining solutions as are used in ordinary histological work. It will be found useful to have a black and white surface as a background for dissecting. White and black paper under a glass plate will serve the purpose.

Technique.—The mosquito should be freshly killed by use of chloroform, hydrocyanic acid, or tobacco smoke. It is important that any blood food should have been digested, so that the dissection is best made several days (two or three) after feeding. The legs and wings should be removed, and the dissection of the body made on a glass slide immersed in a drop or two of physiological salt solution.

To remove the salivary glands, the procedure is as follows: With one needle transfix the thorax in its posterior half; with another needle incise the chitinous covering of the thorax in the anterior median line, then transfix the head with the second needle, and make gentle and slow traction with the needles in opposite directions. It is best to make traction on the head toward the operator, with the thorax needle held away. In pulling the head from the thorax, a small bit of white tissue follows, in which, if successful, the salivary glands will be contained. Upon examination with a low power, sixteen millimeters or four millimeters, these organs may be recognized. The head is then removed from the bit of tissue with a dissecting needle (a Hagedorn needle makes a good cutting needle), and a cover-slip placed over the tissue to be examined.

The six lobules often overlap and are distorted, but may be recognized by their sacculated shape and glistening appearance. If sporozoites are present, these are recognized as fine hyaline rods, within the ducts and glands, or they may be free in the salt solution. The preparation may be dried and stained with a polychrome methylene blue stain, when the sporozoites will appear as blue rods with a red chromatin spot.

To remove the stomach, place the mosquito in one or two drops of salt solution, on its dorsum, on a microscopic slide, transfix the thorax with a needle, and with a second needle make a small transverse cut between the last two abdominal segments, then with the needle on the last segment, make gentle traction. The abdominal contents—intestine, five Malpighian tubules, ovaries, and stomach—may be recognized as they are removed and possibly a portion of the esophagus which breaks off. With a needle the ovaries and other parts may be removed from the stomach. The stomach floating in salt solution may then be covered with a cover-slip, and examined with a microscope, $\frac{1}{6}$ or $\frac{1}{12}$ objective. If oocysts are present, these will be recognized as round or oval thickenings or cyst-like protusion on the stomach wall.

The preparation may be fixed and stained *in situ*. Formalin, two per cent., may be dropped on one side of the cover-slip and with a blotter in contact with the cover-slip on the opposite side, the formalin will be drawn through and under the cover-slip. After repeating this two or three times, follow by water, then with staining solution, using weak fuchsin, thionin, or methylene blue, then wash with water, followed by alcohol, xylol, and balsam, and permanent preparations are obtained.

Pathology and Morbid Anatomy.—It is obvious that the first and main pathological change occurs in the blood where the parasites of malaria invade the red blood cells, and together with their products, namely, toxins, hemolysins, and pigments, formed as a result of the process of multiplication, give rise to other and more serious pathological changes.

To the tertian and quartan parasites have been ascribed the benign forms of malarial fevers, as a fatal termination is extremely rare from these forms of infection. In the subtertian or estivoautumnal type of infection, fatal terminations are common. This is explained by the tendency of the infected cells to agglutinate and adhere to the walls of capillaries, causing a localization of the parasites in an organ, and subsequently profound circulatory disturbances.

The toxin, which is a product of the segmenting parasite, is supposed to cause the symptoms that characterize the disease, also the congestion of organs, and certain metabolic disturbances. That such substance is present, has been shown by Rosenau and his collaborators, who, by filtering the blood, obtained during the paroxysm, reproduced a paroxysm by injecting the serum. Grassi has shown that periodicity is coincident with segmentation of the parasite.

The hemolysin, also a product set free upon sporulation, is destructive to red blood cells and causes the appearance of a yellow pigment (hemosiderin) which is found only in the parenchyma of the spleen, liver, and to a much lesser degree in the kidneys, bone marrow, and other tissues, and not in the blood. Hemosiderin gives an iron reaction and is soluble in alcohol, insoluble in acids and alkalies. An antihemolysin has also been demonstrated.

The pigment or hemozoin, an excrementitious product of the parasite in its action upon the red blood cell, occurs in the blood where it may be seen free or in leucocytes, and in the tissues of the spleen, liver, bone marrow, and other organs. It does not give an iron reaction, is soluble in alkalies, insoluble in acids, alcohol, chloroform, or ether.

The changes in the size, color, form, and staining reactions of the infected red blood cells, have been given under the description of the different parasites. Of the other histological changes the most common seen is the appearance of normoblasts. Basic granular degenerations, poikilocytosis, megaloblasts are seen in the more severe anemias. Anemia is a characteristic condition, and is the result of the destructive influence of the parasites and the hemolysin upon the red blood cells. It is not unusual to find a reduction in the number of red blood cells of from five to ten per cent. after each paroxysm, so that in a few days instead of 5,000,000 red blood cells per cubic millimeter, they will be found to number 3,000,000 or even less. The rapid reduction is to be noted early in the disease, but does not progress beyond a certain limit, although the infection may continue.

The decrease in the specific gravity of the blood follows the decrease in the number of red blood cells, so that it is more marked at the onset of the attack, and less as the infection becomes chronic. The hemoglobin index is also diminished.

Regeneration of red corpuscles is more rapid when proper treatment is instituted after acute attacks than after chronic attacks.

Leucocytes.—The relative and absolute number of leucocytes becomes reduced, except in some of the pernicious attacks, in which leucocytosis occurs with the complications. Stevens and Christophers have shown that at the time of the paroxysm there may be a leucocytosis, the ratio of red and white corpuscles ranging 1 to 90 to 1 to 300, the normal being 1 to 500, while after the rigor the ratio will be much greater, so that there may be a third or fourth as many leucocytes, and a consequent leucopenia occurs.

Differentiation of Leucocytes.—A relative increase of the large mononuclear leucocytes of fifteen per cent. or more has been considered to be of diagnostic importance by many. The increase is to be noted mainly after the temperature has reached normal. Degenerated leucocytes, basket shaped and other misshapen remains of leucocytes are sometimes encountered in large numbers, but are of no diagnostic significance. In making differential leucocyte counts, the personal equation must be considered.

The following are probably typical examples of

counts which were made of cases, before and after quinine administration, which may be compared with the normal count made.

	Normal.		Tertian.		E.-autumnal.	
	Before.	After.	Before.	After.	Before.	After.
Polymorphonuclears	53.0	68.0	50.1	29.1	65.7	44.4
Large mononuclears	6.3	5.1	12.7	19.3	8.0	23.4
Large lymphocytes	24.9	18.5	32.9	44.8	22.8	29.9
Small lymphocytes	10.3	5.2	2.8	5.0	2.7	0.8
Eosinophiles	4.8	2.7	0.6	1.0	0.0	1.0
Mast cells	0.7	0.5	0.9	0.8	0.8	0.5

Daily Count of a Quartan Case.

	June 11.	June 12.	June 13.	June 14.
Polymorphonuclears	593	463	542	668
Large mononuclears	113	146	54	39
Large lymphocytes	212	311	224	186
Small lymphocytes	54	28	102	97
Eosinophiles	28	49	78	9
Mast cells	0	3	0	1
	1,000	1,000	1,000	1,000

Phagocytosis.—All leucocytes are not involved in the phagocytic action, but phagocytosis is mainly seen in the large mononuclear leucocytes and transitional forms, and to a lesser degree in the polymorphonuclear cells. Pigmented leucocytes occur during the pyrexial period and disappear during the apyrexia.

The hemozoin or pigment, residual portions of plasmodia, sometimes plasmodia, and infected or altered red blood cells, may be seen engulfed by the leucocytes. This is best seen upon blood examinations made just after a paroxysm, and is absent when the apyretic period is reached. Other cells which are phagocytic are endothelial cells, macrophages in the liver and spleen, and large mononuclear leucocytes in bone marrow.

The pathological changes are fully described by Marchiafava, Bignami, and others. The principal anatomical changes differ somewhat in the acute and chronic manifestations of the disease. The organs most commonly involved are:

Spleen.—The enlargement of the spleen results from a hyperemia and an infiltration of altered red corpuscles, parasites in cells in various stages of development, and pigmented leucocytes, followed by a hyperplasia of the pulp cells and an induration from connective-tissue increase. In acute enlargement the organ will be found soft and friable, and unless care is taken, may rupture in its removal. Rupture of this organ has occurred spontaneously, or upon a slight injury, causing a fatal termination. On section it will cut "like a clot of blood," is a deep red in color, and diffluent. Microscopically the capillaries and pulp are filled with blood cells, parasites, leucocytes, altered red blood cells, macrophages, and pigment in all its parts.

In chronic enlargement, the spleen is firm and hard, or dark, or slate colored, variable in size, from a slight enlargement to a size that may occupy nearly the entire abdomen, extending down to the pelvis and beyond the median line. The capsule is thickened and adherent. On section, the Malpighian follicles are prominent, fibrous network thickened, and the color the same as that of its surface.

Microscopically, the Malpighian follicles are larger, there is an increase of lymphoid tissue, with hyperplasia of cells and connective tissue with diffuse pigmentation.

Liver.—The liver is enlarged, dark brown, or slate colored. In acute cases, the liver is softer than normal, and on section, blood oozes freely. The gall-bladder is usually distended with bile. Microscopically, degenerative changes are seen in the liver cells with yellow hemosiderin, not hemozoin pigmentation. The endothelial cell, and stellate cells of Kupfer are pigmented. Pigment is also collected in the intralobular spaces which may be found distended with pigmented endothelial cells.

In chronic cases the liver is enlarged, hard, dark in color, surface smooth, capsule thickened. On section the lobules may be seen to vary in size, and the connective tissue thickened.

Microscopically, there is a hyperplasia of connective tissue, pigmentation around the vessels, and alterations in the liver cells.

Stomach and Intestines.—The stomach contents may be bile stained. The mucous membrane becomes congested, and in the choleraic form may have a grayish or black appearance. The intestine may show prominent Peyers patches which may be pigmented; while following a choleraic attack, the outer walls may be dry and sticky, the intestine empty and ribbon like, and the contents may be composed of a very little flaky or serous fluid, which may be bile stained with no solid particles or fecal matter. The mucous membrane may be normal in appearance or even black from pigment deposit in the capillaries.

Microscopically, pigment free and in leucocyte, and red blood cells containing parasites may be seen in the capillaries.

The large intestine will have the same appearance as the small.

Heart and Pericardium.—The pericardium may contain more than the normal amount of fluid. Ecchymotic spots may also be present. The heart in acute cases, will be pale, soft and flabby, distended with blood. The blood upon microscopical examination will show infection of red blood cells, usually the young form, hemozoin (pigment) free and in the leucocytes.

Lungs.—That localization of parasites in the capillaries with consequent engorgement does occur, is more than probable. In pneumonia or bronchopneumonia, a double infection has generally been demonstrated.

Kidneys.—The kidneys will usually appear normal, signs of cloudy swelling may be found. Pigmentation of the endothelial cells of the glomeruli and intertubular capillaries occurs. Parasites are rarely found in the vessels of the glomeruli. There may be evidences of further changes, such as degenerative changes in the epithelium of the condulated lobules, with hyaline, granular, and epithelial casts and yellow pigment. In more chronic cases there may be increase of interstitial connective tissue. At times parenchymatous changes, as seen in Bright's disease, are encountered.

Bone Marrow.—The bone marrow in acute cases may have a normal yellow color, but usually in deaths from malaria, it is of a reddish-brown appearance due to the replacement of the fat by vascular formation.

Microscopically, parasites in all stages of development are found in the medullary tissue. Macrophagi deeply pigmented and free pigment are also present. Crescents in the bone marrow may be demonstrable when not in the circulating blood.

Brain.—When a comatose type of fever has prevailed, there will be evidence of hyperemia and punctate hemorrhages, particularly in the white substance, also there may be pigmentation giving the brain substance a brownish or black color. In the blood-vessels, parasites in all stages of development, or in a single stage may be seen microscopically. The amount of pigment depends much upon the stage of the parasite, being less in the young stage and large in the sporulating stage.

The endothelium of the capillaries is swollen and may even completely close the lumen. With the

change in the vessel walls a diapedesis of red blood corpuscles occurs giving rise to the punctate hemorrhages.

In the choleraic form of malaria, the brain will be pale and bloodless and other changes, occurring in the comatose form, are found absent.

Nuclear changes in the nerve cells, or profound changes of a granular character in the protoplasm may be present.

Amyloid degenerations have also been described as occurring in some of the organs, particularly in cases of malarial cachexia. The organs chiefly affected are the kidneys, spleen, and intestines, and less often the liver.

The *body* of the cadaver has usually a muddy yellowish color of the skin, the conjunctiva also pale and yellowish.

Symptoms.—The classification of malarial fevers according to the etiological division of the parasites associated with them, is believed to be the simplest and most logical.

It is true, that clinically the benign or mild types are usually due to tertian and quartan infections, but deaths from these types of infection have been reported. The estivoautumnal infection is commonly associated with the malignant or severe types, in which pernicious symptoms occur.

The description of the three main forms of malaria fevers will then be considered under acute and chronic malaria, their complications and sequelæ.

A clinical classification under each form may be made:

1. *Tertian:* (*a*) single infection, tertian; (*b*) double infection, quotidian; (*c*) irregular and recurrent attacks.

2. *Quartan:* (*a*) single infection, simple quartan; (*b*) double infection, or double quartan; (*c*) triple quartan, or quotidian; (*d*) irregular and recurrent.

3. *Estivoautumnal:* (*a*) single infection, subtertian; (*b*) quotidian fever; (*c*) irregular, remittent, or continued.

4. *Mixed:* In this any of the two, or even all three types of infection may be present.

Frequency of Types.—In reports by physicians in the Southern States, of 8,519 cases of malaria, in which the diagnosis was confirmed microscopically, 65.2 per cent. or more than five-eighths were reported to have been tertian, 12.78 per cent. or one-eighth quartan, and 22.02 per cent. or nearly one-fourth estivoautumnal in type. In the blood examination of 7,338 persons from various parts of the Southern States made for establishing the endemic index, there were 696 tertian and 431 estivoautumnal, 13 mixed, and 1 quartan infection found. This gives 61 per cent. of tertians to 37.8 per cent. of estivoautumnal, 1.1 per cent. mixed, and 0.01 per cent. quartan. The quartan type is extremely rare, rarer than would be indicated by the reported findings of physicians. It has, however, been found and confirmed at the State Board of Health laboratories in Mississippi and Florida. The writer has seen but three cases which originated in Alabama during the three years of 1910 to 1913.

Mixed infections occur usually in the late fall or toward the end of the malarial season. At times acute paroxysms occur at intervals of six, seven or eight days, or multiples thereof. These are to be considered relapses or recurrences of the other forms and should not be classified as distinct types.

The incubation period covers the time from the introduction of the parasites and consequent multiplication of the parasites to such numbers that their collective toxins, liberated upon segmentation, will produce the active symptoms that characterize the disease. This period averages eight to twelve days, but varies, however, with each type.

Ross gives the extremes and averages for incubation periods for a number of collected experiments, as follows:

	Lowest.	Average.	Highest.
Quartan blood inoculations	11.0	17	25
Tertian blood inoculations	3.0	10	21
Tertian mosquito inoculations	15.0	18	25
Estivoautumnal blood inoculations	2.5	8	30
Estivoautumnal mosquito inoculations	6.0	11	15

The incubation period for quartan is conceded to be longer than either for tertian or estivoautumnal infections, the average for quartan is estimated to be eleven to eighteen days; for tertian six to fourteen days: for estivoautumnal two to ten days.

It has frequently come to my notice in maritime quarantine practice that the incubation periods for tertian and estivoautumnal types were, as a rule, between the average estimate of eight to twelve days.

Acute Malaria.—The paroxysms in typical acute attacks of all forms of malaria have symptoms in common which recur at fairly regular intervals of twenty-four, forty-eight, or seventy-two hours.

When the paroxysm recurs at an earlier hour than the previous one, it is said to *anticipate;* if at a later hour, to *postpone;* and when the paroxysms overlap, so that one attack is not concluded before the next begins, to be *subintrant.*

Febrile attacks having distinct apyretic periods are called intermittent fevers, or agues; when the stage of fever is marked by a fall of temperature not quite reaching normal, it is said to remit, and therefore is called remittent fever. At times the febrile stage is continuous and the course is then called "continued fever" and a double fever when two complete paroxysms occur on the same day.

Febrile attacks with long intervals such as five, six, etc., days, are called quintan, sextan, etc., but are not distinct types. Fevers with irregular intervals are common in the chronic infection, and recurrent attacks, which are relapses, will occur at intervals of seven or more days, or multiples thereof.

The paroxysms may be preceded by prodromal symptoms occurring several hours or days before the onset of a chill. When present they consist of symptoms of general indisposition common to any acute infection, such as fatigue, disinclination to work, lassitude, malaise, loss of appetite, foul breath, irritability of temper, yawning and stretching, and slight febrile elevations.

A paroxysm is characterized by three distinct stages, namely: (1) The cold or chill stage; (2) the hot, fever or pyretic stage; (3) the sweating stage, followed by apyrexia, lasting a longer or shorter time.

The *cold* or *chill* stage usually begins very suddenly, with the sensation of cold in the legs and up the back, which increases until there is a shaking and shivering of the body. The patient appears cold and pale, there is chattering of teeth, lips are blue, and he seeks to get warm by huddling up in the bed with heavy covers, or close to a fire.

The skin has a dusky hue and may be moist and feel rough, giving rise to the condition commonly known as "goose flesh." Nausea and vomiting frequently occur early and there may be diarrhea. Headache and dizziness, aching in the limbs, dyspnea, are also complained of. The pulse is rapid and if the temperature is taken early, will be found to be 38° to 39° C. (100.4° to 102.2° F.) and rising rapidly. An examination of the blood at the onset of this stage will often show segmenting and presegmenting forms of the parasites in the tertian and quartan infections.

The secretion of urine is increased and micturition frequent.

The duration of the chill stage will last from one-half to one hour.

Hot or Fever Stage.—In young children this stage may be accompanied by convulsions. Toward the termination, sensations of cold and heat occur when

the patient enters the hot or fever stage, in which he complains of heat and thirst. The covers are cast off, face is flushed, eyes are red, tongue is coated and dry, headache may be intense. The skin is hot and dry and may have a yellowish muddy hue. Herpes not infrequently appears upon the lips and nose and may be of diagnostic value. At times an urticarial eruption occurs. A general anemic appearance may also be seen which is quite characteristic in the more chronic cases. The pulse will be full, bounding and rapid; the temperature 40° to 41° C. (104° to 105.8° F.), reaching its maximum in this stage.

The tongue is coated, full, broad, and tooth-marked, nausea, vomiting, diarrhea, or constipation may be present. The spleen may be found enlarged and frequently tenderness on pressure over the splenic region may be elicited.

A microscopic examination of the blood will show the young forms, merozoites, which have invaded new red blood cells.

The urinary secretion will be greatly decreased, highly colored, and the solid content of urea, uric and phosphoric acids, and chlorides, increased. Albuminuria is a variable symptom, being more frequent in some regions than in others, the duration of this stage is from three to six hours, or may be even longer.

Sweating Stage.—The beginning of this stage is manifested by the appearance of sweat on the forehead, which continues until the entire body is covered with a profuse perspiration. The symptoms complained of in the previous stage subside; the temperature drops rapidly to normal or subnormal, and with it the pulse and respiration become normal. The patient becomes relaxed and falls into a comfortable sleep, from which he awakes much relieved, but languid and weak. The duration of this stage is approximately two, three, or four hours.

The absence of the chill and sweating stages is not infrequent, to which the term "dumb chill" is applied.

Tertian Malaria.—This is the most common form and most widespread. Plasmodium vivax is the parasite associated with this form, a single infection or group, sporulating every forty-eight hours, causing paroxysms every other day, with an apyretic interval of thirty-six hours, which is characteristic of a simple tertian fever; with two groups, each maturing on successive days, the paroxysms occur daily, giving rise to a quotidian type of fever. Irregular or continued febrile attacks, probably due to irregular sporulating groups of parasites, sometimes occur. The chill is quite constant at the onset, but is sometimes absent.

The temperature course, intermittent in character, is quite typical and of diagnostic importance. The rise is sudden, often reaching 40° to 41° C. (104°, 105°, or 106° F.) with as sudden a drop to normal or subnormal, at the end of eight to twelve hours after the onset.

It is not infrequent to have anticipation, or postponing of paroxysms, which at times occur with some regularity, *i.e.* one or two hours before or after the usual hour for the onset.

Spontaneous recovery is not infrequent, even with an apparent increase of parasites as may be proved upon microscopic examinations of the blood. In these cases also other blood changes may be seen, such as the presence of normoblasts, poikilocytosis, large and small erythrocytes, which are also common in the chronic infections. Relapses are frequent in these cases. The anemia in this form sets in rapidly so that the patient soon has a sallow complexion. This anemia is more easily overcome by proper treatment than in other forms of malaria.

Although quite amenable to treatment, relapses sometimes recur after long intervals.

Quartan Malaria.—The parasite, *Plasmodium malariæ*, requiring seventy-two hours for completing its cycle of development in man, gives rise to paroxysms occurring every fourth day, hence the name given to this type of fever.

The entire cycle of development of the parasite may be studied in the circulating blood. It has already been pointed out that the gamete forms are rather rarely encountered in these examinations, which may explain the infrequency of this infection in our Southern States. Place infection curiously occurs, one instance of this having been brought to the attention of the writer in Scott, Arkansas, by Dr. Thibault, a good observer and microscopist. Other types of infection prevailed in the same region.

The duration of the paroxysms is on the average about as long as in tertian, eight to ten hours. These occur quite regularly. The chill stage is probably more constant than in either of the other forms.

The temperature course resembles that of the tertian but does not reach the height seen in tertian types. It is intermittent in character, with apyrexial interval covering two and a half days in a single infection. Anticipation or postponement sometimes occurs. The presence of two groups of parasites gives rise to paroxysms occurring on two successive days with apyretic interval of one day. The two paroxysms often differ in severity.

When three groups of parasites are present, maturing on successive days, a quotidian fever course is observed. Rarely do the paroxysms become subintrant but these multiple infections may change to double or simple, or *vice versa*.

Irregular types of quartan fever are rare. The great tendency to relapse in spite of treatment, is generally known. Mixed infections, that is quartan and tertian or estivoautumnal, may occur, giving rise to irregular febrile attacks. Only one such instance, quartan and estivoautumnal, has come under my personal observation; in this, however, the estivoautumnal infection predominated and the typical quartan infection was recognized only by the blood examination.

Estivoautumnal (*also called Subtertian and Tropical Fever.*—Some authors describe two febrile courses, one quotidian and one subtertian, as due to two different parasites which produce crescent-shaped gametes. Only one parasite, *Plasmodium falciparum*, or *Laveriania malariæ*, has been described as being associated with this class of fevers by the author, which classification will be continued under the clinical description.

The fevers caused by this parasite, have a more continuous course, sometimes with a short apyretic period, but more commonly remittent, irregular or continuous in character, with a tendency to be subintrant. The paroxysms last usually from thirty-six to forty-eight hours. The chill stage is absent in the majority of cases; the febrile period lasts twenty-four to thirty-six hours, in which the temperature course is quite distinct, with a rise occurring every other day. The temperature course shows an initial rise to 40° to 40.5° C. (104° to 105° F.), which continues several hours, when there is a slight remission falling to 39° to 39.5° C., the pseudo-crisis, followed by a second rise (40° to 41° C.), the precritical rise, and then declines within eight to ten hours to normal or not quite to normal, which is maintained for eight, ten, or twelve hours, when the next rise occurs. Attacks with an afebrile course with subnormal temperatures are described, which are said to be more dangerous to life than the febrile form. The sweating stage is also often absent, though less frequently than the chill. Prodromal symptoms of headache, pains, malaise, followed by the usual febrile symptoms, but more severe and lasting, with a tendency to delirium and other complications of a pernicious or malignant character, are features of this class of fever.

Perniciousness is said to be due to: (*a*) Excessive number of parasites, Golgi's law; (*b*) localization of parasites in organ; (*c*) estivoautumnal parasites which

develop and segment in the organs, causing the infected cells to become adhesive and agglutinate and with the swelling of endothelial cells free pigment and pigmented leucocytes cause blocking of the capillaries; (*d*) toxins; (*e*) individual predispositions.

When there are two groups of these parasites a quotidian type of fever occurs. The paroxysms in these types last twelve to sixteen hours. Irregular and continuous fevers are due to irregular segmentation of small groups of parasites. There are a number of classifications of the pernicious fevers, which in reality are not necessary. The forms which are most commonly encountered will therefore be described.

The bilious remittent form is not commonly pernicious in type. There is a remittent temperature course, and owing to the excessive secretion of bile, bilious vomiting, bilious diarrhea, jaundice, tenderness and enlargement of the liver. The temperatures may rise considerably, when coma and death may supervene.

The algid form is characterized by a condition of profound collapse, in which the body becomes cold, the axillary temperature however records 38° or 39° C. (100.4° to 102.2° F.). The appearance is not unlike that seen in cases of cholera, eyes and cheeks sunken, nose pointed and sharp, lips blue, the skin dusky, cold, and clammy. The pulse is small and thready and may not be palpable at the wrist, becomes rapid, or may even be very slow; respiration is shallow and labored, voice is weak and husky and prostration is marked. Consciousness is maintained. A syncopal attack may precede a fatal termination.

The choleraic form resembles the algid type as just described, but is accompanied by abdominal cramps and profuse stools which become frequent and greenish yellow in color, or even colorless, sometimes tinged with bloody mucus. Collapse occurs early and often proves fatal.

The Dysenteric Form.—Diarrhea is quite common in estivoautumnal fevers, and when accompanied with bloody mucus will resemble a case of dysentery.

The comatose form is probably the most frequent of the pernicious forms of malaria. Infection is intense, so that numerous parasites may be found in every field of a thin blood smear. The attack may set in with sudden unconsciousness. The face is suffused, pupils are contracted or dilated, pulse full and strong and later rapid and feeble; respiration quiet, or noisy. Temperature 39° C., or even subnormal, skin may be hot and dry; sometimes the face and extremities will be cold to the touch; no paralysis and no alteration of reflexes such as the corneal reflex, are noted. Splenic enlargement is variable. Palpitation may elicit tenderness over the splenic region, sufficient to rouse the patient and cause him to groan or move.

The general condition is sometimes erroneously diagnosed as opium poisoning, cerebral hemorrhage, heat or sunstroke. The symptoms may set in more gradually, when headache, giddiness, drowsiness, stupor, and coma may follow in succession. The coma may continue several hours or even a day or two, and the condition continue until death occurs. If recovery occurs, the coma gradually subsides, the patient begins to toss and groan, beads of sweat appear on the forehead, followed by a general sweat; headache and giddiness are complained of for a time. When apparently recovering, a second attack may follow, which will then invariably be fatal.

Other forms are described from their resemblance to other affections, or a predominant symptom, such as

The delirious form, in which the patient has hallucinations and may become maniacal. A case came to the writer's notice, in which the patient was about to be committed to an asylum, when a blood examination showed the presence of parasites. Recovery occurred. In another, the person was taken suddenly with mania while walking on a street.

Hemiplegic, paraplegic, monoplegic, ataxic, and tetanic forms, are among those described, in which nervous symptoms predominate.

The gastralgic form, in which pain is referred to the epigastrium, with vomiting, hiccough and sometimes hematemesis, and cardialgic form, are described.

The pneumonic form in which there is a cough, but the condition is not a true pneumonia.

The diaphoretic form, in which the sweating stage is profuse and continuous. The skin becomes cold, pulse weak and exhaustion with fatal collapse may occur.

The Hemorrhagic Type.—In this type, profuse hemorrhage from the nose, stomach, intestine, or kidneys, occurs. In one case, seen by the writer, the onset began with a prolonged and profuse hemorrhage from the nose, following which the patient became comatose. A blood examination showed numerous parasites of the estivoautumnal variety. In another case epistaxis was so severe and continuous that the blood became pale, resembling serum, and tamponing was resorted to. Both recovered under administration of quinine.

The hyperpyrexial form, in which the temperature rises above 106° which is accompanied by symptoms of delirium and coma.

The Amaurotic Form.—Impaired vision and even blindness affecting one or both eyes as a result of retinal hemorrhages, rarely occurs. If this condition occurs during quinine administration, it may have to be differentiated from quinine amaurosis.

In malaria amblyopia, the pupils react to light, and vision is not entirely lost, while in quinine amblyopia, the pupils are dilated, do not react to light, and vision is lost for a time.

Chronic Malaria and Malarial Cachexia.—The chronic manifestations of malaria follow repeated infection, or relapses as a result of latent infections most frequently due to estivoautumnal infection, and to a less extent to tertian and quartan infections. The condition may continue for months or years before a cachexia sets in.

The symptoms most commonly accompanying chronic malaria are, palor and yellowish muddy color of the skin; slight yellowness of sclera; recurring attacks of fever every two, three, or four weeks, or longer intervals, with slight elevations of temperature, but sometimes quite high elevations without causing a feeling of illness. Cardiac palpitation, weakness, and disinclination to do anything requiring effort, giddiness, digestive disturbances, as anorexia and diarrhea, and many other symptoms are noted.

The anemia is marked, the blood containing 2,000,000 to 3,000,000 red blood cells per cubic millimeter, with a low hemoglobin index, also normoblasts and poikilocytes. The parasites of malaria are also found. The spleen is distinctly enlarged; the edges feel hard and rounded; the liver is also enlarged.

The occurrence of chronic malaria is most frequent in children, and in regions where malaria prevails the impaired mental and physical development among children is notable.

Pernicious attacks, also hemoglobinuric fever, sometimes develop in the course of this condition. When cachexia sets in, anemia is profound, the red blood cells numbering 1,000,000 or even less, with other blood changes present; the spleen is enormously enlarged; emaciation is marked; ascites occurs; low elevations of temperature occur. A blood examination for malarial parasites generally proves negative.

Death from rupture of the spleen or from other complications as a result of organic disease of spleen, liver, kidneys, or intercurrent disease may occur.

Masked or Larvate Malaria.—Masked or larvate malaria is a term used to describe many atypical courses of disease which may or may not be true malaria.

Deaderick states the case thus: "This heterogenous group has been expanded to embrace diseases unrelated in any way to malaria, disease complicating malaria, and symptoms and sequelæ of malaria."

The diagnosis is generally based on the periodicity of symptoms and subsidence under quinine treatment.

The more common forms described include neuralgia and other nervous disorders; dyspepsia and other conditions referable to the gastrointestinal system, hemorrhages, skin affections, etc.

Latent Malaria.—The continued presence of the parasite of malaria in the blood without manifesting any active symptoms of the disease is quite possible. This occurs usually in persons who have had a spontaneous recovery from all symptoms, as often occurs at the beginning of cold weather; or in persons who have received improper or insufficient treatment.

The parasites vary in number, sometimes being so few that it is impossible to find them upon blood examination, as in some chronic cases or cachetics; or they may be so numerous that it seems incredible that active symptoms are not manifested. In these cases the sexual or gamete forms of the parasites are often encountered. These last form a source for mosquito contamination and consequently become largely responsible for the endemicity of the disease, or spread to other communities or regions.

An examination of a number of persons to discover these latent cases, is made for establishing the endemic index, as already mentioned under etiology. Relapses after shorter or longer intervals, even a year or more, are apt to occur in these cases, and are a factor in chronic malaria and malarial cachexia.

Diagnosis.—The clinical diagnosis of the malarial fevers usually rests on the periodicity of paroxysms of chill, fever and sweat, anemia, enlarged spleen, and herpes. To this may be added the amenability to treatment with quinine.

A careful temperature record should be made in all cases when the characteristic differences between the tertian, quartan, and estivoautumnal types can be distinguished. This, with a microscopic examination of the blood showing the parasites, naturally clinches the diagnosis.

Complications with other diseases, or irregular types and manifestations, of course, add to the difficulties in reaching a diagnosis of malaria which can only be made on a microscopical examination of the blood. Great reliance should not be placed on a diagnosis based entirely on the results of quinine treatment.

It may be generally stated that the tertian and quartan types will yield to thirty grains of quinine, ten grains t.i.d., administered on three consecutive days, and that estivoautumnal will yield within five days. There are cases of estivoautumnal which will require longer but this is unusual. As a rule, a fever that does not yield to the treatment with thirty grains of quinine given daily for five days is not malaria and another cause should be sought.

Laboratory Diagnosis.—For the certain diagnosis of malaria, the finding of the parasite upon the microscopic examination of the blood is confirmatory, of secondary diagnostic value is the finding of pigmented leucocytes and the relative increase of large mononuclear leucocytes. These are uncertain, as the presence of foreign matter is sometimes difficult to exclude; and in making relative leucocyte counts, the personal equation, and the fact that a large mononuclear increase is found in other affections, adds to the difficulty. Their finding should be regarded more of interest than essential in making a diagnosis.

The examiner should be familiar with the microscopic appearances of normal blood, both in the fresh and stained specimens.

For the diagnosis of malaria the stained preparation is to be recommended. Where one desires to study the life changes, alteration in shape, motility, segmentation, flagellate bodies, and phagocytosis, this of course must be done in the fresh specimen.

Laboratory Equipment.—The laboratory equipment requires: (1) One compound microscope fitted with a substage Abbé condenser; (2) 2-millimeter oil immersion, and 16-millimeter objectives, 3 ×, or 4 ×, and 6 × oculars; (3) mechanical stage; (4) glass slides 1 × 3 inch; (5) cover-slips, thin; (6) stains; (7) miscellaneous supplies of acids, alcohol, coplin or other staining jar, cedar oil. Little discussion is necessary for the description of these requirements.

An oil immersion objective lens is most essential. No satisfactory examination can be made without it. The magnification given by a 3 × or 4 × ocular, *i.e.* a magnification of 375 and 500 diameters respectively, is all sufficient, and has the advantage of giving a larger field, and makes the examination so much easier.

The sixteen-millimeter objective is convenient for making a general and quick survey of the propagation, and selecting the fields where the cells appear flat, and excluding the fields where the cells appear overlapping or in rouleaux, for the examination with the oil-immersion lens. The effect of staining can also be examined to see if the leucocytes are well stained.

A mechanical stage is essential for blood work, will greatly facilitate the examination, and save time, although the fingers may be used for moving the slide on the stage.

The glass slides and cover-slips must be well cleaned and polished. New slides and slips simply require washing with soap and water, being rinsed in water and dried by rubbing with a clean cloth and, before use, with a linen handkerchief or tissue paper. Old slides should be boiled, or may be cleaned by immersion in equal parts of alcohol and nitric acid, which, however, should be done out of doors, after which, in either case, they should be treated as the new slides.

Stains.—One of the modifications of the Romanowsky stain is best, such as the Wright, Leishman, Giemsa, or eosin and Azur II, or any other containing a polychrome methylene blue.

Trials may be made, but it is best to get familiar with one stain and use that in malaria work to the exclusion of all others. The stains which have given most satisfactory and constant results, and have been easiest of preparation and application by the writer will be described.

The preparation of Wright's stain will be briefly given: Make up a solution of sodium bicarbonate, 0.5 gram; water 100 c.c.; to this add methylene blue, 1 gram, and then heat the mixture for one hour in an Arnold steam sterilizer counting time when steam is up. Stand aside for twelve hours or a day and allow to cool thoroughly.

Make up a solution of eosin, yellow, water soluble, 1 gram; water, 1,000 c.c.

To each 100 c.c. of the methylene blue add 500 c.c. of 1 to 1,000 eosin solution, adding the eosin solution slowly, and stirring constantly. A fine granular black precipitate is formed, and a scum with a purplish metallic luster forms on the surface. The mixture is then filtered through filter paper (white hard filter paper is best) to collect the granular precipitate. It will be found best to make up five times the quantities given.

The precipitate collected on the filter paper is then allowed to dry thoroughly (air dried) and is scraped off, and may be kept indefinitely.

The usual formula is to dissolve 0.3 gram of the dry stain in 100 c.c. of pure methyl alcohol (Kahlbaums); the author makes a saturated solution, then filters, and adds 20 c.c. of pure methyl alcohol to each 80 c.c. of the filtered solution. This constitutes the stock-staining solution, which should be kept in a well-stopped bottle to prevent evaporation of

the alcohol and absorption of moisture from the atmosphere.

Method of Staining with Wright's Stain.—A thin blood smear, air dried, is well covered with the stock-staining solution for one-half to one minute, which fixes the specimen. Then add distilled water (clean rain water will do) to the stain until a metallic scum appears on the surface. The amount of water is about the same as that of stain solution. It is well to keep the metallic scum broken up by adding an occasional drop of water, which helps to prevent precipitates. Staining begins with the addition of water, and should be completed in two to three minutes, at the end of which time the slide should be washed with distilled water (clean rain water will do), one to three minutes will generally be sufficient, until the blood films have a pinkish hue; then dry, and it is ready for examination.

As a matter of fact no fixed rule for length of time for fixation, and staining with the stain can be given. Each batch of stain will be found to vary as to its staining properties and therefore should be standardized with trial blood smears when it is made up.

Azur II eosin stain (original Giemsa) two stock solutions are required, composed of

(1) Eosin, yellowish, water soluble, 0.10 gram; distilled water, 100 c.c. (1½ grains to 3 ounces).

(2) Azur II, 0.10 gram; distilled water, 100 c.c. (about or 1½ grains to 3 ounces).

The stain to be used is made up from the two stock solutions and should be prepared immediately before using.

Take: Eosin solution (1–1,000), 5 c.c., or 1 dram; Azur II (1–1,000), 5 c.c. or 1 dram; water, distilled (or rain), 40 c.c., or 10 drams.

The thin blood smears, air dried, is first fixed by pouring on it or immersing it in pure methyl alcohol one-half to one minute rinsed in water then immersed in the freshly prepared staining solution twenty minutes or thirty minutes, then rinse in water, air dry and examine. A coplin jar is convenient for immersion of the slide in the stain, but a small bottle with a large mouth will do. This stain will not overstain so that a smear may be left in it several hours. It also does not precipitate, and gives quite constant results. In its favor, is the simplicity of preparation, and it requires little attention.

Preparation of Blood Films.—For making any blood films the slides and cover-slips must be thoroughly dry and clean and free from grease, and should be rubbed with a piece of tissue paper (toilet paper serves admirably for this purpose) just before use.

The skin of the ear lobe or end of the finger, from which a drop of blood is to be obtained, should be cleaned by washing and thoroughly dried before making the puncture. Puncture is quickly made with a clean Hagedorn needle or point of a new steel writing pen with one nib broken off. A Hagedorn needle stuck through a small cork with the point of the needle protruding about one-eighth inch makes an excellent puncturing apparatus. The first drop or two of blood should be wiped off.

For making a fresh blood film a small drop of blood is obtained on the middle of the surface of a cover-slip by just touching the top of the drop of blood. This is then placed on a slide, when the weight of the cover-slip will cause the blood to spread out in a thin film between the two pieces of glass. An examination made with the microscope using the sixteen-millimeter objective will quickly determine if the preparation is satisfactory, which should show the red blood cells spread out flat in a single layer in the central area.

The preparation may be ringed with vaseline which will preserve the specimen for a more prolonged examination.

Malarial parasites, if present, may then be studied. Mistakes are frequently made where only very young hyaline forms of parasites are present. It therefore requires some experience to recognize these in the fresh blood. The larger or more mature forms, also crescents, are much more easily recognized and are generally seen pigmented. Care must be taken to recognize crenations and other deformities of red blood cells, vacuoles, artifacts, retractions of hemoglobin, platelets, foreign particles resembling pigments, all of which may confuse the observer, and may lead to an erroneous interpretation for plasmodia.

For making films for staining various methods are described, and good results will be obtained by following and practising any one of them. The following description of making a thin blood film, is recommended. A drop of blood is obtained on the polished edge, narrow end, of a clean slide.

The edge with the drop of blood is then applied to the surface of another slide about one inch from the end (or at the middle); when the blood has spread out along the edge at the point of contact which may be hastened by a slight rocking movement, the top slide held at an angle of thirty degrees to forty-five degrees is pushed, *not pulled*, with one stroke, fairly rapid, over the surface of the lower slide.

The film is dried rapidly. It may be labeled immediately by writing the name, date or other data, directly into it with an ordinary soft black lead pencil which will appear as a black label from the deposit of pencil carbon.

If the smear is made from the middle toward one edge, a second smear can be made on the same slide on the other half taken from another person, with an intervening clear space in the middle of one-eighth to one-fourth inch between the two. This method will save time and slides for staining and examination.

A good film will show the blood evenly spread, sometimes streaked, with the red blood cells lying singly and flat.

These thin blood films are to be fixed and stained by one of the methods already described, and the examination continued for one-half hour before discarding it as negative.

The stained specimen will show the red blood cell colored pink or copper red, platelets a bright red, with a bluish tinted margin. The leucocytes are stained as follows: Polymorphonuclear with purple nuclei, and the protoplasm with scattered fine pink (neutrophile) granules; mononuclear and lymphocytes with a dark purple or violet nucleus, and protoplasm light blue; eosinophiles have a violet nucleus and bright red coarse granules in the protoplasm; most cells blue or violet nucleus with coarse deep blue black granules.

The cytoplasm of malarial parasites are stained blue, the nucleolus, which is spoken of as the chromatin spot, a deep red.

The Ross thick films afford a very valuable method for making blood examinations, as a larger quantity of blood can be examined in a very short space of time. It is particularly valuable when the parasites are few as sometimes occur in active cases, or cases where quinine has been taken. It is applicable also in the blood examinations for determining the endemic index, latent and chronic cases. It requires practice and training to identify the parasite in these preparations, but at the end repays one many times in time and trouble.

The technique for making thick blood smears is as follows: Obtain a large drop or two of blood on the surface of a glass slide, which must be thoroughly clean and well polished. With the convex surface end of a steel writing pen stuck in a cork (a tooth pick or corner of another glass slide will serve) the blood is spread evenly over a circular area about one-half to three-fourths of an inch in diameter.

The slide with blood should then be placed in a

horizontal position and allowed to dry (air dry). When dry, it may be labeled by writing directly with pencil in the blood.

To stain a thick blood smear it is necessary first to decolorize and remove the hemoglobin. Ross advocated gentle washing with water, later water-eosin solution to be used for decolorizing. Ruge employs two per cent. formalin, Henson five per cent. glacial acetic acid, and James methyl alcohol acidified by the addition of ten drops of hydrochloric acid to 50 c.c. of alcohol.

The last (James's) method, slightly modified, has been employed in the examinations made for index work by the writer and has been found most satisfactory; it is as follows:

Decolorize until the blood smear has a ground-glass appearance by immersion in hydrochloric acid, 1 c.c.; seventy per cent. ethyl alcohol, 100 c.c. This also fixes and requires for decolorization one-half to two hours according to the thickness of the film.

Wash in running tap water twenty to thirty minutes.

Without drying immerse in eosin—Azur II stain, freshly prepared, one-half to one hour. Rinse in water, air dry, and examine. If no parasites are seen after five to seven minutes' examination it may be regarded as negative.

A good thick film will give an average of twenty-five to thirty leucocytes to each field. The parasites take their characteristic stain but are seen distorted in shape and at various angles; leucocytes stain deep blue, platelets a bright red, and stroma a pink.

A practical comparison between thin and thick films has frequently shown the value of the thick film. Repeatedly an examination of one-half hour of a thin film will be made before a parasite is seen, whereas in a thick film taken at the same time parasites will be found in every two or three fields.

Another point to be made regarding blood examinations in general, is that negative findings must not always be taken as conclusive; repeated examinations should be made. The first examination may prove negative, but an examination made six hours later may prove positive.

Differential Diagnosis.—The diseases most often diagnosed as malaria in this country are typhoid fever, tuberculosis, endocarditis, or some septic process. Other diseases to be diagnosed from malaria are yellow fever, dengue, dysentery, sunstroke, hepatic abscess, pneumonia, and kala azar.

Many errors would be avoided if a microscopic examination of the blood were more frequently resorted to. If the practitioner has not the time and training for making the examination himself, he should at least be able to make a good blood smear and have it examined at some large city or State laboratory.

No doubt many clinical diagnoses of malaria are correctly made, but as often, too, incorrectly, and this would be avoided if blood examinations were made. The most common disease, diagnosed malaria, is typhoid fever.

Typhoid fever clinically will simulate some forms of malaria. In typhoid, the continued fever will not be influenced by quinine within the five days. A positive Widal, and negative blood finding for parasites, and the continuous temperature course, will often be all that can be found to establish the diagnosis of typhoid. In a frank case of typhoid, there will be the history, fever 103 to 104°, rose spots, headache, delirium, red pointed tongue, tremor, tympanites, diarrhea, etc.

Tuberculosis.—Paroxysms of chill, fever, and sweat, occurring with fair periodicity, occurring in tuberculosis is commonly diagnosed malaria. A slight cough, physical signs, and a sputum examination for the tubercle bacillus will establish the correct diagnosis.

Ulcerative Endocarditis.—This condition often is a sequelæ of pneumonia, so that the history, examination of the heart, and leucocytosis will be sufficient.

Septic processes include puerperal fever, septicemia, pyemia, tonsillitis, pyelitis, hepatic abscess, appendicitis, buboes, etc., which, upon blood examination, will be found to have an absence of the parasites and a leucocytosis.

Eruptive Fevers.—At the beginning of eruptive fevers, the symptoms may be quite similar, particularly in cases of smallpox in the negro. A negative blood finding, eruption and general course will be diagnostic.

Yellow Fever.—In the South the difficulty in making a diagnosis arises in the first or early cases of yellow fever prior to an epidemic. It is important to follow the sequence of symptoms to reach a diagnosis in this disease.

Ordinarily the combination of six chief symptoms is necessary in reaching diagnosis of yellow fever: (1) Facies, congestion, and conjunctival injection; (2) relation of pulse and temperature, *i.e.* irresponsive or divergent pulse; (3) acute fever, with (4) albuminuria on second and third day; (5) tendency to hemorrhages from the mouth; (6) gastric irritability.

Dengue is more often confused with yellow fever, but is recognized by the course of the disease, with remission of temperature on the third or fourth day, secondary rise, pains in muscles, which continue after recovery, photophobia, polymorphous eruption, and its epidemic character.

In the tropics it should be the rule to make blood examinations of all cases of fever, including such cases as sunstroke, apoplexy, cholera, cholelithiasis, pneumonia, filariasis, kala azar, as the parasite of malaria may be found to be the cause of a train of symptoms resembling any of the mentioned diseases.

Prognosis.—The rate mortality from malaria in some of the Southern States, as compared with morbidity reports, shows it to be one death for every 50 to 400 cases reported. The mortality reports from malaria, as well as morbidity reports, are vitiated by the frequent erroneous diagnosis of malaria for typhoid fever. Reliable or more accurate statistics are therefore not yet available.

As a rule, the prognosis as regards life, is good where proper and sufficiently prolonged treatment is instituted, as all forms of malaria are amenable to treatment.

The prognosis is influenced by many conditions, including social and hygienic, constitutional and climatic conditions, types of infection, and complications.

As regards social and hygienic conditions, the prognosis of those of the better class who seek early relief when ill, whose physical comforts and habits add to their well-being, will naturally be better than in the stupid and poor.

Those who constitutionally are robust and have no complicating disease, who are not very young or very old, or who have by nativity gained partial immunity, will have better prognosis.

The prognosis in the tropics is not as favorable as in the temperate zone. This is due to the greater prevalence of the estivoautumnal type of infection in the tropics.

When comparing the types of infection, the prognosis of the tertian and quartan is, as a rule, good, although deaths have been reported from these types. Relapses often occur, and chronicity will lower the vitality and resistance toward intercurrent diseases.

The prognosis of estivoautumnal infections, particularly where complications or pernicious manifestations have set in, is bad.

Deaderick gives a compiled list of 27,039 cases of pernicious malaria, of which number 7,205 or 26.6 per cent. proved fatal. In general it may be estimated that the average mortality of these cases is one out of four.

Prophylaxis.—The measures for the prevention of malaria are based upon the two fundamental facts,

that (1) Malaria is naturally contracted only through the bite of mosquitos belonging to the subfamily of Anophelines; (2) Man being the only known host of the parasite, is the only source of mosquito infection.

In general, then, the factors to be considered are Mosquitos and Man, who are the hosts of the specific parasite.

For all practical purposes, we may therefore consider the subject under the following: (1) Mosquitos —(*a*) destruction, and (*b*) prevention of their access to man. (2) Man—by treatment, (*a*) to free him of parasites; (*b*) to immunize him against parasites.

Mosquitos.—Since the destruction of mosquitos has especial reference to Anophelines, the biology, habits, and life of the species which are the malaria transmitters, must be known. Generally, the attack is made on the places where the larval and pupal stages are found. The measures for this purpose include: 1. Drainage and filling. Drainage is employed to remove standing water, or to effect the movement of water that it becomes unfavorable for establishing a resting place where mosquitos may breed. This is accomplished by various ways.

Ditching.—Ditches may be opened or cut directly in the soil. These should be carefully located as to direction and fall, and made as few and short as possible. They should be constructed with even sloping sides and narrow bottom, so that any water present will be confined to narrow banks which will insure rapid discharge. The bottom and sides to a few inches above the normal water line of ditches, may be lined with cement, stone and cement, or wood, which while more costly at first will cost less for maintenance, and are more permanent. All ditches must be kept clear of obstructions and vegetation.

Drain tiles from three inches to twelve inches in diameter, in one foot to two feet are used for subsoil drainage. These are used for (1) lowering the ground water, (2) more rapid absorption of surface pools of water by the ground, (3) to prevent seepage water from hillsides.

Training of streams, creeks, or any natural water courses, so that the banks will be sharp and clear, with running water, in order to avoid pockets, depressions or eddies, where Anophelines often breed.

Filling.—Shallow collections of water in areas that are too low to drain, or cannot be drained economically, may often be filled. For this purpose, porous material, such as cinders, sawdust, shavings, sand, or other available material may be used to advantage.

Oiling prevents mosquito breeding if the surface of water is completely and continuously covered with a film of oil. It prevents the larvæ and pupæ from reaching the surface to breathe, as they cannot penetrate the oil film with their breathing tube, so they drown and die. Mosquitos do not lay their eggs on the oiled surface of water.

Grades of Oil.—The lighter oils, such as kerosene, spread rapidly, evaporate rapidly, have a high cost and are wasted because of the invisible film formed by small amounts. Heavier or crude oils are cheaper, require larger quantities, and do not spread as rapidly. It has been found that heavy crude oil to which five to ten per cent. of a carbolic larvacide has been added, will spread better and flow better. Oiling is applicable in ponds, streams, ditches, and shallow edges of lakes. Oil may be applied by the use of (1) garden watering pot, (2) knapsack sprayer, (3) drip can for intermittent or continuous oiling, eighteen to twenty drops per minute, (4) saturated bundle of cotton waste.

Larvacides are used as a substitute for oil. It must be remembered that these are poisonous and should be used only under the direction of health authorities. They must mix with water. They destroy larvæ and pupæ when they come in contact with them.

The formula of the larvacide successfully used in Panama, is as follows: Crude carbolic (fifteen per cent. phenols), 150 gallons heated by steam-coil; add common rosin, finely crushed and sifted, 200 pounds; then caustic soda, thirty pounds; dissolved in water, six gallons. Mix and stir. This larvacide is applied by spraying an aqueous emulsion 1 to 5, along margins of pools, ponds, etc., so that the resulting dilution of 1 to 5,000 is represented by a milky opalescence. Other larvacides are sometimes found in waste products from mills and factories, such as dye water, bleaching water, etc., which may be advantageously used.

Natural enemies are top-feeding minnows, water boatman, larvæ of dragon flies, gold fish, and even larvæ of certain species of mosquitos, will devour the Anopheline larvæ. Stocking of ponds and water courses with fish is therefore of value, and is sometimes used to advantage. It is not usual to find Anophelines breeding in artificial containers, and when they have been found, it has been in places where Anophelines were in large numbers, or where there was no natural breeding place near-by.

Measures against Adult Mosquitos.—As a general antimalaria measure, this is not practicable. Where mosquitos are found in buildings or rooms, and it is desired to get rid of them, this may be accomplished by fumigation by burning of sulphur, two pounds per 1,000 cubic feet for two hours. Hydrocyanic acid gas may also be used. Pyrethrum burned in the same amount and for the same time as sulphur, will kill some, but usually stupefies the mosquitos so that they have to be collected and destroyed. Mosquitos may be caught by hand each day, by the use of a bottle with a layer of cotton saturated with chloroform at the bottom, or the bottle may be charged with tobacco smoke. Traps have also been devised and used.

The removal of places of shelter close to residences, such as weeds, tall grass, vines, brush, etc., will prevent the Anophelines from obtaining a resting place near the house during the daytime, and thus lessen the number that will otherwise come out at dusk.

Prevent the Access of Mosquitos to Man.—Anopheline mosquitos usually bite at the hours between sunset and sunrise, so that to avoid malaria one must avoid the bite of mosquitos at night. This is to be accomplished by screening, use of mosquito bars, volatile substances, fans, or constant motion.

Screening is one of the most valuable prophylaetic measures we have. A bedroom might be screened, but it is much better to screen the entire house. Every care must be taken that all openings leading outward, doors, windows, fireplaces, and chimneys, must be absolutely screened. Many details must be looked after in order that this measure may be effective, otherwise a screened house might become a trap. The size mesh recommended is sixteen or eighteen; doors should open outward; windows should be covered entire.

Mosquito bars furnish a certain amount of protection. They should be amply large, made solid without a side opening, and kept in perfect repair. They should be hung so that they may be tucked in under the mattress and never allowed to hang down to the floor.

Volatile substance, such as citronelle oil, kerosene oil, mixtures of essential oils with vaseline, which will keep mosquitos from biting, are used to smear over the exposed surfaces of the body. This, however, has no practical value as a general antimalaria measure.

Man is the intermediate host of the plasmodium, and from him Anophelines become infected, if sexual forms are present in the blood.

The subject of *destruction of the plasmodia in man*, may be considered under its three heads: (1) Treatment of active cases of malaria; (2) treatment of carriers; (3) treatment to immunize man to parasites.

Every active case of malaria should be treated sufficiently long so that the patient may not become a

"gametocyte carrier," in order that the cure may be made complete. Treatment, after active symptoms have subsided, should be continued over a period of at least three to four months. The gametocytes develop in the untreated active cases in eight to ten days, retarded in the improperly treated. Their presence is evidence that the asexual cycle is continuing. The period of time that these gametocytes persist in the blood of man, is given by W. M. James, as ten days for estivoautumnal, four to five days for tertian, and six days for quartan. Treatment of carriers, therefore, is for the purpose of destroying the asexual parasites, and should be continued over a period of three to four months, as in active cases.

The administration of quinine, for *immunizing* man is termed *quinine prophylaxis*, and is a very valuable measure. Quinine taken by a healthy person, or even the latent malarial case, is for the purpose of inhibiting the development or multiplication of the plasmodia. A person may be bitten by an infective mosquito during this period, and may thus harbor parasites but in insufficient numbers to cause symptoms. The continued use of quinine for four to six weeks beyond the season, is therefore advisable. The period of time for taking quinine varies in different parts of the country, but generally in the United States, May 1 to November 1 will suffice.

Various methods of quinine prophylaxis are given. Quinine in five-grain doses for adults, taken morning and evening on two consecutive days each week, for the period May 1 to November 1, will generally prevent malaria. A daily dose of three grains to five grains of quinine sulphate or its equivalent in other salts will also be efficient. Quinine prophylaxis has been extensively employed in Italy, where quinine is sold at cost and distributed free to the poor by the State. As an adjunct to the foregoing, *education* of man in the use of all measures and resources, therefore, is all important.

Treatment.—The treatment of malaria may be considered under the general heads: (1) Specific treatment, (2) general treatment, (3) treatment of special forms.

1. *The Specific Treatment.*—Quinine is the specific remedy or drug to be used in the treatment of malaria; no other should be seriously considered. Its efficiency is ascribed to a toxic action upon the young forms of parasites freed at segmentation, and in the earlier stages of the parasite in the red blood cells. It does not affect the mature forms, nor prevent segmentation, nor does it affect the gametocytes, especially the crescentic form. Whatever the mode of action whether direct upon the parasite, or upon phagocytes, or both, it can be demonstrated microscopically that quinine causes an early reduction or disappearance of the parasites in the circulating blood, so that in the great majority of cases, properly treated with quinine, the result is a complete cure.

The physiological action of quinine varies with individuals. Small doses may produce the symptoms of cinchonism such as congestive symptoms of the head manifested by ringing in the ears, fulness, nervousness, dizziness, while in others, large doses will not have any such effect.

These should not, as a rule, be considered contraindications for its use, except in individual cases where a dangerous idiosyncrasy arises. The untoward symptoms produced may be deafness, amblyopia, metrorrhagia in women; skin eruptions as, urticaria, erythema, vesicles; marked cardiac depression and dyspnea. Hemoglobinuric fever is at times precipitated.

Persons will very often state that they cannot take quinine, and yet, when ignorant of the fact, will take large doses without ill effect. A change in the method of administration, or a change in the preparation or dosage will sometimes make the drug better tolerated. The individual living in a malarious district who "cannot take quinine," that is, who has a genuine quinine idiosyncrasy, had best adopt every prophylactic measure directed toward avoiding the bite of mosquitos, as no satisfactory substitute has yet been found for quinine.

There are a number of salts of quinine in use, some easily soluble, and therefore particularly applicable for hypodermic or intravenous administration; and other salts much less soluble. The total absorption, however, is about the same, being more rapid in the former as evidenced by the early appearance of the salt in the urine. The effect and results obtained in treatment are the same.

Quinine sulphate is the most commonly used, and cheapest, but preference should be given to the bihydrochloride, which, though more costly, will be better absorbed by the stomach. Quinine sulphate is changed in the stomach to the hydrochloride and thus favors absorption. The tannate of quinine is mainly absorbed by the intestines.

When taken as a standard, the equivalent of other salts will then be

		Solubility in Cold Water.
Quinine sulphate	1.00	1–800
Quinine hydrochloride	0.90	1– 40
Quinine bihydrocbloride	1.02	1– 1
Quinine bihydrobromide	1.23	1– 45
Quinine bisulphate	1.24	1– 11
Quinine lactate	0.94	1– 10
Quinine salicylate	1.05	1–225
Quinine tannate	3.67	Slightly sol.
Quinine ethylcarbonate or euquinine	1.00	Slightly sol.
Quinine hydrochloride and urea	1.00	1– 1

Warburg's tincture is a preparation containing a number of drugs together with quinine sulphate, and is given in dose of half ounce (15 c.c.), or one tablespoonful, representing five grains of the drug. At times this preparation is tolerated when others are not. It readily causes sweating, so that it should be used with caution in the weak.

The amount of quinine, time, and duration of dosage, and the method of administrationa re all important in the treatment of malaria. While it is good practice to give an aperient or cathartic, such as calomel followed by a saline before beginning the administration of quinine, yet this is not absolutely necessary, and in the severe infections there should be no delay in beginning quinine.

As a rule in the great majority of cases, thirty grains of quinine sulphate, or equivalent in other salts, given in ten-grain doses three times a day to an adult will control the paroxysms within five days. If the active symptoms are not controlled in this time then another cause for symptoms should be looked for. Equally good results in treatment have been obtained by administering five-grain doses, but repeated oftener. The smaller doses are sometimes better borne. A good rule for the amount to be used in children is one and one-half grains a day for each year of age up to twenty when the full adult dose should apply. At times, double this amount in children up to ten years may be given and is frequently found necessary in cases of estivoautumnal forms of malaria.

Various methods are in vogue regarding the time of quinine administration. These are: (1) Tarti's or the Roman method, which consists of the administration of a single dose of fifteen grains, four to six hours before the expected paroxysm. (2) Sydenham's, or the English method, which consists of the administration of a single dose about fifteen grains, at the decline of the paroxysm. (3) Fractional method, which consists in giving five- or ten-grain doses, repeated during the day.

In treating tertian and quartan cases, the author has obtained equally good results by administering quinine in five-grain doses every two hours beginning eight hours before the expected paroxysm, which

totals five doses; or by giving ten-grain doses three times a day regardless of the stage of the paroxysm.

In treating estivoautumnal cases, in which case segmentation is irregular it has been my rule to administer ten grains three times a day, total thirty grains, but in some it was found necessary to give the dose every six hours, day and night, making a total of forty grains in the twenty-four hours and reducing this to thirty grains a day when the temperature reaches normal. The treatment is continued for one week which should certainly control any case.

It is very important, however, that quinine be continued longer than this. The dosage is lessened, and some rule can be adopted that will provide for a period of treatment covering three or four months. The author varies this, giving quinine during the second week in five-grain doses three times a day, after meals, in tertian and quartan cases, and ten grains morning and evening daily, after meals, in the estivoautumnal infections. At the end of the second week, quinine is given, ten grains a day on two consecutive days each week, for a period covering the malarial season to November 1, which in no case, however, should be less than three to four months, or ten grains, in five-grain doses morning and evening every fourth day beginning with the first day of the month, and thereafter on the dates divisible by four.

The author usually advises those who have had malaria during the previous season, and who continue to live within the same district to take a prophylactic course of treatment during the succeeding year. This for two reasons: (*a*) to prevent a possibility of relapses in those who had suffered an attack late in season and did not continue treatment for a sufficient period; and (*b*) because the individual who had suffered an attack the previous season is the one most likely to be a carrier, and thus might be a source of infection for Anophelines, which might be avoided by the prophylactic dosage of quinine.

Quinine given after the first week (when the paroxysms have been controlled) will be better tolerated if given after meals.

Methods of Administration.—The various methods are (1) by the mouth, (2) by hypodermic injection intramuscularly, (3) by intravenous injections, (4) by rectum.

By the Mouth.—This is the most common and usual method employed. Quinine in solution gives the best results but is very disagreeable. The formula used by the author is:

℞.			
	Quinine sulphate	8.00 gm.	(ʒij.)
	Aromatic sulphuric acid	8.00 c.c.	(ʒij.)
	Distilled water	120.00 c.c.	(ʒiij.)

Each 5 c.c. contains five grains (0.30), or each teaspoonful, or one dram, equals five grains. The syrup of yerba santa, or cocoa may be added to disguise the taste.

It may also be given in capsules which should be followed by a bite of food, or a drink of lemonade or orange juice, or some dilute mineral acid, *e.g.* ten drops of dilute hydrochloric acid in a half glass of water. Some persons will take quinine in powder, or in cachet. Pills and tablets and capsules are apt to become hard with age and will then not be absorbed.

The tannate of quinine must be given in much larger dosage, about three and one-half grains being equivalent to one grain of the sulphate. It is almost tasteless, and when put up in chocolate form, is quite popular for administration to children, both in treatment and prophylaxis.

By Hypodermic Injection.—This method is applicable in cases where it cannot be given by mouth, or where immediate administration is desired, as in comatose or other complicated cases. According to some observers, it is said to be less rapidly absorbed by this method than when taken by mouth. It should be given intramuscularly, into the deltoid or gluteus muscles. The solution should not be concentrated and is best given in a dilution of one in ten.

For hypodermic injections, the bihydrochloride or bisulphate being more soluble, may be given. The common formula is:

℞.			
	Quinine bihydrochloride	1.000 gm.	(gr. xv.)
	Sodium chloride (common salt)	0.075 gm.	(gr. i.)
	Distilled water	10.000 c.c.	(ʒijss.)

Glass ampules containing sterile quinine hydrochloride and urea, each 1 c.c. containing 0.30 of quinine, afford a convenient form for use, but these should be diluted to one in ten. The dosage is 0.5 gram (seven and one-half grains) and may be repeated every six hours. It has been found to cause milder symptoms of cinchonism and is sometimes valuable in those who "cannot take quinine." The administration should be made under aseptic conditions. The site where injection is made should be painted over with tincture of iodine, and with a sterile solution and sterile hypodermic, given intramuscularly (not subcutaneously), no complications or subsequent abscesses should arise.

By Intravenous Injection.—This method is used in the treatment of severe complicated forms of estivoautumnal infections. The solution is the same as is used in the hypodermic method, but the dilution should be much greater, not less than 1 to 150 parts. The solution is:

℞.			
	Quinine bihydrochloride	1.00 gm.	(gr. xv.)
	Sodium chloride	2.25 gr.	(gr. xxxv.)
	Water, at a temp. 100°–110° F.	150 to 300 c.c.	(ʒv–x.)

Sterilized and administered directly into a vein. Not less than one gram (fifteen grains) should be administered at one time. It may be repeated in twelve to twenty-four hours.

By the Rectum.—Quinine in solution in double dosage, in combination with some opiate to allay irritation may be administered by this method, which is occasionally applicable to children. It is a method rarely resorted to. There are other preparations which are sometimes employed in treatment, but none has been found that would supplant or compare with quinine. Of these, some good results have been reported from the use of methylene blue, medicinal, in doses of gr. iii. to v., three or four times a day.

The treatment with other quinine compounds, serum, violet rays, Röntgen rays, have all been used, but have proved unsatisfactory.

Arsenic in some form, is quite popular among many physicians, the most popular preparations being Fowler's solution; others, as atoxyl, soamin, cacodylate of soda, also have their advocates. Arsenic will not influence the paroxysm, and is therefore useless in the treatment of active symptoms. The author found that cocodylate of soda, 0.3, given hypodermically for ten days, apparently had no effect upon the parasite. The use of Fowler's solution, or arsenic trioxide, in convalescence, or in the anemia of some of the chronic and cachetic cases, acts beneficially, and improvement is constitutional.

Salvarsan given intravenously is reported to be destructive to the tertian parasites, and not to the other forms.

General Treatment.—Rest in bed, during the paroxysms and until the temperature becomes normal, is an aid. Not infrequently paroxysms will cease merely by keeping the patient in bed, administering a cathartic and a light diet.

The treatment of the acute symptoms accompanying the paroxysms is symptomatic. During the cold stage warmth is applied. In the warm stage, sponging, hot drinks of lemonade or tea, and plenty of water, Vichy or other effervescent waters are given to encourage perspiration and the excretion of toxins.

For headache, an ice-cap, or cloth wrung out in cold water applied to the head; for vomiting, cracked ice, or a mustard paste over the epigastrium, will sometimes relieve these symptoms.

Diet should be light, chiefly milk, during the active period, but increased as soon as the patient can be up and about. During convalescence, a tonic consisting of reduced iron, gr. ss.–i.; quinine, gr. iij.–v.; strychnine, gr. $\frac{1}{60}$; arsenic trioxide, gr. $\frac{1}{60}$; cascara sagrada, gr. jss. may be given three times a day.

If symptoms of cinchonism are distressing, then sodium bromide, gr. xxx. (two grams), or potassium bromide, gr. xv. (one gram), will often alleviate these. A change in the method of administration, or in the salt, will sometimes give the same results.

Where there is depression, strychnine, gr. $\frac{1}{30}$ hypodermically, or other heart stimulants will be necessary.

Treatment of Special Conditions.—Chronic malaria and malarial cachexia should be treated by rest in bed, good diet, a course of quinine, and a tonic of arsenic, iron, and strychnine.

In pregnancy the high temperature in the course of a paroxysm, is more likely to cause death to the fetus, or abortion, than is the use of quinine. In such cases, quinine should be given in smaller doses, gr. iii. to v. every four to six hours.

Diarrheal or dysenteric symptoms may be controlled by opiates.

The algid type requires stimulation, warmth, and an intravenous injection of quinine one gram in 300 to 500 c.c. of physiological salt solution.

Hemorrhagic Types.—Absolute rest in bed, light diet, the administration of calcium salts may be tried. In epistaxis it is sometimes necessary to resort to tampons. Uterine hemorrhages may be treated with ergot.

R. H. VON EZDORF.

BIBLIOGRAPHY.

Much of the subject of malaria is common knowledge so that there has been no intention to give more than this in the preparation of this article. References are fully given in the following list of books consulted:

General Literature Containing Numerous References.

Marchiafava and Bignami: (1900), Twentieth Century Practice, vol. xix.

Rogers: (1910), Fever in the Tropics, 2d Ed.

Stephens and Christophers: (1907), Practical Study of Malaria.

Thayer: (1897), Lectures on Malarial Fevers.

Castellani and Chalmers: (1913), Manual of Tropical Medicine, 2d Ed.

Craig: (1910), The Malarial Fevers.

Deaderick: (1909), A Practical Study of Malaria.

Henson: (1913), Malaria.

Manson: (1914), Tropical Diseases, 5th Ed.

Daniels: (1913), Tropical Medicine and Hygiene, 2d Ed.

Scheuba: (1902), The Diseases of Warm Countries, 2d Revised Ed.

Ross: (1910), The Prevention of Malaria.

Howard, Dyer, and Knab: (1912), The Mosquitos of North and Central America and the West Indies, vol. i. and ii.

Special Articles.

James W. M.: Notes on Etiology of Relapse in Malarial Infections. Journal of Infectious Diseases, vol. xii., 1913.

Darling, S. T.: Studies in Relation to Malaria. Isthmian Canal Commission, 1910.

Craig, C. F.: The Prophylaxis of Malaria with Special Reference to the Military Service, 1914. Bulletin No. 6, War Department, Office of the Surgeon General, 1914.

Bass, C. C., and Johns, F. M.: Cultivation of Malarial Plasmodia *in vitro*. Journal Tropical Medicine, 1912, vol. xvi.

Bass, C. C.: American Journal Tropical Diseases and Preventive Medicine, February, 1914.

Knab, Frederick: The Species of Anopheles that Transmit Human Malaria. American Journal Tropical Diseases and Preventive Medicine, vol. i., No. 1, July, 1913.

Transaction of the American Society Tropical Medicine, vol. iii., 1908.

Reprints United States Public Health Reports.

Carter, H. R: "Antimalarial Measures for Farmhouses and Plantations," Report No. 105.

"Malaria in North Carolina," Report No. 156.

"Quinine Prophylaxis for Malaria," Reprint No. 175.

"Screening as an Antimalarial Measure," Reprint No. 183.

von Ezdorf, R. H.: "Malarial Index Work," Reprint No. 159.

"What the Farmer can do to Prevent Malaria," Supplement No. 11.

"Prevention of Malaria—Suggestions how to Screen the Home etc," Reprint No. 170.

"Malarial Fevers" In Alabama, No. 186; in Arkansas, No. 160; in South Carolina, Georgia and Florida, No. 172; in Mississippi, No. 193.

Malgaigne, Joseph François.—Born at Charmes-sur-Morselle, in the Vosges Mountains, France, February 14, 1806. As his father was a poor country practitioner, he was obliged to teach anatomy and physiology, while he was studying medicine in Paris. He received his doctor's degree in 1831, and shortly afterward he took part in the Polish insurrection as a Division Surgeon in the National Army. He was present at the capture of the city of Warsaw, on which occasion there was great bloodshed. In 1835, after passing with marked distinction a severe competitive examination, he was appointed Surgeon and Professeur agrégé at the Bureau Central. This appointment enabled him to give public lectures on surgical anatomy in the École pratique; and these lectures, which

FIG. 3916.—Joseph François Malgaigne.

were much appreciated on account of their originality and their instructiveness, formed the basis of the treatise which he published a few years later: "Traité d'anatomie chirurgicale et de chirurgie expérimentale," Paris, 1838, two volumes (2nd edition in 1859). At a still earlier date (1834) he had published a book ("Manuel de médecine opératoire") which was translated into nearly all European languages, and which brought him great celebrity. Then followed several other publications which were highly appreciated—as, for example, his edition of Ambroise Paré's works ("Oeuvres complètes d'Ambroise Paré, etc.;" three volumes 1840), and a number of shorter treatises on topics such as "The Mortality in the Paris Hospitals," "Wounds of Arteries," "Operation for the Cure of Cataract," "Puncture of a Chronic Hydrocephalus," "On Irrigation in the Treatment of Surgical Affections," etc. Finally, in 1842–1855, he published his great work on fractures and dislocations, in two volumes, with an atlas of thirty folio plates, translated by Dr. John H. Packard of Philadelphia in 1859. Malgaigne was also connected, at one time or another, with several of the prominent Paris hospitals, the Hôpital de Lourcine, The Bicêtre, Hôpital Saint-Louis, and the Charité. It was only in 1850, however, that he finally received a professorship in the Medical Faculty. He died October 17, 1865, from cerebral apoplexy.

Malgaigne's name was given to a number of surgical appliances, a form of amputation of the foot, and some anatomical structures. Pagel says in terms of praise: "Malgaigne was unquestionably one of the most learned, the best informed, and the most critical

of modern surgeons; at the same time he was a most brilliant and fascinating speaker, and a writer whose style was most clear and finished. As to his personal character he was distinguished by a strong love of truth and by an unswerving fidelity to the motto of the Société de Chirurgie: "Verité dans la science; moralité dans l'art." A. H. B.

Malic Acid.—($C_4H_6O_5$). An organic acid widely distributed among plants, especially in fruits, and more especially in those related to the apple. It occurs in odorless and colorless crystals, deliquescent in the air, freely soluble in water, and of a pleasant acid flavor. Its general properties are much like those of citric acid. It has been very little used.

HENRY H. RUSBY.

Malingering.—From the beginning of the human race affections of a surgical or medical nature have been simulated. This has not been confined to one class, but has been encountered on every side. Most cases though are noted among soldiers and sailors, inmates of institutions, and those persons who expect personal gain or more favored treatment if some injury or diseased condition is present. Though at frequent intervals observers report individual cases of interest—these reports are so scattered that it is very difficult for the younger and inexperienced men to refer to them, and therefore their usefulness is much impaired. Feigned affections are comparatively rare in private practice and we are apt to be caught off our guard and do not recognize the fraudulent symptoms when they appear. Therefore it is necessary for the medical attendant to acquire a knowledge not only of the disease which may be feigned, but also of the motives and characters of those most likely to feign them. The medical officers of the army and navy, resident physicians in institutions such as penitentiaries, jails and insane asylums, insurance examiners and examiners for public service corporations should always be on their guard and make such thorough examinations of patients brought before them that mistakes can seldom occur. With two exceptions the text-books now published pay little attention to the subject in all its phases and, if mentioned, particular stress is placed upon nervous diseases, general surgical and medical affections being ignored. Peterson and Haines in their excellent work on legal medicine have a chapter entirely devoted to the subject, but the diseases which they note are mostly nervous and mental in character, whereas such feigned illnesses are least often met with, and when encountered are so clumsily simulated as to be very easily detected. The recent work "Malingering," by Sir John Collie, most thoroughly covers the ground and is well worth a careful perusal by those interested in the subject.

From time immemorial the military service has been considered the particular field for malingerers, but fortunately at the present time the number is small. It must be recognized, though, that one feigned case can cause more trouble than a number of really ill men, particularly as these men report to the hospitals just before active field service or more strenuous duty is contemplated.

During an engagement, frequently numbers of shirkers show up at the different aid stations with trifling wounds or complaints of sickness, but summary action is always taken in these cases and the men returned to their commands under guard. The class of cases handled in the military service cannot be considered as special in character, as the same problems will occur to all physicians who come in contact with persons who desire to deceive in order that they may personally gain by the simulation of disease or injury.

Most medical men when brought in contact with such conditions are divisible into two classes:

First.—Those whose sympathies are easily aroused and who take all statements made to them as facts and allow the patient to impose upon them completely and gain his object.

Second.—Those who consider all men who have no visible signs of disease as malingerers, and frequently neglect men who are really ill and in need of medical attention.

These two extremes are undesired, but the young medical man is very liable to gravitate into one class or the other, on account of his ignorance of conditions governing the life of the average patient whom he is called upon to examine.

This state of mind can be obviated only by a thorough knowledge of the subject, which can be obtained only by previous personal experience or by the results of the study of older practitioners, imparted to the young doctor on his entrance into the profession. In the following article it will be my endeavor to touch the subject in such a way as to render some assistance to physicians in the consideration of those cases.

I will take up in regular sequence the local affections of different parts of the body beginning at the head, and will mention first surgical and then medical conditions, appending to each its proper treatment.

HEAD.—Men do not often purposely injure the head or face nor do they simulate injuries to these parts, but the supposed results of injuries are often met with. The principal symptoms complained of are persistent headache, neuralgia, or vertigo following a previous injury. In addition to these some complain of more or less trouble with the eyes. These cases are very difficult and should be carefully examined primarily to discover whether an injury had really been incurred. As persistent headache is a symptom of so many serious conditions in the cranial cavity, all cases must be kept under observation until they clear up. This observation frequently cures the malingerer if the patient is isolated in a darkened room without companions or reading matter and on a liquid diet. Few men can stand the isolation for any length of time. Of course during such treatment careful watch must be kept and all actions of the patient reported to the attending surgeon. One of the most frequent results of injury to the head complained of is epilepsy, but that will be considered more at length under a separate heading.

Eyes.—If there is complaint of loss of vision or other eye troubles, a careful examination can be made and any defect discovered at once, but in spite of this, eye troubles are frequently simulated. Loss of vision both partial and complete and conjunctival troubles are met with. The former is readily detected by placing a plus 12 lens before the supposedly sound eye and a plain glass before the blind eye. If the patient is able to read even large print heis not blind. Numerous other tests can be applied in conjunction with a careful ophthalmoscopic examination of the retina and most cases should be easily detected.

Conjunctivitis caused by irritants self-applied requires careful observation to detect any interference by the patient. Ptosis is sometimes complained of, but if simulated can be easily detected by suddenly directing the patient to look up when he involuntarily raises his lids.

Under the general head of eye diseases several interesting cases can be cited.

A man complained of complete blindness and had to be led about, making a truly piteous picture. To test his sight he was asked to pick up a wax vesta from the floor. He groped about for some time all around it, but failed to find it. He was then told to dress, and meanwhile the doctor pushed a black safety pin he had been wearing off the table onto the black floor.

He proceeded with his toilet and presently quite innocently stooped down and picked up the black pin from the black floor without the least hesitation. (London Correspondence: *New York Medical Journal*, vol. xcii., page 777.)

De Loffre reports a case of a man who complained of lacrymation, burning of the eyes, and inability to read. Ophthalmoscopic and retinoscopic examination showed nothing. He was examined with test lenses and read as well with a 0.25 D. S. as a 3.50 D. C. He was put to bed with his eyes bandaged for eight days and was then discharged after being admonished.

In my experience I have encountered several men who complained of defective sight, but after using the test lenses in the same manner as outlined above they found that their sight had suddenly returned.

I also had a case of severe and persistent conjunctivitis which I very soon decided was self-caused, but for some time could not detect the method used; but when it was finally discovered it was found to be very simple; the man had merely placed lime dust in his eyes.

Ears.—Deafness is noted frequently and many soldiers try this means of avoiding disagreeable service. Of course where the proper instruments are convenient, the detection of these cases is simple, but when no such means are at hand the result is a battle of wits with all the sympathy on the side of the malingerer. In the general examination of a patient supposedly deaf in one ear a very careful testing of his hearing should be conducted. The patient is blindfolded and each ear closed in turn; he is then tested at varying distances by means of a watch, tuning fork, or whispering. If his hearing is not impaired it is very difficult for him to keep accurate track of the different tests and his deception is soon exposed. A very simple test is made by closing his good ear and placing a tuning fork behind the supposedly deaf ear. If he denies hearing the sound he is a malingerer for the bones of the head readily conduct the vibrations to the good ear.

In a case of my own where deafness was simulated the man was brought into the operating room, and an elaborate examination was conducted, after which he was left standing for some ten or fifteen minutes while some cases were attended to, and immediately after dressing an interesting case the supposedly deaf man was told in a low voice to take a seat. He did so without thinking and of course his deception was exposed. The following case is reported by Furlong. A private of marines alleged almost total deafness. His attitude was very suspicious. One day he was asked to blow his nose and as he pulled a handkerchief out of his pocket a nurse dropped a half dollar on the deck. This the man immediately stooped to get. The incident was closed.

Neck.—There are practically no simulations of injuries or diseases of the neck.

Thorax.—Injuries to the thorax particularly in the dorsal region are frequently complained of. The degree of disability can usually be determined by a history of the case and by a careful examination of the part injured, but in many cases there is complaint of severe pain without any visible or palpable injury. If the painful localities are superficial, pressure can be applied to them frequently in the course of a stethoscopic examination without protest from the patient.

These cases may be treated in several different ways. The thermocautery can be used over the location of the pain complained of or blister plasters one inch wide can be applied to the skin, one strip each day applied to unbroken skin in juxtaposition to the strip of the previous day. The discomfort of this treatment soon has its effect and the patient gets well rapidly.

Malingerers frequently complain of cough which has existed for weeks, but a careful thoracic examination will detect the deception. Combined with the foregoing they will report that they have "spit up blood," but the complete examination of the chest and sputum will quickly discover any pathological entity. In connection with this point a number of cases have been reported where blood from domestic animals had been supplied the patient by an outside confederate. This deception is easily discovered by microscopical examination.

I do not wish it to be understood that the detection of supposed consumptives is always easy. Far from it. In my own experience I have encountered three such cases, one of which completely fooled me for some time as the man obtained tubercle sputum from some source and substituted it for his own. The *modus operandi* was never discovered, but the man recovered so rapidly on isolation that the case was quickly decided to be assumed. The other two men puzzled me particularly as another surgeon had made a decided diagnosis of tuberculosis in both cases. I never could discover any physical signs and finally taking the bull by the horns I sent both men to duty keeping them under close observation. Under severe physical exertion they put on flesh and when last seen they were pictures of rugged health with no signs of lung involvement.

There is frequently complaint of heart disease which is most often reenforced by the statement that doctor "So and So" had said his heart was in bad shape. Examination will show the falseness of his claim and after such a negative examination little confidence should be placed in the reported statements of other practitioners.

Abdomen.—Injuries in this part of the body are frequently complained of and the methods of treatment may be used as outlined under injuries of the thorax, but on account of the great possibilities that a serious injury may exist without external signs such cases may be kept under observation for some time. The principal organs contained in the abdomen are considered separately.

Liver.—A most difficult class of cases to be dealt with come under this head. A man will give a complete history of trouble with the gall-bladder or ducts, but on examination the surgeon is inclined to doubt his statement. In such a case the quickest method to pursue is to announce to the patient that an operation is necessary and after preparing him therefor start to anesthetize him. This will sometimes fail and in these cases the anesthesia can be made complete and the man bandaged as if he had been operated upon and removed to a recovery room. Of course if his trouble has disappeared he is a malingerer.

Under this head simulated jaundice should be placed. This is not very often encountered in this country, but is frequently noted in Europe. A small dose of picric acid is self-administered and in a short time the entire body takes on the icteric hue. Of course a careful examination of the urine will detect the cause of the discoloration.

Kidneys.—Pain in the region of the kidneys coupled with frequent urination is the principal complaint in this part of a man's anatomy and it requires considerable thought to determine the category in which to place the patient. But a careful urinary and cystoscopic examination will expose the faker who can then be treated in much the same manner as described under the head of injuries to the thorax.

In a number of recorded cases the patient has added sugar to the urine, even going so far as to obtain grape sugar for the purpose, but of course these men are very seldom encountered for it requires more education and intelligence than are usually found among soldiers or inmates of institutions.

Stomach.—Repeated vomiting is sometimes a simulated condition, but can be easily detected on observation. This act of vomiting is accomplished by

placing the fingers in the fauces, repeated forced belchings, or by taking some substance which will nauseate, such as tobacco. A case of this nature can best be treated by administering a nauseous dose at regular intervals. A good formula for this is as follows:

Ol. morrhuæ	8 c.c.
Emul. asafœtidæ	8 c.c.
Quininæ sulph	500 gm.

Frequently when soldiers are dissatisfied with their company messes or when prisoners in the guard house are put on bread and water, complaint of dyspepsia is made. Where possible an examination of the stomach contents after a test meal should be made, but, if that is impracticable a few days on liquid diet is sufficient for a cure.

I have encountered a great many of these cases and find that this type of malingerer usually responds rapidly to the above treatment. They are not difficult problems.

Intestines.—Appendicitis is often complained of especially if several real cases have been treated a short time before without operation. If on examination this condition is seen not to exist the same procedure may be used as in cases of supposed bladder affections. At times when the patient really has intestinal colic he will make it as severe as possible and for a few hours the doctor is uneasy and cannot decide whether there is really appendicitis or just plain colic. In these cases it is never wise to discharge him from the hospital but *always* give him the benefit of the doubt.

In such cases where severe pain is complained of careful observation of the pupils, when pressure is made over the affected part, will give a sign of considerable importance. If pain exists the pupil will be seen to dilate. Sleeplessness if present is a symptom showing that severe pain does exist, and on the contrary if the patient sleeps well without an opiate we can be assured that he is exaggerating his illness.

At one time I operated on three severe cases of appendicitis within forty-eight hours and by actual count there were ten simulated cases within the next week.

Diarrhea is a constant cause for admission and can be very easily handled by confining the patient to bed and ordering the use of a bed pan for all defecations.

Such cases should be treated in the same way as outlined under diarrhea and all cases of dysentery not showing mucus and the special microorganisms in the stools should be suspected.

Hemorrhoids is one of the favorite complaints, but a careful examination will eliminate the case *usually.* In considering this disability one must remember that one or two small piles are frequently noted and if the patient has eroded the same his case becomes more difficult.

I have had a number of such men to deal with and must confess that for some days they have imposed upon me, but in all work of this nature patience receives its reward and the case is finally placed in its proper category.

Hernia.—This subject requires careful consideration, not in cases of frank hernia, but when the belly wall bulges slightly on coughing. The difficulty in the determination of these cases is occasioned by the fact that in the military service hernia is a condition which requires the consent of the soldier for operation. A man with a bulging of this character will present himself at the hospital for treatment, refuse operation, and request discharge. Careful examination is necessary and the thorough weighing of the evidence of disability, bearing always in mind that the majority of mild hernias give no discomfort whatever.

Recently in Europe a method of obtaining an artificial hernia has been described. The inguinal rings are stretched instrumentally, thereby weakening the wall at that point. This method is said to have been much used among Russian conscripts to avoid service.

In medicolegal cases where it is claimed that hernia is the result of some accident the disability is always present and no surgeon can state that even a small hernia does not render the subject incapable of doing his work.

Bladder.—Complaints of frequent urination accompanied by distress in the region of the bladder come under the same head as complaints of kidney trouble and should be treated in the same way. These cases are very frequent.

A case of this character was under my charge several years ago and may be interesting. A prisoner entered the hospital complaining of pain on urination, tenderness over the lower abdomen, and frequent urination. The urine was carefully examined with negative results and though the patient constantly complained of pain my suspicions were aroused. In passing, I should state that his control of the vesical sphincter was such that he could urinate every half hour if he desired. As soon as I was able I made a cystoscopic examination and found a normal bladder. The examination was made without anesthetic and strange to relate the discomfort of passing the cystoscope cured the case.

Penis and Urethra.—Much to my surprise I have frequently encountered simulated cases of gonorrhea. The soldier knows that such cases are treated in hospitals and by only a slight irritation of the delicate mucous membrane of the urethra he can cause a decided inflammation with profuse discharge which may continue for several days. In addition to this, canned cream may be injected into the urethra to simulate the same disease; but I have never encountered such a case. Of course during the time he is kept in the hospital the cause of such inflammation is very hard to detect especially as this condition does occur from intercourse with a woman with profuse leucorrhea, etc. Each case will therefore have to be treated on its merits with the great probability of the doctor being completely deceived.

Varicocele.—Men with very slight varicocele complain bitterly of great disability and state that they are unable to do their work. Of course in a number of cases this is true as the psychical effect is often marked, but there are a large number who use it only as a means toward a long loaf in the hospital. Most cases will disappear when operation is mentioned, but there are others who realizing the minor nature of such operation request it with the idea of having a holiday of a week or so. Such men should be discharged from the hospital as soon as possible.

Some soldiers make great complaint of a small varicocele and then refuse operation, hoping thereby to be discharged from the service, but as the operation can be performed under a local anesthetic such efforts on their part should be futile.

In this connection I might state that in the Russian military service injections of paraffine are made into the tunica to cause the simulation of tumor so that the individual may escape military service. I have never heard of such a case being encountered in our service.

The Extremities.—Under this head opens up a long line of complaints of more or less severity which tests the powers of observation of the surgeon to the utmost.

Almost every day in the military service and in large industrial works men will present themselves with contusions or wounds of the soft parts mostly desiring only dressings or alleviation of a certain amount of pain, but at intervals a vociferous complaint will be made that he cannot perform his duties. Wounds received may be kept open artificially and inflammatory swellings may be simulated by placing rubber bands around an extremity and removing them just before examination. Cases of this kind are encountered by every one at some time, and I have a case of my own which illustrates the condition very well.

A corporal was brought to the hospital one evening suffering from a badly lacerated wound of the great toe; in fact, the toe was practically destroyed. He gave the history of having started to clean his rifle and unknown to himself some one had placed a cartridge in the chamber and on handling the piece it was discharged causing the injury in question. The tale seemed true and as the soldier bore a very good reputation he was believed, but on further investigation several men including the first sergeant testified to having seen the man place the cartridge in the chamber and deliberately fire it at his foot. On being closely questioned, detailing the evidence in hand, he confessed that he desired to leave the service and took this means to provide a pension for himself.

Fractures.—Of course one cannot simulate a fracture, but in some cases after union has taken place complaint of pain or loss of function is made. A careful anatomical examination is necessary, including a clear skiagraph.

A case in point was that of a soldier who had a simple fracture of the left femur, middle third. After a very good union of the fragments with no deformity he began to complain of attacks of excruciating pain at the location of the fracture and loss of function in that leg. A careful examination revealed no cause for his complaint and suspicions were aroused by the fact that this pain was noted only when he was on duty. After being under observation for about six months he was tried for malingering and convicted. On his arrival at the prison all symptoms disappeared.

Rheumatism.—This is the *bête noir* of all physicians for it is, of course, understood that muscular or subacute articular rheumatism may exist without objective symptoms, consequently it is by far the most frequent ailment complained of by malingerers. If suspicion is directed to the case he should be treated as follows: Strict confinement to bed on liquid diet and the daily application of a blister plaster (6″ ×1″) to the extremity affected. This should always be applied to sound skin and by the time the circuit of the limb is made by daily fresh applications the first part has healed. In addition to this the Paquelin cautery is freely used. This treatment is fairly severe, but will cure a malingerer in short order, particularly if the rheumatism complained of is located in the back, the treatment compelling him to lie on his abdomen.

In this connection a case reported by De Loffre could be cited: A patient on examination was diagnosed as suffering from acute muscular rheumatism of lumbar and cervical muscles. He declared that the pain was so exquisite he could hardly move. He was put on the usual treatment, but showed no improvement. Suspicion was aroused and he was prepared for operation by scrubbing his back with a stiff brush with no result, so on the next day he was prepared again and acupuncture of the lumbar muscles was performed under partial anesthesia with complete recovery.

Numbers of cases coming under this head are frequently met with and any one having been employed by large industrial concerns can cite examples.

Skin.—Artificial eruptions of the skin are easily caused by chemical applications and are very puzzling. Frequently the deception is carried out so well that no suspicion is aroused. And even if the attendant should suspect such a case it is difficult to verify his beliefs.

The eruptions or ulcerations caused by these local irritants are usually very circumscribed and differ from pathological lesions by having a distinct line of demarcation and being surrounded by normal skin. The treatment is always to remove the cause and expose the patient. Furlough reports a case where a seaman reported sick with a muscular and papular eruption over the body. There were no other symptoms. On investigation it was found that the man had anointed himself with croton oil. In my own practice I encountered a case which presented a foul sloughing ulcer of the forearm which was very puzzling, but its regularity caused me to become suspicious and I found that the man had heated a penny repeatedly and applied it to the skin causing necrosis of the area combined with some slight copper poisoning.

General Diseases.—Always look out for men who come repeatedly to the hospital with a slight fever up to 100°. We are all familiar with the operation of taking a mouthful of hot water just before the temperature is taken, but an easier and surer way of raising the temperature is to rapidly rub the tongue over the bulb of the thermometer while it is in the mouth. Careful watching will detect this ruse. Under general diseases a great number of ailments may be simulated, but on account of the lack of knowledge of such disorders the average man does not often go into this field. He confines his operations to diseases with symptoms which are of common knowledge.

Nervous System.—Next comes the simulation of nervous diseases. A large field and much worked over by this class of patients. This will run from convulsions to maniac insanity and will test the doctor's powers of observation to the utmost. Convulsive seizures and simulated epilepsy can, after the deception has been detected, be treated only by making the patient uncomfortable during his fit and letting him thoroughly understand that you are certain he is a malingerer.

The insane man so called is very hard to treat and each case must be handled on its own merits.

When the suspect simulates mania he should be controlled by restraint apparatus, and treatment such as ice baths instituted. All of these cases though have to be observed very carefully for some time before the attendant can be satisfied in his own mind that the man is not insane.

Where melancholia or delusional insanity is simulated a careful isolation of the patient on liquid diet and denial of all reading matter will frequently produce a cure; a suspect must be watched continually without his knowledge and every move noted. After several weeks a magazine may be left on his bed or an attendant may converse with him on the news of the day. Very few can stand the isolation without reading or talking and soon break down under the treatment.

In the literature numerous cases are cited under this head and the details of a few of these may be of interest.

Two cases reported by De Loffre are as follows: Trumpeter L. A. was brought into the hospital apparently unconscious, his mouth and face covered with foam, eyes tightly closed, breathing labored, pulse and temperature normal, convulsions of right arm and leg. It was noticed that he resisted the opening of his eye and pressure over the supraorbital notch produced a grimace of pain. He was put to bed and watched, when he was noticed to come to and roll a cigarette. On the surgeon reentering the ward he feigned insanity at once. He was put on liquid diet and discharged from the hospital.

S. M. O. His case was diagnosed acute neuritis of the left median and musculospiral nerves with paralysis of the extensor muscles of the left hand. On observation, suspicion was aroused and the man was anesthetized and found normal. The swelling of the forearm with redness was caused by friction self-administered.

I myself have had a number of cases of supposed insanity to treat at the Military Prison one of which may be well worth reporting: On arrival I found one man in a ward apparently suffering from delusional insanity. He imagined himself the leader of a band and to keep him quiet music scores were given him. He would give no rational answers to questions put to him and seemed a hopeless paranoiac. I watched him

closely for a week or two and decided that his face showed too much interest for an insane man. He was then isolated for a week under the treatment outlined above, and at the end of that time a magazine was casually introduced into his cell when the daily distribution of reading matter occurred. He paid no attention to this at first, but finally succumbed and began to read it. When this was noticed I accused him of malingering and he confessed.

For a more detailed account of the methods used for the examination and detection of mental and nervous malingerers the reader is referred to the standard works on legal medicine.

In conclusion I would state that the detection and treatment of malingerers of all kinds requires careful study and no doctor is justified in jumping at conclusions without a thorough examination. It is frequently noticed that where a surgeon is known to be thorough in his examination of all cases, malingerers are few and unimportant.

William N. Bispham.

Malpighi, Marcello.—Born at Crevalcuore, near Bologna, Italy, March, 10, 1628. He began the study of medicine at the University of Padua, and received his degree from that institution in 1653. Not long after he had graduated he accepted a call from Ferdinand II., Grand Duke of Tuscany, to fill the Chair of the Theory of Medicine in the University of

Fig. 3917.—Marcello Malpighi.

Pisa. The climate of this city, however, did not agree with Malpighi's health; and so, in 1660, he decided to return to Bologna and accept the Chair of Anatomy and Physics. In the following year he published his first treatises on anatomical subjects—treatises the excellence of which put him at once in the front rank of anatomists. In 1663 he was called to Messina to fill the Chair of Medicine which Castelli had resigned. In 1666 he was invited to return to Bologna, where the fees connected with his professorship were sufficiently large to retain him for several years in this place. Finally, in 1691, Pope Innocent XII., who as Cardinal Pignatelli had known Malpighi well in Bologna, called him to Rome to be his chief physician. His residence in the latter city was of short duration; he died there suddenly of cerebral apoplexy November 29, 1694, in the palace of the Quirinal.

The following are a few of the more important published writings of Malpighi, of whom the writer of the biographical sketch in the "Dictionnaire Historique de la Médecine" says that he might with propriety be called "the creator of structural anatomy." "Observationes anatomicæ de pulmonibus," Bologna, 1661; "Exercitatio de omento, et adiposis ductibus," Bologna, 1661; "Epistola anatomica de cerebro," Bologna, 1665; "Epistola anat. de lingua," Bologna, 1665; "Epistola anat. de externo tactûs organo," Naples, 1664; "Marcelli Malpighii opera omnia, figuris elegantissimis, in aes incisis illustrata, tomis duobus comprehensa," London, 1686. A. H. B.

Malpractice.—Malpractice is judicially defined as the bad professional treatment of disease, pregnancy, or bodily injury, from reprehensible ignorance, or carelessness, or with criminal intent.

The degree of care, skill, and diligence required of a physician and surgeon in the practice of his profession is not the highest degree attainable, but that which is ordinarily possessed by the average of the members of his profession in good standing, practicing in similar localities, according to the state of medical science at the time. He impliedly contracts that he possesses and will use such a degree of care and skill, and exert his best judgment in the treatment of his patients. Whether or not the physician or surgeon exercised the necessary degree of care and skill in a particular case is to be settled according to the rules and principles of the particular school of medicine he follows, and not by those of other schools. Anyone who professes to cure disease by a system of treatment which is not a recognized school of medicine will be held to the standard of care of the ordinary physician in good standing. A physician is, of course, bound by what is considered as universally settled in the profession, and he should, in order to escape liability, follow recognized and approved methods, and beware of trying experiments which might result in injury to his patient.

Unless he contracts to effect a cure a physician or surgeon does not warrant that the result of his treatment will be successful. And the circumstances of the particular case or the duty to be performed may have an important bearing upon the degree of care, skill and diligence called for. The same degree of care, skill, and diligence is required from a practitioner who treats a patient gratuitously as where compensation is received. And a practitioner holding himself out as a specialist is held to that degree of care, skill, and diligence which is possessed by specialists in the same branch. But one not professing to practise as a physician, who gives advice or aid merely as neighbor or friend, is not liable for a failure to use such care, skill, and diligence as a practitioner. A physician may elect whether or not he will treat a case, but if he does undertake it he is, in the absence of a special agreement, bound to continue it as long as it requires his attention, or until he is discharged by the patient, or has himself given sufficient notice of his intention to withdraw from the case as to enable the patient to secure the services of another practitioner. He must also exercise ordinary care and skill in determining whether the patient requires further attendance.

A physician is liable for failure to exercise the required degree of care, skill, and diligence in making a diagnosis, if injury to the patient results from consequent improper treatment. If no injury results, the wrong diagnosis will give no right of action. And a general practitioner will not be held liable for a wrong diagnosis of a disease so rare as to require an expert for its detection. It would seem that a physician who, knowing that he has an infectious disease, visits a patient without informing him of the fact, and taking proper preventive precautions, is liable for the damage caused by communicating the disease to the patient. The negligent use of x-rays may incur liability for injury caused thereby.

If the physician knows that the patient's disease is incurable, and fraudulently informs him that it is curable in order to induce him to undergo a useless course of treatment, he will be liable in an action of deceit, but the plaintiff must prove the fraudulent intent as well as the falsity of the statement. A physician may be liable for injury or death resulting from

a mistake in a prescription, even if the druggist also makes a mistake in compounding it. He will be liable for failure to give the patient or his nurses or attendants proper instructions for his treatment, resulting in injury. A patient who is in possession of his faculties, and may be consulted as to his condition, is entitled, where no emergency exists, to have an opportunity to give or withhold his consent to the performance of a surgical operation; but in an emergency, where immediate action is necessary for the preservation of the patient's life or health, and his consent, or the consent of someone authorized to give it for him, cannot be obtained, it is the surgeon's duty to perform the operation without such consent.

A physician or surgeon who possesses the requisite qualifications and applies his skill and judgment with ordinary care and diligence is not liable for damages for an honest mistake or error of judgment in making a diagnosis or prescribing treatment, where there is reasonable doubt as to the course to be pursued. The question of liability for errors of judgment will depend not upon the ordinary skill of the physician, but rather on the skill and diligence displayed by him in the particular case.

A member of a partnership engaged in the practice of medicine is liable for the negligence of his partners while acting within the scope of the partnership business, but not otherwise. A physician is liable for the malpractice of his apprentice, assistant, or agent. He is not liable for the malpractice of a substitute or another physician whom he has recommended, on being himself unable to undertake or continue the treatment of the case, and who is in nowise in his employment. Nor is a physician liable, as a rule, for the negligence of hospital nurses or attendants of which he is not personally cognizant.

Contributory negligence of the patient at the time is a good defense to an action for malpractice, where it proximately contributes to the injury caused by the defendant's malpractice; but the subsequent negligence of the patient conducing to the aggravation of the injury primarily sustained by the negligence of the physician or surgeon, is not sufficient to defeat the action, though it is pertinent in mitigation of damages. Contributory negligence on the part of the patient barring recovery may take the form of refusal to permit proper treatment; insistence, against the advice of the practitioner, on unnecessary or improper treatment; interference of the patient while the surgeon is performing an operation; where the patient failed to return to the physician as soon as he felt pain, as told to do, but delayed a week after feeling pain. Even without express instructions, the failure of a patient to observe the ordinary prudence to be expected of a person in his condition will bar recovery.

It would appear that a practitioner may protect himself against liability from malpractice by contract to that effect with the patient. A recovery by the physician for services is a good defense, where the malpractice was set up as a defense; in New York, even where the judgment was by default.

As a rule, actions for malpractice are civil suits for damages, criminal actions being confined almost altogether to actions for criminal abortion. The burden of proof in an action for malpractice is on the plaintiff to show want of reasonable care, skill and diligence, and also that the alleged injury was the result of failure to exercise these requisites. The burden is also on the plaintiff to prove want of consent to an operation to which he has voluntarily submitted. On the question of negligence of the defendant, expert evidence naturally figures largely; but the plaintiff may introduce any legal evidence tending to show improper treatment, and the defendant any legal evidence in rebuttal to show want of negligence. It has been said that in determining the relative value of the evidence of medical experts the jury must consider their professional knowledge and experience, freedom from bias, and the reasons they are able to give for their conclusions.

Where it is impossible to distinguish between the consequences of the ailment to treat which the defendant was called and those of the maltreatment, only nominal damages can be recovered. Where the injury is clearly the result of the defendant's negligence, the damages are, as a rule, the loss or injury directly and naturally flowing from such negligence. As said before, where the subsequent negligence of the plaintiff has aggravated the injury, that will mitigate the damages; as may also the fact that another physician subsequently treated the plaintiff improperly. JOHN SIMPSON.

Malta Fever.—*Synonyms:* Undulant fever. Febris undulans. Mediterranean, Rock, or Neapolitan fever.—The disease caused by an invasion of *Micrococcus melitensis*, Bruce, 1887.

HISTORY AND DISTRIBUTION.—The disease was for a long time confounded with typhoid fever and malaria. The discovery of its cause by Bruce in 1887 established its specific nature. The investigations of the British Royal Commission appointed in 1904 showed that it was a common infection in several of the lower animals, especially in goats in whose milk and urine it is excreted, the use of goats milk being the usual cause of human infection. The discovery of this fact enabled the British military authorities to reduce the incidence of the disease in Malta from 643 cases in 1905 to seven cases in 1907, and one case in 1910. Believed formerly to be peculiar to Malta, the disease is now known to be distributed not only all round the Mediterranean littoral where it is known under various names but in many other tropical and subtropical countries. It is therefore of special interest to naval and military surgeons. In the endemic localities its incidence is greatest in the season of lowest rainfall.

ETIOLOGY.—*Micrococcus melitensis* is a minute coccus 0.33μ in diameter, exhibiting a Brownian movement in hanging drops, decolorized by Gram's stain. It occurs singly, in pairs, and in short chains. It is abundant in the spleen, but for a blood culture it is necessary to take at least 2 or 3 c.c. of blood. It grows slowly on gelatin without liquefaction. In broth it produces a cloudiness with deposit but without film formation. On agar, at blood heat in two days, at room temperature in three or four days, it produces minute transparent colonies. These gradually become amber colored, and in four or five days opaque with a slight orange color, and round with granular margins. At 37° C. they retain their vitality for three months. When inoculated into apes they produce a febrile disease running a long course and the cocci can be demonstrated in culture from the animal's blood.

An agglutination reaction is available for diagnosis of the disease in man, using a fresh forty-eight hour broth culture, a serum dilution of one to thirty, and the same technique as in typhoid fever. Manson states, however, that this agglutination reaction is not to be relied upon for diagnosis. Hewlett states that with graduated dilutions there are irregular zones of reaction, and that the test can be relied upon if several dilutions be employed, with controls.

M. melitensis is capable of retaining its vitality in a dried state for a long time, and may thus cause infection when inhaled with dust. The organism is discharged in the urine of the patient and thus by infection of streams and pastures may be transmitted to other animals, especially to goats, in whose milk it occurs abundantly. Infected goats do not show any signs of disease, nor do asses, horses, sheep, cows, and rabbits, though all these animals are apparently

capable of carrying and spreading the infection. The common, almost invariable mode of infection for man is through the alimentary canal by the ingestion of goats' milk. The disease is inoculable through the skin, but no case is known to have arisen in this way, nor has it been known to be transmitted by any biting or blood-sucking insect. Several laboratory infections have occurred, one from a splash of a broth culture into the eye.

Nègre and Raynaud have isolated a *M. paramelitensis* which causes a para-undulant fever similar to Malta fever.

Pathology.—The organism is found in the blood, urine, milk, and bile, and in the liver, spleen, and other organs. The spleen is enlarged as in typhoid, weighing in fatal cases ten to forty-four ounces (Castellani), average seventeen ounces (Manson). It is dark red and friable. The liver, kidneys, and lungs are congested, but there is usually no nephritis. Patches of catarrhal pneumonia are sometimes seen. The alimentary canal is apt to show congestion, and sometimes ulceration or hemorrhage, particularly in the colon. The disease is a true septicemia, the organism producing hemolysins and the body reaction agglutinins which may be present for several years after an attack. There is, however, no satisfying evidence that an immunity is acquired.

Symptoms.—After an incubation period of from two to nineteen days, usually fourteen days, following the ingestion of infected milk, the disease is ushered in with headache, muscular pains, general malaise, and moderate fever. After four or five days with increasing pains and a temperature of 103° or higher, the patient shows a coated tongue and complains of abdominal pain and heaviness, with cough and perhaps sore throat. In the course of a week splenic enlargement can usually be demonstrated. In a further course of a week or two, temperatures of 104° or 105° may occur, with profuse sweats, increasing prostration, and painful swelling of some of the large joints resembling rheumatism. A remission then occurs, with perhaps a short non-febrile interval. After a day or two the fever recurs, and the alternation of remission and relapse continues for an indefinite period, usually for several months. The patient becomes weaker and more and more anemic and the fever takes on an undulant course, lower in the morning, higher at night, and with no definite remissions. Headache becomes more constant and severe and the increasing weakness verges on prostration. Pulmonary congestion and bronchitis may have culminated in a bronchopneumonia. The heart becomes weaker and hemic murmurs may be heard. Neuritis sometimes occurs, and bedsores or abscesses may be among the complications. Orchitis or parotitis may occur. Albuminuria is rare. The blood shows a secondary anemia without leucocytosis, but with a relative increase in the mononuclears, sometimes to eighty per cent. The average duration of the disease is three to four months, though it may last ten months.

Diagnosis.—This is based clinically on the mild long course of the disease, the undulant temperature, the splenic enlargement, prostration, profuse diaphoresis, and the tendency to joint complications. From typhoid it is distinguished by the absence of the eruption, diarrhea, hyperpyrexia and Widal reaction present in that disease, as well as by blood culture; from malaria by the absence of the parasites and the fact that it is not influenced by quinine. The agglutination test for Malta fever is usually positive at the end of the first week. It may be made with dead cultures. The possible coexistence of typhoid or of malaria is not to be forgotten.

Prognosis.—This is in general favorable. The average mortality is about two per cent.

Prophylaxis.—Cruising vessels should avoid an endemic locality in the dry season. In Malta this is from June to September inclusive. In the presence of the infection all drinking water and fresh milk should be boiled, and utensils cleaned with boiling water. The substitution of condensed milk for fresh milk is advisable. Cases of the disease should be notified to the health authority and isolated. Public prophylaxis should be enforced by bacteriological inspection of goats with slaughter of the infected and vaccination of the uninfected, disinfection of stables, and prohibition of the importation of infected goats.

Treatment.—Catharsis by a dose of calomel and jalap at the beginning is recommended by Manson. In general, orders for treatment should be similar to those in typhoid fever; rest, liquid or soft diet of a nourishing kind, sponging for hyperpyrexia, avoidance of salicylates or other depressing drugs. Affected joints should be protected with cotton wool. Pulmonary complications may require appropriate treatment. Liquor hydrargyri chloridi, or Sternberg's mixture, has been recommended as a gastric and intestinal antiseptic. Hexamethylenamine might favorably affect the septicemia and bacteriuria, but does not appear to have been tried. Treatment with vaccines and serums has not been successful. A change of locality may sometimes be of benefit, but should not be undertaken if it involves an exhausting journey. J. F. Leys.

Maltase.—To the enzyme capable of transforming malt sugar, or maltose, into two molecules of dextrose the name maltase is given. It also has an action upon amygdalin whereby the latter is split into mandelic acid, nitrile glucoside, and dextrose. This reaction may be reversible for from these decomposition products amygdalin may be reconstructed. By the action of maltase dextrose may be changed into isomaltose. F. P. U.

Maltose.—Malt Sugar. See *Aliment.*

Malvaceæ.—This large family, of some thirty-three genera and nearly a thousand species, has yielded a large number of articles to the Materia Medica, besides *cotton* and *marshmallow*, which are elsewhere described. The most important of these substances are the leaves and flowers of the Hollyhock, *Althæa rosea* (L.) Cav., and of various species of *Malva*. All have been used chiefly as demulcents, for the mucilage with which they abound, the flowers also for their coloring matter, in coloring tinctures and other preparations. Their properties are thus of the simplest possible character and this brief mention is accorded them on historical, rather than on any practical grounds. Henry H. Rusby.

Manacá.—*Mercurio Vegetal.* The root of *Brunfelsia Hopeana* Benth. (fam. *Solanaceæ*).

It contains resin, gum, tannin, and probably an alkaloid, in small amount.

Manacá is a well-accredited drug throughout Brazil in the treatment of syphilis, but this repute is apparently due, for the most part, to erroneous diagnosis. It is also credited with antirheumatic properties. There is a small steady sale for it and its preparations in the United States. Certainly when given in large quantity it has very active properties, being purgative, diaphoretic, and narcotic. Its continued use by those who have had experience with it at least justify a credence in some alterative virtues. The dose is gr. viij. to xxx. (0.5–2.0). Henry H. Rusby.

Manaceæ.—See *Irondale Springs.*

Manganese.—I. General Medicinal Properties of Compounds of Manganese.—In their medicinal relations the compounds of manganese may be divided into two distinct groups, the one in which the metal is the basic radical of the compound, the other in which, on the contrary, it is the acid radical. The compounds of the former group, after absorption, probably affect nutrition after the general manner of the heavy metals, tending in small dosage to improve blood quality and quicken general assimilation, and, in large, to derange the nutritive processes, leading to emaciation and nerve poisoning. Locally, the effects differ with the individual compounds according to their solubility. Therapeutically, the constitutional influence of manganese has been sought as an adjuvant to that of iron, largely upon theoretical grounds, because of the alleged presence of manganese, in small quantity, in association with iron in the composition of hemoglobin. Doubtless the influence in cachectic states is good so far as it goes, but doubtless also it is, in degree, insignificant as compared with that of iron, with which medicine manganese is, for the present purpose, almost invariably prescribed. Physicians generally have, therefore, failed to see the necessity for combining a salt of manganese with their chalybeates. Locally, the therapeutics of the compounds of manganese are individual to the compounds, and will be detailed below.

The second division of the manganese compounds, where the metal occurs in the acid radical, is represented in medicine by but a single salt, namely, *potassium permanganate*, whose virtues inhere mainly in the property of permanganates to act as oxidizing agents, as will be set forth further on.

II. The Preparations of Manganese used in Medicine.—These are, of manganese as basic radical, *manganese dioxide*, *manganese hypophosphite* and *manganese sulphate*, and of the metal as an acid radical, *potassium permanganate*.

Manganese Dioxide: MnO_2. This compound, commonly known as *black oxide of manganese*, is a native mineral, and of a quality representing at least sixty-six per cent. of the pure oxide, is official in the United States Pharmacopœia under the title *Mangani Dioxidum Præcipitatum*, Precipitated Manganese Dioxide. The mineral differs a great deal in appearance according to the source from which it is derived. It occurs sometimes in metallic-looking lumps, sometimes in fine shining crystals—the form in which it is purest—but yet is most commonly found in the condition of powder. This powder is heavy, grayish-black in color, more or less gritty and without odor or taste. It is insoluble in either water or alcohol. At a red heat it gives off oxygen gas. Manganese dioxide, as usual with the insoluble metallic oxides, is locally bland, and in the stomach tends to allay irritability of that organ. Continuously given, it is capable of absorption, with constitutional effects of manganese. Medicinally, the oxide has been applied in skin disease, in ointment (twenty-five per cent. strength), and has been given internally in gastric irritation; but its grittiness makes it an unpleasant medicine to take in form of powder. The average dose is gr. x. (0.65) three times a day. Much more important than any medicinal application is the use of the dioxide in the laboratory, in the preparation of oxygen gas, chlorine, and also of iodine, when the latter is obtained from kelp.

Manganese Hypophosphite: $Mn(PH_2O_2)_2+H_2O$. This is official in the United States Pharmacopœia as *Mangani Hypophosphis*, Manganese Hypophosphite. It occurs as "a pink, crystalline powder, odorless, and nearly tasteless. It is soluble in 6.6 parts of water at 25° C. (77° F.), and in 6 parts of boiling water; almost insoluble in alcohol" (U. S. P.). It is said to be a "nerve stimulant." The pharmacopœial dose is 3 grains (0.2 gm).

Manganese Sulphate: $MnSO_4+4H_2O$. The salt is official in the United States Pharmacopœia as *Mangani Sulphas*, Manganese Sulphate. This salt occurs in colorless or pale rose-colored transparent prismatic crystals, which may contain variable proportions of water of crystallization according to the temperature of the mother solution. The Pharmacopœia recognizes crystals containing four molecules of water of crystallization. The salt dissolves in less than one part of water, cold or boiling, but is insoluble in alcohol. It effloresces slightly in dry air and should be kept in well-stoppered bottles. Manganese sulphate is sharply irritant and specifically purgative, and has the reputation of being also specifically cholagogue. This latter reputation is based largely on an old assertion of C. G. Gmelin, that in experimenting with animals with the salt, a considerable outpouring of bile was determined. Rutherford's later and careful experiments, however, failed to produce a like effect. In large dose, manganese sulphate is an irritant poison. Medicinally, the purgative and alleged cholagogue action have been utilized by some prescribers, but since the salt is harsh in action and disagreeable to the taste, its use as a medicine has not found much favor. The pharmacopœial dose is 4 grains (0.250 gm.).

Potassium Permanganate: $KMnO_4$. The salt is official in the Unites States Pharmacopœia as *Potassii Permanganas*, Potassium Permanganate. It occurs in deep purple-violet, or nearly black, needle-shaped, rhombic prisms, of a metallic luster, without odor, but with a sweet, afterward disagreeable, astringent taste. It is permanent in the air; dissolves in fifteen parts of cold and in three parts of boiling water, and is decomposed by alcohol. Weak solutions of potassium permanganate are of a delicate rose color, which should be free from tinge of green. Strong solutions are of deep purple, and have the troublesome property of staining, not only fabrics, but the skin; and even porcelain-ware will be colored a rusty purple under sufficient contact. Potassium permanganate in strong application is irritant and even caustic, but its medicinal application hinges mainly on its peculiarity of being a powerful oxidizing agent, because of the ready disengagement, in presence of oxidizable matters, of a portion of the oxygen of the permanganic acid. By virtue of this property the salt promptly destroys fetor and fetid materials as such, and is one of the most efficient agents known for such purpose. Its disadvantages are its comparative costliness and proneness to stain. Because of its oxidizing tendency, it is necessary to keep the compound in well-stoppered bottles, and to avoid admixture with it of organic or other easily oxidizable matters. Trituration of the crystals with inflammable substances may even determine explosions. Potassium permanganate is a valuable detergent for foul surfaces, as of sloughing wounds, ulcerated cancers, etc., and is applied in aqueous solution ranging from one-fifth per cent. to four per cent. in strength. The weaker solutions are used where a mere deodorizing is sought, the stronger where a vital action also is desired, as in the case of gangrenous ulceration. To sweeten foul drinking-water a solution of the salt may be added to the water gradually, so long as the color is discharged on stirring, a circumstance that will continue as long as any organic matter remains unoxidized. So soon as the coloration persists, even in faintest shade, further addition is to be discontinued. The small percentage of permanganate then remaining in excess will neither be perceived in taste, nor will it do any harm. Solutions of the permanganate is an excellent disinfectant by which to cleanse and sweeten water-closet traps, etc. For this purpose the impure salt, which is much cheaper than the pure, may be used. A dram or so of the impure crystals may be dropped into the water of a water-closet trap and allowed to remain for a few minutes, when the trap should be flushed. Care

should be taken not to leave a strong solution in contact with marble or porcelain for any length of time, lest staining occur. Potassium permanganate has been used internally as an emmenagogue, in doses of a grain, increased to two grains, three or four times a day; also in cases of menorrhagia and metrorrhagia, as well as of amenorrhea. The medicine is best borne in pill form, but even when so taken occasionally produces a great deal of gastric distress. Because of the powerful oxidizing property of the permanganate, care must be taken in the selection of excipients for making the medicine into pills. The following has been recommended as an excipient: "Vaseline, two parts; paraffin-wax, one part; melt, stir till cold, and add kaolin, three parts; mix well." The pills, after being made, are to be dusted with kaolin.

The permanganate decomposes alkaloids, by oxidation, and has been recommended, accordingly, for internal giving in cases of alkaloidal poisoning, particularly in poisoning by morphine, in order to destroy such of the poison as may still be present in the stomach. Similarly it has been recommended to inject a solution of the permanganate into the tissues of a part bitten by a venomous snake, if the application can be made soon after the infliction of the bite.

EDWARD CURTIS.
R. J. E. SCOTT.

Mania.—The term mania (Greek *μανία*, from *μαίνεσθαι*, to rage) has been used rather loosely; in popular speech indicating in a normal person, "an ardent or uncontrollable desire," "a craze for something," while in a pathological sense morbid tendencies strong enough to contain the element of impulsion have been called "manias," a suitable prefix indicating the nature of the act toward which the subject is impelled, as "kleptomania," a morbid impulsion to steal, "pyromania," an impulse to set fire to buildings, etc. In its usual psychiatric application, however, mania indicates specially a morbid state characterized by exaltation and excitement. In this last sense alone it will be considered here.

Since a form of mental disturbance expressed in lack of self-control, excitement, and violence, would naturally attract the attention of even the most unobservant, mania was undoubtedly the earliest psychosis to be recognized. While mania, melancholia, and dementia were for a long time the only forms of insanity described and the two former were considered the direct antitheses of one another, more careful observation has shown that there are comparatively few cases of excitement in which at least a fleeting phase of depression is not present at some time during the course of the disease and *vice versa*, hence the tendency of recent years, to which the influence of Kraepelin has chiefly contributed, has been to class these two conditions together as different phases of one and the same disease, under the name of "manic-depressive or psychosis," which will find more extended consideration later.

It is true that some authors decline to accept this classification and continue to describe mania as a separate disease, while admitting that maniacal symptoms may be present as an episode in other forms of insanity. While not denying that there are cases which present purely the traits of mania, it seems best for practical purposes, to consider it here as a symptom-complex, referring to the article on *Psychoses, Manic-depressive* for a fuller discussion of the subject.

SYMPTOMS.—In the majority of cases mania begins in early adult life. Its onset may be sudden, but more usually it is preceded by a period of longer or shorter duration, during which the patient complains of depression, mental slowness, and inhibition, with headache or unpleasant feelings about the head, sleeplessness and paresthesias of various sorts. From this the condition passes gradually or suddenly into one of excitement and there are developed the symptoms of mania which, according to Ziehen, may be comprised under the two heads of (1) exaltation of mood, and (2) increase in the rapidity of cortical associations. Both the psychomotor excitement and the flight of ideas which are often included among the cardinal symptoms of mania, he considers due to this increased ease of association, while as to the relation of these symptoms to the feeling of exaltation, whether they are independent of one another or are connected as cause and effect cannot be definitely stated, although this author considers them as primary and coordinated.

The severity of these symptoms and the relative extent to which each is developed may vary greatly and several grades of mania are recognized. The usual division is into (1) simple maniacal exaltation (hypomania), (2) acute mania, and (3) hyperacute mania (acute delirious mania, acute delirium or typhomania).

In the first there may be only an increased excitability and egotism, constant talking, prolific letter writing and fussy activity, which may not impress an ordinary observer as abnormal and might readily be estimated as an exaggeration of the natural traits of the individual. The patient is entirely oriented, may keep within the bounds of propriety and is only disturbing to his surrounders as an officious, conceited, and somewhat quarrelsome individual. He may still think logically, but the tendency to flight of ideas and the restless activity, to the trained observer makes plain the mental abnormality. Again, the euphoria and increased feeling of self may be shown by fantastic changes in dress or demeanor, particularly in women, while increased sexual feeling may occur in either sex and may be manifested in looseness in conduct or merely by indelicacy in conversation. In men there is apt to be increased indulgence in alcohol.

In acute mania, the above mentioned symptoms are greatly exaggerated. While exaltation dominates the picture, there is great lability of mood, sudden changes from laughter to tears being not infrequent. On account of the increased rapidity of association the patient experiences a feeling of well-being and mental power as never before and may even impress outsiders as being specially bright and witty. If, however, his mental processes are scrutinized more closely, it will be found that his ideas are shallow and superficial and that on account of the extreme distractibility he never carries anything to an end. His feeling of self-importance is greatly increased and he is full of ambitious projects, but on account of the rapid flight of ideas, before he can make a move to carry one out, it is chased from his head by another. In severe cases the flight of ideas is so rapid that the patient (as he may tell you afterward) cannot speak fast enough to express all that comes into his mind, so that there may appear to be a certain amount of confusion.

At the height of the attack the patient talks incessantly, sings, shouts, or roars day and night. He is in constant motion, getting up and sitting down, gesticulating, walking, dancing, jumping, running up and down if permitted, and while he rests not at all, he shows no fatigue and keeps up his noise until he gets too hoarse to be heard any longer. He is irritable and brooks no contradiction, but reacts by violence against any one who opposes him or may happen to displease him in any way, hence is dangerous, though since his mood is in the main a happy one and his distractibility great, his violence is not lasting.

At the height of the disease there may be hallucinations, illusions, and delusions, but the illusions are mainly due to imperfect observation and distractibility and the delusions are seldom permanent or systematized accurately, though the patient may hold for

some time to the idea that he is a great personage or has some extraordinary power. The moderately excited maniac, however, may show neither false perceptions nor delusional ideas and these are not an essential feature in mania.

Since the processes of association in the maniac are increasedly rapid, they are usually imperfect and there is often a tendency to association of words of similar sound, but having no other connection, to rhyming and to alliteration.

In acute delirious mania, the flight of ideas is so rapid that there is almost complete incoherence, the excitement and motor activity are intense, the patient's face is congested and swollen, the veins on his forehead bulge, and he presents the picture of wild frenzy. His extreme violence is bound to lead to (at least superficial) injuries, which as the patient will not keep them properly dressed are apt to become infected, so that the case may become complicated with sepsis. Emaciation and exhaustion are rapid and extreme, the patient falls into a typhoid state and may die. It is a question as to what extent acute delirious mania is to be considered an excessively severe form of mania. Some cases presenting this clinical picture are undoubtedly instances of galloping general paresis, others again depend upon pneumonia, nephritis, or some other condition producing a toxemia which it is difficult to diagnose under the circumstances, autopsies often disclosing such conditions. (See also *Delirium.*)

Mania may also be subacute or chronic, though our application of the term "Chronic Mania" has been much restricted of recent years. Cases beginning acutely, may run their course in from three to six months or, on the other hand, may last for one or two years and still recover; indeed there are observations of recoveries even after a number of years.

While a certain number of cases terminate in dementia, this outcome should in general make us reconsider our diagnosis, as mania is not essentially a dementing psychosis. The tendency to recurrent attacks is however very great. (See further the article *Psychoses, Manic-depressive.*)

As already indicated, there may be episodes of excitement in other forms of insanity, the differentiation of which from mania is important on account of the very different prognosis. In the first place we should be very cautious about diagnosing mania in a psychosis occurring for the first time after thirty years of age.

Diagnosis.—Liable to be mistaken for mania are general paresis, dementia precox, amentia, delirium from various causes, paranoia, epilepsy, and senile dementia. *General paresis* begins as a rule between thirty and fifty years of age, in its exalted form there may be a stage of excitement, with agitation, restlessness, and flight of ideas, also the grand delusions of the paretic may be not unlike those of mania, although they are, as a rule, more senseless and improbable and cannot be sustained by any reasoning as in mania, while the signs of mental weakness, failure of memory, judgment, etc., are continually more apparent. Besides some of the somatic signs of general paresis, such as the failure of the pupils to contract for light, stumbling speech, tremor, incoordination, exaggeration or loss of knee-jerk are present, and if an epileptiform or apoplectiform seizure occurs, the nature of the disease is made clear. Also a positive Wassermann reaction from the blood or spinal fluid and increased globulin reaction and an increased number of lymphocytes in the latter should remove the last doubt.

Dementia precox in its hebephrenic and catatonic forms may show a stage of excitement, but the affect is superficial, there is a foolishness and childishness of demeanor lacking in mania, there is rather planless unrest than definite psychomotor excitement, there are apt to be mannerisms, negativism, stereotypy, and verbigeration, a tendency to form new words and to perpetrate senseless witticisms, while the mental weakness becomes continually plainer. Also periods of excitement may alternate with stupor and mutism, and in catatonia with cataleptoid phenomena.

In *amentia* there is great confusion and disorientation with numerous hallucinations and illusions upon which the labile affective condition and the excitement depend, while the physical signs of exhaustion and the history of recent disease or great stress is seldom missed. In the deliria also there is along with the excitement great confusion and some etiological factor can usually be unearthed.

Paranoia in its full development is usually a disease of the mature individual. On account of the delusional ideas there may result secondarily states of excitement, but the delusional system dominates the picture, there is seldom the marked flight of ideas met with in mania, and its development is usually slow, extending over years.

Epileptics are subject to states of excitement in which there may be great exaltation with motor excitement often with causeless violence, but flight of ideas is usually less marked than in mania and there are apt to be numerous hallucinations often of an ecstatic or on the other hand of a terrifying character (visions of angels, hearing heavenly music, the voice of God, crowds rushing to attack them, blood, flames, etc.) and disorientation is usually great. The history of convulsions or temporary disturbances of consciousness can usually be obtained.

In *senile dementia* there are frequent phases of excitement, but the plain signs of mental weakness with memory defects, etc., along with the somatic symptoms of senility should make the diagnosis clear, though in patients who have previously had attacks of mania the proper estimation of the case may present some difficulty. The outlook as to recovery from the individual attack of mania is very good, according to Ziehen ninety per cent. of the cases recovering, while five per cent. die and four per cent. pass into dementia.

Treatment.—In the treatment of mania the prime indications are to remove as far as possible all external sources of irritation, to combat the often enormous waste by supplying the patient with an abundance of readily assimilable food, to conserve his strength as much as possible, to procure for him a reasonable amount of sleep, and to see that he does not injure himself and others. Nowhere can these indications be so well met as in a properly equipped institution for the insane and the attempt to manage a maniac at home or in a general hospital will usually prove unsatisfactory in any but the mildest case. During the acute stage, the treatment is greatly facilitated by keeping the patient in bed and surrounding him with the atmosphere of the sick room. The question of restraint is still unsettled, but it can be safely said that it should be restricted just as much as possible and since the great sedative effect of the prolonged warm bath has become generally known, it has been found possible to discard both this and the use of sedative drugs to an extent not formerly deemed possible. In the absence of facilities for applying this measure, the warm pack may be used but this has been found much more depressing and should be applied only with caution in debilitated individuals. Of the various hypnotics medinal, luminal, veronal, or trional may be used, while for the calming of psychomotor excitement no drug is so powerful as hyoscine—best given hypodermically as the hydrobromide, in doses of $\frac{1}{200}$ to $\frac{1}{100}$ grain—though its use should be restricted to strong patients without heart or kidney disease, and even in them it should be exhibited with caution, as in some persons it increases the

excitement. The nutrition of the patient is probably the most important single indication, as the constant activity causes enormous tissue waste, so that milk and eggs, strong broths, etc., should be furnished in adequate quantity, by tube feeding if the patient cannot be gotten to swallow them. Most excited patients are best isolated with an attendant, as the noise of the ward serves as an irritant though others again can be managed in the observation ward among the other bed patients. They should in any event be constantly watched while the excitement keeps up. As the patient quiets down he may be gradually allowed up more and more, and as soon as his condition seems to justify it, can be taken into the yard. His convalescence will be favored by fresh air and suitable tonics—as iron, quinine strychnine, arsenic, etc. On no account should he be discharged until he has complete realization of his condition and has regained his self-control.

CHARLES LEWIS ALLEN.

Manic-depressive Insanity.—See *Psychoses, Manic-depressive.*

Manila.—See *Philippine Islands.*

Manitou Springs.—El Paso County, Colorado.

POST-OFFICE.—Manitou Springs. Hotels: Cliff House, Grand View Hotel, Mansions, and numerous boarding-houses.

ACCESS.—Via Denver and Rio Grande Railroad and Colorado Midland Railroad.

Manitou (the Indian name for "Great Spirit") is situated six miles west of Colorado Springs, immediately at the foot of Pike's Peak. Here are located the celebrated effervescent soda and iron springs which in early days gave the name of springs to the town of Colorado Springs. An electric railroad, with cars at frequent intervals, unites the two places. The town of Manitou Springs contains a permanent population of more than 2,000 souls, which number is augmented during the summer months by about 125,000 visitors from all parts of the United States and from foreign countries. Dame Nature was in a fanciful mood when she fashioned the topography of this wild and rugged region. Few similar areas of the earth's surface present a greater number and variety of weird, grotesque, and romantic features than are to be found in the vicinity of Manitou Springs. The scope of this work allows us to enumerate only a few of the more prominent points of interest within a few miles of the place. Iron Springs, one mile; Rainbow Falls and Grand Caverns, one mile and a quarter; Crystal Park, three miles; Garden of the Gods, three miles; Glen Eyrie, five miles; Monument Park, by rail seven and one-half miles, North Cheyenne Canyon, eight and one-half miles; South Cheyenne Canyon, nine miles; Summit of Pike's Peak (via cable road), twelve miles. In addition to these well-known localities there are scores of canyons, caves, waterfalls, and charming nooks which the sojourner may seek out for himself. The railroad journey to the top of Pike's Peak is one never to be forgotten. The view from the immense height of 14,147 feet is almost appalling in its scope and grandeur. A post-office for the benefit of tourists is maintained at the apex of the Peak by the national Government during the summer season. It has been well described as the loftiest post-office in the United States. The meteorological conditions at Manitou and Colorado Springs are very favorable to invalids, the climate being dry and the temperature even and not subject to sudden changes. The winter months are mild and pleasant—so mild, indeed, that excursions are almost daily made to the neighboring canyons and glens, where outdoor picnics are held with as much safety to health as in the summer.

Within the town limits are fourteen cold springs, which are divided into two groups: (1) the Soda Springs which resemble in taste and properties the well-known Apollinaris water; and (2) the Iron Springs. These springs are controlled by the Manitou Mineral Water Company, and, in addition to the immense local consumption by visitors, the waters are bottled and sold to dealers throughout the United States. The Manitou ginger-ale and Manitou soda-water also have an extensive sale, and an inspection of the immense bottling establishment of the company is one of the features of a visit to the resort. The following analyses of five of the springs at Manitou show the mineral ingredients of these waters:

GRAINS PER PINT.

	Shoshone.	Iron.	Navajo.	Manitou.	Mansions.
Sodium carbonate	1½	4½	8½	3½	7⅝
Lithium carbonate	Trace	Trace	1/30	1/17	1/10
Calcium carbonate	7⅗	4⅓	9 1/17	7¼	1 1/7
Magnesium carbonate	.....	1 1/10	2⅓	1⅓	3⅓
Iron carbonate	.....	⅓	Trace	.....	¼
Potassium sulphate	⅓	⅗	1 1/7	1	2¼
Sodium sulphate	1⅗	2½	1¼	5⅗	1/8
Sodium chloride	3	2½	2¾	2⅓	2½
Silica	Trace	⅕	1/15	1/7	⅛

The waters of the two Manitou springs that have been examined for radioactivity have been found to possess this feature in marked degree.

The waters of these springs are especially recommended in dyspepsia. A glass of this water will almost instantly give relief in pyrosis, acid eructations, or flatulence, and its habitual use prevents the recurrence of these disagreeable symptoms. They are further of decided benefit in renal and bladder disorders. The waters of the Soda Springs, being clear, sparkling, and very palatable, form an excellent table beverage. The iron waters are highly beneficial in debility, in early phthisis, and in anemia and chlorosis. The visitor will find all the arrangements for his comfort and well-being equal to any that may be found at a first-class Eastern resort. EMMA E. WALKER.

Manna.—"The concrete, saccharine exudation of *Fraxinus Ornus* L. (fam. *Oleaceæ*)" (U. S. P.). Numerous other varieties of manna than this, the official one, are known, and some of them will be noticed at the close of this article.

This, the manna-ash of Italy, Sicily, Asia Minor, etc., is a small, graceful tree, with smooth gray bark, slender branches, odd pinnate leaves, and the characteristic inflorescence and fruit of the genus. It grows to about twenty feet in height, and is often cultivated, both in and beyond its natural habitat, for ornament, but does not yield manna excepting in southern climates. In Sicily, whence most of the manna of the present time comes, the trees are regularly cultivated for this purpose, being planted in rows in "orchards," and allowed to grow unmolested until the stems are nearly as large as the leg. Then the tapping is begun, and repeated every summer for a dozen or more years, until the tree is exhausted. The usual method is to make a transverse cut through the bark near the base of the trunk, and to follow it each day with another, about an inch higher up than the last, during favorable weather. It is done in the middle of the summer, and hot, dry days are essential to success. The sap exudes from these cuts—a thick, syrupy, very clear, and sweet liquid—and soon concretes on the bark of the trunk, or on leaves, sticks, straws, etc., laid for it. These lumps are either cut or "flaked" off, great care being taken not to get any of the bark, and in this state they constitute the highly

prized "flake manna," which is graded in sizes. The exuding tears often drop to the ground, and sometimes form large masses at the base of the trunk. This, with the scrapings from the trunks, is assorted into inferior grades, "small flake," "sorts," "cake manna," etc., some of which are very impure.

Description.—Manna suitable for medicinal use is thus described in the Pharmacopœia: "In flattish, somewhat three-edged pieces, occasionally eight inches (twenty centimeters) long, and two inches (five centimeters) broad, usually smaller; friable; externally yellowish white, internally white, porous, and crystalline; or in fragments of different sizes, brownish white, and somewhat glutinous on the surface, internally white and crystalline; odor, honey-like; taste sweet, slightly bitter, and faintly acrid. On heating five parts of manna with one hundred parts of alcohol to boiling, and filtering, the filtrate should rapidly deposit separate crystals of mannit. Manna consisting of brownish, viscid masses containing few or no fragments of a crystalline structure should be rejected." There is much opportunity for economy in purchasing a good grade of manna, without selecting the very high-priced flakes, which are superior in appearance only.

Composition.—Fine qualities of this drug contain seventy or eighty per cent. of *mannit* ($C_6H_8[OH]^6$), a sweet, crystalline, sugar-like, peculiar substance, also found in other sweet saps. There are also traces of *fraxin*, a neutral bitter substance which is found in the bark of several other species of ash, and which injuriously affects the quality.

Action and Use.—The best (not bitter) specimens of manna contain nothing of importance besides this *mannit*. They are not poisonous or deleterious in any quantity, and exert on the human body simply a cathartic action. Manna has been for a long time a favorite laxative for infants and children, on account of its pleasant taste, but it is becoming scarcer and is used less and less frequently. Dose (adult), from ʒi. to ʒ iss. (30.0–15.0), which may be taken in substance or dissolved in water. The only official preparation is the compound Infusion of Senna (*Infusum Sennæ Compositum*, U. S. P.), made as follows: Senna, 6 parts; manna, 12 parts; sulphate of magnesium, 12 parts; fennel, bruised, 2 parts; boiling water, 80 parts; water. Macerate, strain, and add water enough to make 100 parts—a cathartic.

The name "manna" has been applied to a number of sweet exudations from trees and plants which grow in various parts of the world. *Fraxinus excelsior* L., the common European ash, like many others of the genus, yields a sweet sap, and is said to yield a little manna in Sicily. Alhagi manna, from a small leguminous plant of India, is in small, roundish, hard tears. Tamarisk manna, from Arabia and Persia, is also in small tears. "Shir Khist" is from a species of *Cotoneaster*, collected in India; oak manna, from several species of oak, and Briançon manna, from the larch. None of these has, however, in European markets, any importance as compared with the variety here described. Henry H. Rusby.

Mannose is a hexose, a monosaccharide carbohydrate which may be prepared by the oxidation of mannite. By hydrolysis of some of the naturally occurring carbohydrates, as salep slime and cellulose from the ivory nut, mannose may also be formed. Like dextrose it is dextrorotatory and also shows other characteristics very similar to those of dextrose. F. P. U.

Marasmus.—(*Synonyms:* Infantile atrophy, Athrepsia, Simple wasting.) Marasmus may be described as progressive wasting in infants without discoverable organic cause.

Symptoms.—The striking feature of the condition is failure to gain in weight or slow but progressive loss in weight. Meanwhile increase in length of the bony skeleton and the eruption of the teeth proceed at almost the normal rate; so that the resulting appearance is peculiar and characteristic. The body is thin and markedly emaciated, all the subcutaneous fat having disappeared except the sucking pads in the cheeks; so that the bones and muscles are plainly made out through the loosely hanging skin and the face takes on the appearance of an old man. The color is pale or yellowish gray; the eyes have an anxious expression, and the child is looking about in search for food and is putting its fingers into its mouth or grasping at anything near by to suck. There is a constant fretful cry which later becomes a whine. Very young infants may not even cry, but sleep most of the time, so that the family is lulled into a false sense of security. These infants are always hungry, and the hunger is not appeased for more than a few minutes after the taking of food. The stools may be large or small; in recent cases they may show evidences of indigestion, but in well-developed cases that are properly managed the stools are smooth and contain neither curds nor mucus. Their color depends upon the food being administered. Cases in which there is diarrhea are complicated by intestinal indigestion or inflammation. The fontanelle is depressed to a greater or lesser degree, the temples are sunken, the mouth and tongue are dry and in advanced cases glazed and covered by patches of thrush. The intercostal spaces are depressed so that it is impossible to use a stethoscope satisfactorily upon the front and sides of the chest. The skin becomes thin, loses its elasticity, and hangs in folds particularly on the abdomen and on the inner sides of the thighs. The abdomen may be either distended in cases where indigestion is present, or it may be flaccid and depressed as is usually the case with patients who are being carefully fed. There is enlargement of the liver discovered by palpation, but no enlargement of the spleen. Movements of the intestines, particularly the colon, are readily observed through the abdominal wall. The temperature is apt to be subnormal, 96° to 97° F. in the rectum being a common reading. The extremities are cold. The superficial lymph nodes on the abdomen, in the groins, in the axillæ, and in the neck are frequently somewhat enlarged.

On account of the extreme emaciation, there is a great tendency to the formation of bed-sores upon the sacrum, the crests of the ilium, and the back of the head, so that constant change of position is absolutely necessary, together with the greatest care of the skin in these situations. Petechiæ may develop, usually first upon the abdomen; they are not necessarily of bad prognostic significance, for I have seen recovery in even the severest cases.

There is a peculiar tendency of these infants to develop suddenly a general edema. This appears first in the feet, hands, and eyelids, and then extends to the genitals and the rest of the body. Frequently the first sign of such developing edema is a sudden gain in weight of three or four ounces in twenty-four hours; so that one is always suspicious that any gain of several ounces in twenty-four hours will prove to be spurious and due to this condition.

The weight of marantic infants is of course far below the normal for their age. We frequently see infants suffering from this condition whose weight at six months or later is less than their birth weight. I have frequently seen babies at six months weighing six pounds and not uncommonly those at one year with a weight of ten pounds. On account of the growth of the skeleton in length, these infants appear to weigh less than they actually do.

Physical examination of the chest sometimes reveals

a slight blowing cardiac murmur; at other times a loud congenital heart murmur is found. At the back of the chest between the scapulæ there are frequently heard, especially in advanced cases, fine crackling râles, which are due to hypostatic congestion, the result of the feeble circulation and of lying upon the back.

The emaciation continues until assimilation is re-established; but the baby will remain fretful and even hungry until the weight increases to within a couple of pounds of what is normal for the infant's age.

If no improvement takes place the baby dies either from exhaustion or from some intercurrent disease, particularly acute gastroenteric infection, bronchopneumonia, or sepsis from infection arising at the sites of decubitus ulcers.

In many cases there is a peculiar tendency to hold the head retracted in a condition of cervical opisthotonos, and there is also a tendency of the extremities to be held rigid in a condition of semiflexion, resulting in the presence of Kernig's sign and leading falsely to the diagnosis of tuberculous meningitis. This rigidity diminishes and disappears as the nutrition of the child improves and as the fontanelle resumes its normal level.

Diagnosis.—The condition must be distinguished from congenital syphilis, pyloric stenosis, tuberculosis, and acute inanition.

Pathology.—Very careful studies have been made of hundreds of cases of marasmus, but the findings do not satisfactorily explain the condition. The question always arises whether the postmortem conditions are the cause or the result of the prolonged wasting. The constant lesions found in the alimentary tract are a marked thinning of the intestinal mucous membrane with atrophy of the intestinal villi and tubules. The stomach is often dilated and its mucous membrane coated with tenacious mucus. In some cases there has been found hyperplasia of the epithelium and connective-tissue infiltrations of the mucous membrane of the intestines together with atrophy of the glandular substance. The solitary and agminated follicles are frequently somewhat swollen and pigmented, presenting the so-called "shaven-beard" appearance, and there may be some enlargement of the mesenteric lymph nodes. Bloch (*Jahrbuch f. Kinderheilkunde*, 1904, lix.) found that Paneth's cells in the ducts of Lieberkühn contain few or none of the granules which are regarded as indicating that the cells have normal functional power. The liver is often found much enlarged and fatty. The lesion under the microscope is shown to be a fatty infiltration. According to Holt, this lesion is not more frequent in marasmus than in infants dying from other diseases, so that too much must not be made of this finding. The brain is anemic. Thrombi are rare. The heart muscle is pale and thin; the kidneys may show parenchymatous degeneration, but are commonly normal. Hypostatic congestion of the lungs along the posterior strips is common.

Pathogenesis.—The essence of the condition seems to be a failure of absorption or assimilation or both combined. In numerous instances there is added an autointoxication by decomposition products absorbed from the intestine. The existence, however, of cases in which there is no discoverable evidence of indigestion, and in which a quantity of food sufficient or more than sufficient for the caloric needs of the infant is being taken and digested, proves that some interference with absorption and assimilation is present. Absorption depends, of course, upon the epithelium in the intestinal wall, and perhaps upon the intestinal juices, while assimilation depends upon chemical processes, most likely ferment action in the body cells. The atrophic condition of the intestinal wall, together with the fatty condition of the liver, has been thought by many to explain this failure of absorption and assimilation. It is not certain, however, that the atrophy of the intestinal wall may not be a result of the starvation rather than its cause.

Another theory is that the condition is the result of infection, and that it can be communicated from one child to another. In support of this are brought forth the cases in which marasmus develops in several infants in a hospital ward. Against this theory it is to be remarked, however, that such infants are prone to develop marasmus because of "hospitalism," and that the condition also develops in private practice where there are no other children to give the infection. Keller thinks the condition is frequently an acid autointoxication; undoubtedly this is true in some cases. Wentworth ascribes the condition to lack of the only food, *i.e.* breast milk, capable of adequately activating the digestive functions.

Perhaps the best explanation of the condition is that proposed by Edsall (*Journal of the American Medical Association*, May 4, 1907). His idea is that the defect is one in the ferment action of the intestinal wall and of the body cells. In the process of metabolism food stuffs are broken down into simpler products by ferment action, are absorbed, changed into the forms in which they circulate in the blood, and built up into human tissue also by ferment action. The catabolism and the anabolism are carried on, in many instances, by the same ferment, the action in the two cases being merely reversed. It is probable, according to Edsall, that, except with human milk as the food, the ferment action of catabolism is incomplete, and that the end products of protein digestion are not suitable for being built up into human protein. The infant can use the heterologous protein for obtaining energy, but cannot use it for building up its own body cells, since this requires homologous protein. Moreover, since the ferment that causes the final breaking down of foreign protein and the initial building up of the fragments into homologous protein is the same (the action in the latter instance being merely reversed), and since, moreover, this catabolic ferment is deficient in its power, necessarily the anabolism is likewise defective, and the baby fails to grow.

Etiology.—In considering the etiology it must first be noted that this condition occurs almost wholly in the first year of life and in the majority of the cases during the first six months. It is very rare among breast-fed infants and is commonest in artificially fed babies that have had an attack of gastroenteritis, particularly those that live in institutions or homes for infants. It is therefore met with most frequently during August and September. The condition does occur in private practice, but is rather rare.

Etiologically the cases can be divided into (*a*) those that are secondary to congenital syphilis, congenital heart disease, tuberculosis, and acute pulmonary inflammations; (*b*) those in which the malnutrition is a symptom and result of the existing gastroenteric inflammation or indigestion; and (*c*) those that give no evidence of any organic or functional abnormality save the failure of assimilation. It is only the last class of cases that this article considers. These cases in turn may be divided into those due to congenital debility or insufficiency of the assimilative function, such that not even breast milk, let alone cow's milk or other food, can be utilized; and those that arise after a period of gastroenteric indigestion or inflammation, generally the result of withdrawing breast milk or of inability to adapt the modified cow's milk to the digestive capacity of the baby. It is to be kept constantly in mind, however, that after this condition of marasmus is once established the infant may show absolutely no signs of any digestive disturbance, and the function of the stomach and bowels may be performed with apparent perfection, there being no vomiting or colic, no excess of gas, and the stools appearing perfectly normal. Moreover, in many cases the absorption of

the food seems satisfactory, the stools not being more copious than in normal infants taking the same quantity of food.

Some change in the food, particularly the substitution of breast milk, either wholly or in part, for the previous diet may tip the scale for the better with the result that the infant begins to gain in weight and progress, and the recovery is steady although sometimes slow. These cases where recovery occurs upon the addition of breast milk to the diet would support the theory of Edsall or that of Wentworth that the pathogenesis of the condition lies in the insufficiency of ferment action or inability to activate the digestion. Another class of cases will improve upon the addition of pancreatic ferments to the food, or upon the addition of malt diastase. These also would bear out these theories. Still another class of cases will not improve until alkalies are added. These cases bear out the contention of Keller, who considers the condition largely an acid autointoxication.

Treatment.—*Feeding.*—The consideration of the etiology of the condition as well as the results of practical experience make it evident that *prophylaxis* is best obtained by promoting so far as possible the breast-feeding of all infants, particularly those that are congenitally weak, and those that have suffered from severe gastrointestinal or other disorders. Next best is the careful adaptation of modified cow's milk to the digestive capacity of the infant, with particular caution against the use of all mixtures rich in fat, which so often result in acid autointoxication, and with caution also against overfeeding.

When the condition is once established, breast-feeding should be advised in all cases, and the breast milk should be adapted to the digestion of the infant either by the use of simple diluents (such as water, barley-water, or either with limewater added) given before the nursings, or by the use of some of the digestive ferments suspended in limewater or barley-water. Combinations of the ferments seem to give the best results. In the great majority of cases, breast-feeding will result in a speedy improvement of the baby. It is often necessary, in order to secure the best results, that the wet-nurse's baby should continue to nurse its mother so that the breasts may have a sufficiently strong nursing stimulus to keep up the activity of the glands. If it is impossible to get a wet-nurse, it is at times possible, nevertheless, to obtain breast milk for some of the feedings, or to have the baby nursed once or twice each day. On account of the ferments in the breast milk and on account of the ease with which the breast-milk proteids can be digested and built up into human tissue, even a little breast milk is of great value. According to Wentworth, the breast milk increases the amount of hydrochloric acid and of secretin, and these in turn activate the pancreas.

When it is impossible to obtain any breast milk, one must continue with artificial feeding. According to the most improved methods of milk modification, the milk should be fresh, clean, and raw. Inasmuch as these babies do not digest fat satisfactorily, a mixture having a low percentage of fat should be used. Top-milk mixtures and mixtures of cream and milk are therefore not so satisfactory as mixtures made from whole milk or even from skimmed milk. The resulting formula should have the percentage of fat not higher than that of the proteid. For instance, a healthy baby of three months would probably be taking six or seven feedings daily of 3½ to 4 ounces of modified milk, whose composition would average 3 per cent fat, 6 to 7 per cent. sugar, and 1.5 per cent. protein. The marantic baby of the same age weighing seven or eight pounds would probably do better upon eight feedings of 3 to 3½ ounces each, of a formula: 0.5 to 1 per cent. fat, 6 per cent. sugar, and 1 to 1.5 per cent. protein. It is often advisable to peptonize this food, and if the baby is over three months old to use barley-water as a diluent instead of plain water. Frequently it is wise to use whey and milk in making the mixtures in order to increase the quantity of soluble proteid therein; for instance, in making up a quart of modified milk, instead of using 8 ounces of mixed milk, it would be wiser to use 4 ounces of mixed milk and 12 ounces of whey, together with the required amount of milk sugar and water or barley-water. In this way the percentage of the easily digested lactalbumin is increased. At times it may be necessary, for a short period, to use whey alone or even peptonized whey. The whey should not be continued for a long time, however, because it lacks the nucleoprotein contained in the casein of the milk. If the baby is not satisfied with the food, first the quantity and then the strength of the food may be increased, care being taken to make any change gradually. The whey can gradually be replaced by milk, and in cool weather, for the sake of its higher caloric value, by top milk of increasing fat percentage. This can be substituted an ounce at a time for the mixed milk or for the skimmed milk.

If the peptonized modified milk does not result in a relief of symptoms and gain in weight, it is of advantage in cases where there is neither vomiting nor diarrhea to make use of Keller's malt-soup mixture. This is a modification of cow's milk made up with wheat-flour gruel and a specially prepared alkaline malt extract. Keller's directions are to take three ounces of specially prepared malt extract containing potassium carbonate (made by Loeflund and known as Loeflund's malt-soup extract) and to dissolve this in one pint of water. Two ounces of wheat flour are suspended in a pint of milk, thoroughly stirred and drained through cheese cloth. The malt-extract solution and the milk containing the flour are then mixed in a vessel and set over the fire for about one-half hour, being stirred constantly. When the mixture begins to boil, the food is removed and put into the feeding bottles. The mixture contains dextrinized cereal and maltose in addition to the milk which has been sterilized.

The writer has had personal experience with this form of feeding in his hospital and private cases for several years, and has found it oftentimes of the greatest value. Usually, however, at the outset the milk and flour should be employed in about one-half the quantities mentioned, otherwise some indigestion, shown either by loose stools or by vomiting, may result. As the infant becomes accustomed to the new food, the quantity of the flour and of the milk can be safely increased.

General Hygiene.—These infants require intelligent care; they must be kept warm, but must not be coddled in close rooms. Plenty of fresh air, day and night, is absolutely essential, so that the infants must be kept out of doors or on a balcony as much as possible. The skin must be kept clean by a daily bath, after which an inunction of equal parts of olive oil, cod-liver oil, and lanolin should be made. In winter it is often necessary to wrap the extremities in cotton, as one would swathe a premature infant; hot-water bottles should be kept at the feet and mittens on the hands to prevent the extremities becoming chilled.

Special Treatment.—As an aid to the dietetic treatment it is sometimes advantageous to administer minim doses of dilute hydrochloric acid after the feedings. If stimulation is needed, heat to the extremities, nux vomica by mouth, and hot saline irrigations of the colon are most efficacious. The colon irrigations may be given every day or two, as they seem to retard the loss in weight. If edema develops, all salt should be withdrawn from the food and saline irrigations discontinued. An increase in the proteid content of the food should be made and any irrigations used should be of plain warm water. The edema seems to depend in some cases upon salt being retained in the tissues, in others upon lack of proteid in the food.

Frequent change of position and attention to the

diapers are necessary to prevent the development of bed-sores, as well as to prevent hypostatic pneumonia. If bed-sores develop they must be treated on surgical principles. Thrush is best combated by painting the mouth every second day with one-per-cent. formaldehyde solution, and by using a solution of bicarbonate of sodium or of borax subsequently as a mouth wash.

Careful study of the digestive peculiarities of the infant, together with the careful application of our present knowledge of the pathogenesis of this condition, will result in the saving of many cases formerly considered hopeless. LINNÆUS E. LA FÉTRA.

Marat, Jean Paul.—Born at Boudry, near Neuchatel, Switzerland, on May 24, 1743. After studying medicine, first in Bordeaux, and then in Paris and Holland, he began the practice of his profession in London, England. In 1775, upon the recommendation of certain Edinburgh physicians, he was given the degree of Doctor of Medicine by the University of St. Andrews. In the same year he published in London a brief "Essay on Gleets" and another which bore the title "Enquiry into the Nature, Cause, and Cure of a Singular Disease of the Eyes," with a dedication to the Royal Society. By this time he had acquired considerable reputation as a clever physician, and he seemed to be deeply interested in his professional work. In June, 1777, the Comte d' Artois, afterward Charles X. of France, made him by brevet physician to his guards, with 2,000 livres a year and allowances. Then, during the next ten or eleven years, he devoted a large part of his time to scientific work, especially the study of heat, light, and electricity, on which subjects he presented memoirs to the Académie des Sciences. The academicians, however, were horrified at his temerity in differing from Newton, and were not willing to accept him as a member of their association. Benjamin Franklin, on the other hand, took a great interest in Marat's experiments, and made frequent visits to his laboratory. Goethe, to whom these researches appealed strongly, always regarded his rejection by the Academy as a glaring instance of scientific despotism. In 1787 he published a new translation of Newton's Optics, and in 1788 his "Mémoires académiques, ou nouvelles découvertes sur la lumière."

At this stage of his career Marat seemed to abandon all interest in scientific questions, and, instead of pursuing such researches, he plunged deeply into the politics of the French Revolution. We cannot follow him through this part of his eventful life. His tragic end, which came in 1793, is thus described by the writer of Marat's biography in the Encyclopædia Britannica: "The Girondins conquered at first in the Convention, and ordered that Marat should be tried before the Revolutionary Tribunal. But their victory ruined them, for on the twenty-fourth of April Marat was acquitted, and returned to the Convention with the people at his back. The fall of the Girondins on the thirty-first of May was a triumph for Marat. But it was his last. The skin disease he had contracted in the subterranean haunts was rapidly closing his life; he could ease his pain only by sitting in a warm bath, where he wrote his journal, and accused the Girondins, who were trying to raise France against Paris. Sitting thus on the thirteenth of July he heard in the evening a young woman begging to be admitted to see him; saying that she brought news from Caen, where the escaped Girondins were trying to rouse Normandy. He ordered her to be admitted, asked her the names of the deputies then at Caen, and, after writing their names, said, 'They shall be soon guillotined,' when the young girl, whose name was Charlotte Corday, stabbed him to the heart." A. H. B.

Mardela Springs.—Wicomico County, Maryland.

POST-OFFICE.—Mardela Springs.

This resort is located on the Baltimore, Chesapeake and Atlantic Railroad, twelve miles west of Saulsbury. Under the name of Barren Creek Springs they have been used for medicinal purposes for many years. There is much charming scenery in the neighborhood, and the atmospheric conditions during the summer months are of a very desirable character. The location is about two hundred feet above the sea-level. The following analysis was made by Prof. P. B. Wilson, of the Baltimore University School of Medicine:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Silica	1.28
Arsenious acid	Strong trace
Ferric oxide (iron sesquioxide)	11.50
Alumina	0.34
Sodium chloride	0.78
Calcium carbonate	1.35
Magnesium carbonate	0.04
Calcium sulphate	0.01
Sodium carbonate	Trace
Total	15.30

The water is a strong chalybeate. It is a very efficient tonic and diuretic, and contains sufficient arsenic to give it valuable alterative properties. It promotes the appetite, aids the digestion, and increases the general powers of nutrition. It is highly recommended by physicians of Baltimore in cases of weakness and irritability of the bladder, anemia, and chlorosis, dyspepsia, chronic cystitis, and urethritis, and in amenorrhea, leucorrhea, and other functional disorders of the female pelvic organs when due to debility. The water is found in the Baltimore markets. EMMA E. WALKER.

Mareschal, Georges.—One of the great surgeons of France during the latter part of the seventeenth and early part of the eighteenth century. He was born at Calais in 1658. He began his medical studies at Paris at an unusually early age, and manifested great zeal in the performance of his duties as an interne at La Charité hospital. He received the title of Master in Surgery in 1688, and was almost immediately appointed the successor of Morel, whose poor health had compelled him to resign the position of Surgeon-in-Chief of La Charité. The skill and excellent judgment which he displayed in this very responsible position soon gave him an honored place among the great surgeons of that epoch. In 1703 the king, Louis XIV., appointed him his first physician. Three years later he was given a patent of nobility, and, upon the death of the king, Louis XV. reappointed him to the office of first physician. He died December 13, 1736.

Posterity, says Dezeimeris, is greatly indebted to Mareschal and Lapeyronie for their valuable services in placing surgery upon a firmer and more honorable basis. Although Mareschal was a surgeon of great merit and famous for his skill as an operator, he made no contributions to medical literature. A. H. B.

Marey, Etienne Jules.—Born at Beaume, Côte-d'Or, France, March 5, 1830. He studied medicine at Paris, and received his doctor's degree in 1859; his graduating thesis bearing the title: "Recherches sur la circulation du sang à l'état physiologique et dans les maladies." Soon afterward he began giving instruction in experimental physiology, and as early as in 1862 he delivered public lectures on the circulation of the blood and on the diagnosis of diseases of the heart and blood-vessels in the Ecole Pratique. In 1864 he established a laboratory for physiological

researches. In 1867 he was appointed Professor of Natural History in the Collège de France, to take the place of Flourens, recently deceased. It was while holding this position that he made a number of discoveries in physiology which aided materially in advancing the science of medicine—such, for example, as his contributions to our knowledge with regard to animal heat, the functions of muscles, the action of nerves, the effects of certain poisons, the phenomena of electricity, etc. He also invented several instruments, as, for example, the sphygmograph and the cardiograph. He died in 1904.

Marey's most important published writings are probably the following: "Recherches sur le pouls au moyen d'un nouvel appareil enregistreur—le sphygmographe," 1860; "Physiologie Médicale de la circulation du sang, Casée sur l'étude graphique des mouvements du coeur et du pouls artériel, avec application aux maladies de l'appareil circulatoire," 1863; "Du mouvement dans les fonctions de la vie. Leçons, etc.," 1868; and "La machine animale. Locomotion terrestre et aérienne," 1874. A. H. B.

Margarin.—The mixture of the fats, tristearin and tripalmitin, was formerly called margarin.

F. P. U.

Margaropus.—*Boophilus, Rhipicephalus.* A genu. of ticks, *Rhipicephalina*. *M. annulatus* and *M. decoloratus* spread *Babesia bigemina*, the parasite of Texas or red-water fever. See *Arachnida*.

A. S. P.

Marienbad.—"This is a well-known Bohemian spa, lying in a pleasant valley, surrounded by forest-covered hills, not far from Carlsbad, whose waters are similar to those of Marienbad. Its elevation is about 2,000 feet above the level of the sea. The climate is mild and equable in summer, during the season, and the air is fresh and bracing. There are eight springs known as the Kreuz-, Ferdinands-, Carolinen-, and Ambrosius-Brunnen, and the Wald-, Wiesen-, Rudolfs-, and Marien-Quelle, of a temperature of 52° F. Of these the most important are the two first mentioned. The following is the composition of four of the springs, according to analyses made at different times by different chemists. The proportions of the solid constituents are given in grams per liter.

	Kreuz-brunn	Ambrosius-brunnen.	Wald-quelle	Rudolfs-quelle.
Sodium sulphate	3.873	0.275	1.06	0.11
Potassium sulphate	0.054	.....	0.20	0.02
Sodium chloride	1.237	0.075	0.37	0.06
Sodium carbonate	0.995	0.115	1.00	0.14
Calcium carbonate	0.556	0.270	0.38	1.12
Magnesium carbonate	.....	.....	0.40	0.67
Aluminum carbonate	0.405	0.200	.....	.....
Lithium carbonate	0.005	.....	.....	.....
Strontium carbonate	0.001	.....	.....	.....
Ferrous carbonate	0.040	0.035	0.02	0.04
Manganous carbonate	trace.	.....	trace.	0.07
Aluminum and calcium phosphate	0.001	.....	.....	0.03
Silicic acid	0.007	0.050	0.10	0.01
Bromides, fluorides, organic matters, etc.	traces.	traces.	traces.	traces.
Total solid constituents	7.174	1.020	3.53	2.27

The springs all contain a certain proportion of carbonic-acid gas. They are employed for the greater part internally. The Marienquelle, however, is used for bathing; it is very weak in solid constituents, containing only 0.182 part per thousand, but is pleasantly carbonated.

The waters of Marienbad are known as alkaline aperient waters, the most important constituent being sulphate and chloride of sodium, and are prescribed in cases of abdominal plethora, gout, hemorrhoids, chronic dysentery, hepatic congestions, etc., occurring in well-to-do individuals accustomed to indulge rather freely in the pleasures of the table. They are also very useful in obesity, and are especially recommended in affections associated with the menopause. The waters of some of the springs have considerable reputation in the treatment of neuralgia and of chronic catarrhal troubles of the respiratory organs and bladder. Ordinary baths are not much employed, though gas, milk, whey, pine-cone, and mud-baths are made use of to some extent. The season at Marienbad lasts from the beginning of May to the beginning of October. The waters are exported in very large quantities. They have a salty taste not particularly disagreeable and are clear and without odor. This spa is much frequented, the average number of guests each year being 21,000.

Obesity is "the great specialty here," and corpulence stalks abroad on every hand. When one, however, has rid himself of his superabundant adipose tissue, great care must be paid to the diet, else the "too, too solid" fat will not remain melted. The accommodations are abundant and good; there is an English and Scotch church service, and there are over forty doctors. Marienbad is reached from London via Cologne, Nuremberg, and Eger in thirty hours. Edward O. Otis.

Marietta, Georgia.—Situated in the northwestern part of the State, twenty miles from Atlanta, at an elevation of from 1,100 to 1,200 feet above sea-level. It is a town of some 6,000 inhabitants, with a dry sandy soil, and an invigorating climate with a large proportion of sunny days. In 1888, there were 263 sunny days, and 102 rainy or cloudy days. For the same year the average minimum and maximum monthly temperatures, the extremes of temperature, and the rainfall were as follows for the months of October to May:

	Average minimum temperature of month. Degrees.	Average maximum temperature of month. Degrees.	Minimum temperature. Degrees.	Maximum temperature. Degrees.	Rainfall. Inches.
October	49	64	37	77	3.93
November	44	58	26	75	4.38
December	34	49	18	64	4.97
January	36	49	12	72	3.10
February	40	54	10	69	4.00
March	39	58	19	77	9.81
April	52	73	42	82	1.68
May	57	74	41	85	5.13

The average yearly temperature is 57.66° F.

There are no humidity statistics known to the writer, but at Atlanta, twenty miles distant, the average relative humidity, as ascertained from observations taken at 8 A.M. and 8 P.M., is 71.8 per cent., with an average mean yearly temperature of 60.7° F.

It is said to be a breezy region, but there are no wind storms or fogs. Malaria does not exist here. There are two hotels, well kept, quiet, and comfortable, good boarding-houses, and a few houses for rent. The summer climate is also said to be "delightful," and the place is much resorted to at that season. Marietta is easily reached from New York and Washington. Edward O. Otis.

Marlin Hot Wells.—Falls County, Texas.

Post-office.—Marlin. Hotels. Sanatorium. Bath-house.

Access.—Via the International and Great Northern, and the Houston and Texas Central Railroads.

Marlin has the deepest and hottest artesian wells in the world. These famous mineral wells are more than half a mile deep and have a daily output of 380,000 gallons of water. Although the water passes up through pipes for more than half a mile, it reaches the surface at a temperature of 147° F. The climate of Marlin is delightful at all seasons of the year. The winters are mild and the springs are balmy, while the Gulf breezes temper the heat of summer. Dr. J. W. Torbett who has been in Marlin for seventeen years and who is the proprietor of the sanatorium, has courteously sent information about the institution, comprising three buildings, sanatorium, bath-house, and hotel, that so closely resembles those at many European spas. The buildings are of brick and possess all modern improvements and appliances. There are in all one hundred beds and practically under one roof with the baths, the whole equipment being one of the best and most complete in the South. The hot artesian well is located immediately in front of the bath-house, where experienced attendants are prepared to give hot and cold baths, sprays, fomentations, sweats, and massage, according to physician's directions. The new Hot Well has two flows of different analyses, and each being better for certain diseases. The sanatorium has a well-equipped laboratory. Besides the dietetic and hydriatic departments of the hotel and bath-house, the sanatorium is provided with a variety of batteries, vibrators, static machines, *x*-ray coils, Oudin sprays, autocondensation couch, Neal-Armstrong ozone machine, high-frequency and hot-air apparatus, violet and leucodescent lamps, for the treatment of chronic diseases.

The following analyses have been made:

Marlin Hot Well No. 1.

Depth 3,350 feet. Temperature 147° F.

Sodium sulphate	312.32
Sodium chloride	112.39
Potassium sulphate	0.80
Iron sulphate	3.00
Calcium carbonate	34.10
Calcium sulphate	3.95
Sodium bicarbonate	11.66
Magnesium sulphate	16.15
Alumina sulphate	12.20
Insoluble matter	1.88
Total grains per gallon	508.45

Free carbonate and acid gas per gallon in the Marlin water 3.60 cubic inches.

Marlin Hot Well No. 2.

First Flow.		Second Flow.	
Sodium chloride	221.463	Sodium carbonate	0.916
Sodium sulphate	304.210	Potassium chloride	3.831
Potassium sulphate	5.313	Sodium chloride	11.127
Magnesium sulphate	11.443	Sodium sulphate	305.884
Magn'm bicarbonate	9.599	Magnesium sulphate	17.554
Calcium bicarbonate	33.311	Calcium sulphate	51.250
Aluminum sulphate	0.723	Calcium bicarbonate	13.273
Iron sulphate	0.029	Alumina	0.531
Silica	1.260	Ferric oxide	0.006
Insoluble residue	0.373	Silica	1.866
Total	587.724	Total	406.238

The wells furnish laxative, alkaline waters, similar in composition to the Sprudel, Carlsbad's hottest spring. The waters have proved very beneficial in the treatment of liver, stomach, rheumatic, catarrhal, and skin diseases. Emma E. Walker.

Marrubium.—Horehound. "The dried leaves and flowering tops of *Marrubium vulgare* L. (fam. *Labiatæ*)" (U. S. P.).

Description.—Leaves opposite, exstipulate, shortly and broadly petioled, the blades two to four centimeters (one to one and one-half inches) long, roundish ovate, truncate or subcordate at the base, obtuse, strongly rugose-veiny, more or less white-hairy, especially underneath; stems quadrangular, densely white-hairy; flowers in dense, axillary, white-wooly whorls; calyx tubular, five- to ten-nerved, with ten almost equal, erect-spreading, pungent teeth; corolla whitish, bilabiate; stamens didynamous; fruit of four ovoid, obtuse, smooth nutlets; aromatic and bitter.

A spurious marrubium is sometimes sold, having leaves of about half the size, petioled, thinner, less rugose and five of the calyx teeth much smaller or wanting.

Horehound is a European herb which has been introduced into this country, and in many places has escaped from old-fashioned country gardens to meadows and moist waste-places. Its woolly aspect and bitter odor and taste, combined with its characteristic labiate flowers and quadrangular stems, make it easily recognizable. It is also a native of western Asia and northern Africa.

The use of horehound dates from the ancient Romans, or even farther back. It has been a popular febrifuge and aromatic bitter tonic in many countries. The leaves and tops of the plant should be collected for use when it is in full bloom, and before the former have become old and dry; they are dried without heat, and should be preserved in dry boxes or drawers.

The most important constituent is the crystalline, neutral, bitter substance, *marrubiin*. There are, besides, a little *resin*, a little *essential oil*, *tannin*, and a considerable amount of alkaline and earthy salts.

Horehound was formerly prized as a febrifuge and antispasmodic, and used in numerous obscure diseases (hepatic, uterine, etc.), and in intermittent fever. It was also used for the only conditions for which it can be said to have any value, and for which it is still a little employed, viz., dyspepsia and debility. When a stomachic and bitter tonic is indicated, a tablespoonful or two (15.0 to 30.0) of an infusion, made in the usual way, strength one-tenth, is a tonic dose.

H. H. Rusby.

Marshmallow.—See *Althea*.

Marsupialization.—This term (from *marsupium*, a small pouch) means literally the process of making a small pouch similar to that in marsupials. Surgically, it is a recognized method of dealing with a cyst, usually abdominal, that it would be injudicious to ablate, chiefly because of adhesions, but also for other reasons. The operation is mainly performed for adherent ovarian cysts, and occasionally for hydatid cysts, especially of the liver, for here it eliminates hydatid toxic poisoning.

The cyst is opened and its edges are stitched to those of the abdominal incision—a procedure comparable to inguinal colostomy. The contents are evacuated, and the cavity tamponed. Little by little the wall of the cyst granulates, the cavity is filled and the cyst shrinks.

Marsupialization is a method of necessity, and as such is a safe procedure. As O'Conor states, it is by no means a utopian performance, for it entails a long convalescence, and frequently the patient is much debilitated before the cavity is finally closed.

Morris Booth Miller.

Martha's Vineyard.—See *Nantucket, Martha's Vineyard, and Cape Cod*.

Massæ.—A pill mass (*massa*) is a combination of medicinal substances blended with enough of a fluid

excipient to make a resulting solid sufficiently plastic to be readily rolled into pills. A good pill mass is adhesive, firm, and plastic. There are two *massæ* official in the United States Pharmacopœia; and one is mentioned in the National Formulary.

		Composition.
Massa Copaibæ (Mass of copaiba; solidified copaiba).	N. F.	Copaiba, 94; magnesia, 6; water, *q.s.*
Massa Ferri Carbonatis (Mass of ferrous carbonate).	U. S. P.	Ferroussulphate, 100; monohydrated sodium carbonate, 46; clarified honey, 38; sugar, 25; syrup and distilled water, each a sufficient quantity to make 100.
Massa Hydrargyri (Mass of mercury).	U. S. P.	Mercury, 33; glycyrrhiza, 10; althæa, 15; glycerin, 9; honey of rose, 33.

R. J. E. Scott.

Massage.—Definition.—Massage (from the Greek, *masso*, I knead or handle; Arabic *mash*, press softly; Sanskrit, *makch*, to strike, to press, to condense) is a term generally accepted to signify a group of procedures which are best done with the hands, such as friction, kneading and manipulating, rolling and percussing the external tissues of the body in a variety of ways with either a curative, palliative, or hygienic object in view. In many cases massage should be combined with movements, passive or active, assistive or resistive, as may be required, and these are often spoken of as the Swedish movement cure. Most scientific men prefer to have the word massage embrace all these varied forms of manual therapeutics, for the reason that the word cure attached to any form of treatment whatsoever is often misleading.

History.—Massage, in some crude form or other, has been used from time immemorial by savage and civilized people, because it is founded on instinct. The history of massage is coeval with that of mankind, and those who have thought it worth while to record their appreciation of it have in almost every instance been men of eminence either as physicians or as philosophers, poets, or historians. The aphorisms of Hippocrates embodied the wisdom of the past and presaged the developments of the future to a greater extent than most ancient or modern writers on massage have shown any evidence of understanding. He says: "The physician must be experienced in many things, but assuredly also in *anatripsis*, the art of rubbing up; for things that have the same name have not always the same effects. For rubbing can bind a joint that is too loose and loosen a joint that is too rigid. Rubbing can bind and loosen; can make flesh and cause parts to waste. Hard rubbing binds; soft rubbing loosens; much rubbing causes parts to waste; moderate rubbing makes them grow." The results which he has predicted will follow when the necessary previous conditions have existed.

Among the old Greeks and Romans massage in some form or other was patronized by people of widely different classes, from the patricians, the wealthy and the learned, down to poor decrepit old slaves; and for the most diverse purposes; with some as a means of hastening tedious convalescence, with others as a luxury in conjunction with the baths, and with still others to render their tissues supple and enduring preparatory to undergoing feats of strength, so that there would be less likelihood of sprains and ruptures.

To Peter Henrik Ling, of Sweden, credit is given for having instituted what is so well known as the "Swedish Movement Cure." In 1813 the Royal Central Gymnastic Institution was established at Stockholm in order that Ling might practise and teach his gymnastics, which were adapted to the well and the sick. The critics of Ling quickly brought forward testimony to prove that his method was but a revival of that of the ancients. But, however his genius and the claims of priority made for him may have been disputed, there was no doubt as to the merits of the system which he rescued from oblivion. In some of the large cities of this and other countries, institutions similar to the one at Stockholm exist where movements and stirring up of the external tissues of the body by hand and by machinery are employed. When they rely too much on machinery for this purpose their existence is generally brief.

The field of usefulness of massage has gradually been extending, so that now it has found its way into every general and special branch of medicine, frequently meeting with signal success after the apparent failure of every other means. He who would understand this art, its indications and contraindications in all their ramifications, ought to be a well-informed man.

Seventeen of the German universities with medical faculties give special instruction in physical therapeutics. Practical courses in massage are combined with instruction in orthopedics. Some of the leaders in German medicine show their interest in this new movement by giving personal instruction in physical therapeutics, and physicians of international reputation in internal medicine are teaching physical therapeutics

Mode of Applying Massage.—Vague generalities still exist as to the best manner of doing massage; and these are not rendered clearer by calling slow and gentle stroking, *effleurage;* or by speaking of deep rubbing as *massage à friction;* or by using the word *pétrissage* for manipulation or kneading without friction; or by calling percussion, *tapotement.* These and other subdivisions of massage can all be grouped under four heads: friction, percussion, pressure, and movement. Manipulation, malaxation, deep rubbing, or kneading is a combination of pressure and movement without allowing the hand to slip on the skin. It is of more value than all the other procedures, and constitutes the massage, properly so called, of the older writers and also of the later ones who know anything about it. Each and all of these may be gentle, moderate, or vigorous. Some general remarks will save repetition: 1. All of the single or combined procedures should at first be begun moderately, then gradually increased in force and frequently to the fullest extent desirable, and should end gradually as begun. 2. The greatest extent of the hands and fingers of the manipulator, consistent with ease and efficacy of movement, should be adapted to the surface worked upon, in order that no time shall be lost by working with the ends of the fingers, or with one portion of the hands, when all the rest might be occupied. 3. The manipulator, if too near the patient, will be cramped in his movements; if he is too far away, they will be lacking in energy, indefinite, and superficial. 4. The patient should be in an easy and comfortable position, with joints midway between flexion and extension, in a well-ventilated room, at a temperature of 70° to 75° F. Any sensations of tickling will soon disappear when firm, steady, deep kneading is employed. 5. The directions of the procedures usually should be from the insertion to the origin of the muscles, from the extremities to the trunk, in the direction of the returning currents of blood and lymph, unless there be a plug in a vein. 6. What constitutes the dose of massage is to be determined by the force and frequency of the manipulations, and by the length of time during which they are employed, considered with regard to their effect upon the patient; in other words, the reaction must be studied. A good manipulator will do more in fifteen minutes than a poor one in an hour, just as

an old mechanic working deliberately will accomplish more than an inexperienced one working furiously.

In using friction upon the limbs, after the strong upward stroke, the hand should return gently grazing the surface, so as to impart a soothing sensation; it should not press upon the parts so vigorously as to retard the currents pushed along by the upward stroke; and thus a saving of time and effort will be gained. The manner in which a carpenter uses his plane represents this to-and-fro movement very well. Six to a dozen or more of these up-strokes and as many returning may be used at a time, according to the effect desired. On the hands and feet the friction may be done in a rectilinear manner, parallel to the long axis of the limb, and on the arms and legs it can be used not only in straight lines but also by long oval strokes extending from joint to joint, the strong stroke up, the light one returning. It is well to begin these strokes on the inner side of both arms and legs so that the larger superficial and deep vessels may first be emptied, as this makes room for their tributaries to pour their contents into them. From the base of the skull to the spine of the scapula forms a well-bounded region for downward and outward semicircular friction; and from the spine of the scapula to the base of the sacrum forms another surface over which one hand can sweep in downward and outward strokes, alternating with those of the hand at work upon the shoulder, the patient for this purpose lying on the opposite side. The application of friction to the hip should be done in an upward direction with alternate strokes from the insertion to the origin of the glutei; to the chest, from the insertion to the origin of the pectoral muscles; and to the abdomen, from the right iliac fossa in the direction of the ascending transverse and descending colon. Friction over the stomach should be upward and inward from the left side, and over the liver, up and in from the right side.

For manipulation or kneading the same division of surfaces and direction of working should be made as for friction; and it is a very good rule, but not an absolute one, that stroking and kneading should alternate. Adapting as much as possible of hands and fingers to the part to be *masséed*, making three manipulations and passing three times over a surface, as from wrist to elbow, constitute a very good plan; then half a dozen strokes should be made, and so on. The grasps should alternate, one hand contracting as the other relaxes, and the advance on new territory should be such as to permit of the hand overlapping one-half of what was *masséed* at the previous grasp. For this purpose the two hands may encircle a limb, one slightly in advance of the other; or a single group of muscles may be *masséed* at one time by alternate squeezes with each hand.

For manipulation of the back we have the patient lie on one side as for friction, and then, while steadying the head with one hand pressed against the temporal region, we make the fingers of the other work vigorously from the median line upward and outward toward the insertion of the muscles at the base of the skull. The direction of the manipulations on the rest of the back should generally be downward and outward from the spine in graceful curves, and on the hip upward and outward, the two hands alternating in the same direction. On large people with very firm tissues, one hand should often be reënforced by placing the other upon it, the *masséing* thus being done with all the strength that can be put forth. The force used here and elsewhere must be carefully graduated so as to allow the patient's tissues to glide freely over each other; for if it be too great the movement will be frustrated by the compression and perhaps bruising of the patient's tissues; if it is too light the manipulator's fingers will slip; and if gliding with strong compression be used the skin will be chafed. In order to avoid this last objection, which is almost a universal error, greasy substances are employed, so that would-be masseurs may rub without injuring the skin. When the skin is cold and dry, or cold and moist, and insufficiently nourished, as in certain fevers and other morbid conditions, there is no doubt of the value of inunction; but no special skill is required to do this. Removal of hair is also unnecessary; for massage can be done as effectually on the head as on any other part.

On the chest and abdomen the same general direction will be observed for manipulation as for friction, but the pressure will be more gentle than on the back and limbs, as the tissues here will not tolerate being so strongly squeezed. On the chest, alternate circular kneading may be done with one hand on each side; or one side may be done with both hands, one at the upper, the other at the lower part, the direction of the circular kneading being down, in, out. On the abdomen, firm, deep kneading is usually best in the direction of the colon, the greatest force being used with the heel of the hand on the side of the abdomen next the operator, and on the other side the strongest manipulation being made with the fingers, care being taken to avoid the frequent and disagreeable mistake of pressing at the same time on the anterior parts of the pelvis.

Percussion, often useful for relaxed muscles, may be done in a variety of ways. In the order of their importance they are as follows: 1. With the ulnar borders of the hands and fingers. 2. The same as the first, but with the fingers separated. 3. With the tip ends of the fingers united. 4. With the palms of the hands. 5. With the ulnar borders of the fists. 6. With the palms of the hands held in a concave manner so as to compress the air while striking. The blows should be smart, quick, and springy, and usually with the ulnar borders of the hands directed transversely to the muscular fibers; except in the case of the back, which may not only be percussed with the hands at right angles to it while the patient lies face down, but also still more effectually when the patient stands slightly bent forward so as to put the dorsal muscles on the stretch. The hands of the percussor are then most easily held parallel to the spinal column, and can rapidly strike the muscles on each side of it, causing, we have every reason to suppose, a vibratory effect as when the string of a bow is struck. Moreover, in this position, the muscles, being tense, protect the transverse processes from the impact which the blows communicate to the roots of the nerves as they emerge from the intervertebral foramina, and the vibratory effect of this upon the distribution of the nerves is perceived as a peculiarly delightful and agreeable thrill. Most people prefer percussion by hand to that done by vibrators, as the effect seems to be equally good and more agreeable.

Remedial movements, wrongly called medical gymnastics, have been more fully than clearly described in books on "Movement Cure." According to the descriptions of them which I have read the patients would have to be made for the movements rather than the movements adapted to the patients. Passive movements should be given to parts which the patient cannot move; assistive movements when the patient can do but a part and not the whole of a movement; resistive movements, when the patient is strong enough to oppose resistance for the purpose of cultivating increase of strength. Much learned nonsense has been written about various movements and these have been given the names of their advocates. The truth simply amounts to this: find out what the patient can do and gradually increase this in such a manner as to invigorate and not fatigue. The inventive genius of any one may thus be called into play. Except in the case of relaxed joints passive motion should be employed in the treatment of joints which have been too long at rest until a degree of resistance is exerted by the patient which is percepti-

ble to the manipulator; for this is the only way in which we can know that the natural attachments of the joints are being acted upon. Resistive movements are of two kinds: those which the patient can make against the efforts of the operator, and those which the operator overcomes while the patient resists, as when a group of muscles is voluntarily contracted and then pulled out into extension against the patient's resistance. The former have been called double concentric, the latter double eccentric by some eccentric individuals. When muscles are very weak, and it seems desirable to exercise them, it is better that they should first be contracted to their utmost, for then they can put forth much more strength in resisting extension than they could in passing from relaxation to contraction. Most frequently, however, it will be necessary to make resistance against the contraction of the patient's muscles, and then the opposing force should be kept carefully and instinctively within the limits of the patient's strength, so that he may not recognize any weakness; and this, with all the other procedures, should stop short of fatigue, at least such fatigue as is not soon recovered from. To resist alternately flexion and extension is the *pons asinorum* of manipulators, and in a long experience of teaching massage I have found but few who could learn to do this well, and many who could not learn to do it at all. Many a patient who has recovered from an old injury is still as much incapacitated as ever, from the fact that his latent energies can be discovered and cultivated for greater use only in this manner.

Midway between passive and resistive movements in the course of certain recoveries come assistive movements. They are but little understood and seldom used, the patient being credited with complete loss of the power of motion. For instance, in the absence of completely and permanently disabling injury or disease, let it be supposed that the deltoid has but one-half the requisite strength to elevate the upper arm. So far as any use is concerned, this is practically the same as if no power of contraction were left in the muscle. But if only the other half of the impaired vigor be supplied by the carefully graduated assistance of the manipulator, the required movement will take place; and in some cases if this be regularly persisted in, together with manipulation and percussion of the faulty muscle, more vigorous contraction will be gained, and by and by the patient will exert three-fourths of the necessary strength, and later the whole movement will be done without aid; and as strength increases, even resistance may be opposed to the movement. The importance of these measures can hardly be overestimated in cultivating the strength of weakened muscles, while at the same time we find out how much they can be used. Still another kind of movement deserves mention here, namely, vigorous passive motion with a view of breaking up adhesions in and around joints. It is the secret of success and of failure of people who call themselves "bone-setters."

Physiological Effects of Massage.—The pressure of massage exerts a simultaneous influence upon all the tissues within its reach—upon skin, fasciæ, muscles, blood-vessels, lymphatics, and nerves.

Skin.—Tough, flexible, and elastic as the skin should be in its natural condition, owing to the white fibrous and elastic tissues entering into its composition, it is rendered none the less so by a prolonged course of massage. While it becomes softer, more supple, and finer under massage, it also at the same time becomes more tough, flexible, and elastic, so that whereas at the beginning of massage it could scarcely be pinched and grasped without pain, later on, the patient will almost allow himself to be lifted up by the skin like one of the agile domestic animals; thus showing a marked change in the sensibility of these parts. The soothing effect of gentle stroking is familiar to every one, and the analgesic or agreeably benumbing influence which follows vigorous pinching is also well known. These peculiarities can often be utilized in gradually approaching painful places which could not have been directly pressed upon. The various reflexes from the skin have not yet all been solved by our best neurologists which shows how vast our subject is. This is a good way for a young doctor to immortalize himself by discovering some new reflex or the absence of it, like the Babinski.

Muscles.—After massage muscles are more supple and comfortable, have greater power of endurance, and respond more readily to the will, to the faradic and to the galvanic current than they did before. When fatigued they recover more rapidly under massage than they do under the influence of rest alone, and are capable of doing about twice as much work as they can after resting for the same length of time. Zabludowski found the effects of general massage on healthy people to be an elevation of the functions of life in general, and with an improved frame of mind were associated easier movements of body, increase of muscular strength, greater appetite, more vigorous and regular action of the large intestines, and more profound and refreshing sleep. Professor Maggiora, of the University of Turin, by an interesting and accurate series of experiments, has demonstrated the restorative effects of massage upon his own muscles when fatigued and weakened by physical or mental labor, by electricity, by hunger, by loss of sleep, and by slight fever. For this purpose the fatigue curves of the right and left middle fingers were taken in maximum voluntary flexion every two seconds, the weight employed being one of three kilograms. The average results showed that the muscles concerned in this movement could do about twice as much work after a few minutes of massage as they could without. After five minutes of massage they could so as much work as after resting two hours. When, however, the brachial artery was compressed and the supply of blood shut off, massage had no effect at all. Of the three principal forms of massage, friction and percussion were much alike in the restorative effects produced by each, while *pétrissage*, or kneading, had a much greater influence than either of the others. When all three were used, the greatest effect was obtained. As to the effects gained by the length of time during which the massage was used, he found that a period of five minutes for the finger and for the forearm, brought forth a greater capability of work than when the massage was employed for either a longer or a shorter time. I have always maintained that manipulation, kneading, or *pétrissage* is of more value than all the other procedures of massage put together.

Flow of Blood and Lymph.—When the contraction and relaxation of muscles no longer take place, the circulation languishes and then the assistance of massage may be invaluable; for by upward friction and deep manipulation the veins and lymphatics are mechanically emptied, the blood and lymph are pushed along more rapidly by the *vis a tergo* of the massage, and these fluids cannot return toward the extremities by reason of the valvular folds on the internal coats of their vessels. More space is thus created for the returning currents coming from beyond the region *masséed*, and the suction power induced at the same time adds another accelerating force to the more distal currents. The effect may well be likened to the combined influence of a suction and a force pump, and in people who are not too fat the superficial veins can be seen collapsing and filling up again as their contents are pushed along by the hands of the masseur. In this way the collateral flow in the deeper vessels, as well as the more distal stream in the capillaries and arterioles, is accelerated and the engorgement relieved. One would naturally suppose that the blood in the larger arteries would thus be inter-

rupted. But herein comes an additional advantage to aid the circulation; for the compression being but momentary causes a dilatation of the arteries from an increased volume of blood above the parts pressed upon, and, as soon as the pressure is removed, this accumulation rushes onward with greater force and rapidity in consequence of the force of the heart's action and the resiliency of the arteries acting upon the accumulated volume of blood. Gentle upward stroking, though soothing, is a mild irritant, in a physiological sense, of the superficial vessels, causing a narrowing of their caliber and a stronger and swifter current in them by reason of its stimulating influence on their muscular coat and vasomotor nerves. But let centripetal stroking, or any other form of massage, be continued for a sufficient length of time, or become stronger, and hyperemia will result, indicating relaxation of the vascular walls due to overexcitation or exhaustion of the tone of their muscular coat and vasomotor nerves. Retardation is, however, obviated by the mechanical effect of the massage pushing along the returning current. By reason of the fact that more blood passes through regions *masséed*, there will be an increase in the interchange between the blood and the tissues; and thus the work done by the circulation will be greater and the share borne by each factor less.

Brunton has shown by means of a glass tube inserted into a blood-vessel that the blood passes three times more rapidly through a part while it is being *masséed* than when it is not. The fact that the peripheral circulation is thus helped along in so appreciable a degree lessens the work of the heart in pumping it around, and makes it easy to understand why massage is so useful in nearly all forms of cardiac trouble. J. K. Mitchell has found that in many cases after massage there was a great increase in the number of red globules and of the hemoglobin also. Oliver, of London, has pointed out that any influence causing rise of blood pressure would slightly concentrate the blood. In view of Mosso's discovery that when the blood of a fatigued animal is injected into another at rest, symptoms of fatigue are induced in the latter, it is not unlikely that when massage is applied to a fatigued person the blood of this individual resumes the condition of that which it has when he is rested, for massage certainly dispels fatigue, often very quickly.

In all the experiments made in dogs for the purpose of determining the rapidity of flow of the lymph stream—by the insertion of a glass tube either into the thoracic duct or into the large lymph vessel which accompanies the saphenous vein—it has been found that the activity of the flow is greatly increased by means of massage and passive motion, much more so than when galvanism is used; and it has also been observed that in cases of inflammation the flow is much more abundant than it is from healthy parts.

Upon the nervous system as a whole, massage usually exerts a peculiarly delightful and at the same time decidedly sedative and tonic effect. While it is being done, and often for hours afterward, those who submit to it are in a blissful state of repose; they feel in a short time as if they were enjoying a long rest, or as if they had just returned from a refreshing vacation; it makes optimists of them for the time being. An aptitude for rest or for work generally follows. Those who submit to this treatment experience a sense of relief from the apprehensions which previously distressed them. No unpleasant after-effects ever follow the judicious employment of massage. Through the medium of the central nervous system the effects of even a local massage are radiated or reflected throughout the body, thus acting as a nervous and vascular revulsive. The transmitted and reflected influences of massage are as extensive as the distributions and connections of the sensitive nerves that are accessible to its impressions. From mechanical impressions like massage upon sensitive nerves in their connections with other sensitive nerves we may expect to get modifications of sensation; through the connections of sensitive nerves with motor nerves we may expect to see an influence exerted upon motion; and, finally, through the relations which the nerves directly affected by massage bear to secretory and inhibitory nerve fibers, we may also expect that this therapeutic procedure will cause changes to take place in the functions of secretion and nervous inhibition.

Diseases in which Massage May be Employed to Advantage.—*Neurasthenia.*—The following conclusions are amply justified by experience: (1) Massage induces sleep. (2) Even when it is applied in the forenoon the soporific effects may not disappear before bedtime; though in general the later in the day it is used for promoting sleep the better. (3) When massage is administered in the forenoon the disagreeable feelings of drowsiness and languor do not necessarily intervene till bedtime, when sound sleep is almost sure to come. Aptitude for rest or for work generally follows massage. The mind is clearer and in a better condition for prolonged and effective work, and the muscles do not tire so soon. (4) When people are wakeful after massage they are not likely to be restless or to feel the loss of sleep on the following day. (5) Spinal irritation is relieved or disappears under massage. (6) For local neurasthenia there is no need of general massage, unless the whole system be secondarily affected. (7) When affections have come to a standstill under massage, improvement may yet go on after the manipulations have been discontinued. (8) As a means of improving the nutrition of nerves and muscles, and of restoring natural sensation and motion, massage may succeed when other means have failed. (9) Deep massage without friction has proved, in suitable cases, of more value in my hands than all other forms of massage put together. (10) Massage can be overdone; in which event the effects produced will be the opposite of those which follow a moderate use of this therapeutic procedure. (11) Besides massage, carefully graduated exercises at regular times are valuable accessories in the restoration of motion. (12) Massage is not the only means of treatment for neurasthenia. Its selection is usually decided upon after the failure or the exhaustion of every other means. (13) From a wide consideration of the effects of massage in neurasthenia it must appear that massage produces a normal cenesthesia, *i.e.* a combination of all the good feelings, mental and physical, sometimes called the sixth sense, which is different from that produced by rum and has no bad after-effects.

Writer's Cramp and Allied Affections.—Overuse of nerves and muscles, especially in fine work requiring a high degree of delicate coordination of voluntary impulses and individual movements, as in writing, sewing, knitting, watch-making, playing the piano, harp, or violin, gives rise, especially in those who are somewhat neurasthenic, to disorders similar to the affection known as writer's cramp. So does also, but less frequently, excessive use of muscles in heavier occupations, such as painting, telegraphing, tailoring, shoemaking, blacksmithing, and milking, occasion like disturbances of sensation and motion. The predominating symptoms may be of a spastic, tremulous, or paralytic form, accompanied by extreme fatigue, pain, formication, hyperesthesia or anesthesia, and thrills like electricity. There may be partial or total inability to perform the accustomed movements; if they be attempted for but a few minutes the symptoms named may arise. The spasm may affect either the flexors or the extensors; there may be rigidity or contraction of the muscles, local or general tremor. No two cases are exactly alike, as these symptoms are variously combined. As a rule, they develop only when an attempt is made to resume the work that brought them on, while for all other purposes the hands and arms are as good as ever. Recent and slight

cases are almost invariably cured by massage and suitable exercises. But it is quite otherwise with those of long standing, unless the physician can discover some causal objective points—such as neuritis, a painful scar, or bad writing materials—the removal of which would expedite recovery. People with too long necks to their wrists seem to be predisposed to writer's cramp.

Chorea.—Encouraging success has attended the systematic use of massage and gymnastics in chorea. It is generally agreed that the seat of the malady is for the most part in the brain, though the spinal cord and peripheral nerves may share in the disorder, which is of such a nature as to weaken the force of the nervous system without destroying it. Recent investigations seem to show that the erratic movements are due to organic change in the brain and spinal cord. That these have been benefited or cured by massage is strong proof of its far-reaching and powerful influence, extending from periphery to center. Rest, massage, and abundance of easily digested food have proved successful in the early or acute stage; and in the decline of the malady, when slight irregular movements still linger, massage, exercise, and calisthenics have done well. In 1847 Laisné of Paris treated 108 cases of chorea by means of massage with almost invariably good results. Goodhart and Phillips of London have treated a number of acute cases of chorea by massage, suitable nourishment, and rest and the advantages proved to be that when the massage was carefully performed, flabby and thin muscles became plump and firm. Marked improvement was observed in every case in the rapid subsidence of all the more violent movements; in improved circulation and warmth of the extremities; in the pulse becoming more regular; in the patients sleeping soundly after the massage; and in their decided increase in weight. The massage was given for fifteen minutes, twice daily.

Wry Neck.—Wry neck occurs in many different forms, too numerous to mention here, sometimes behaving like writer's cramp and chorea, however different the etiology may be. That presenting itself with chronic spasm ought to be the most favorable for treatment by massage and exercises. Starr and Brill of New York have each reported cases of *paramyoclonus multiplex* that were much improved by massage, rest, and suggestion after the failure of other means. Prevalent opinions of our best authorities can be summed up in a few words: Massage and stretching of the neck with systematic exercises often help; neck stretching alone will often suffice.

Neuralgia and Neuritis.—In neuralgias of mild form, and in what seem to be the incipient stages of more severe attacks, as well as in old cases, in which every other remedial measure has been tried in vain, massage often yields favorable results. Used between the paroxysms of severe neuralgic pains, it generally lengthens the intervals between these attacks and lessens their severity. Pain arising from disturbance in the central nervous system is frequently relieved by massage. In cases of peripheral neuralgia when the affected nerves can be reached, massage may be expected to produce still better results. In well-marked degeneration of nerves, and when pain is dependent upon mechanical pressure that cannot be removed, we should naturally not expect any result.

The late Dr. Symons Eccles of London treated successfully a number of cases of acute sciatic neuritis occurring in previously healthy people by means of massage, position, and rest. The massage consisted of effleurage, kneading, and percussion, and in the intervals the leg was suspended in a Salter swing, as this was the only position that afforded rest. Prof. Max Schuller of Berlin prefers massage to any other means in the treatment of sciatica. Of fifteen cases that were dealt with from the first by massage, he found that the severe pains soon abated, becoming less even after a severe and painful massage. When they recurred they were less severe, and gradually they disappeared altogether. It required eighteen days on an average for cure. We seldom hear of massage being tried in acute neuritis in the United States.

Affections of the Central Nervous System.—When paralysis of central origin has come on suddenly, I prefer to abstain from the use of massage until the perturbation in general has subsided and the patient has become somewhat accustomed to his unnatural condition. But in the mean time, while we are thus waiting to spare the nerve centers any supposed extra commotion, the peripheral pathological changes are gaining ground. These are: interference with the supply and return of the circulation owing to the accelerating influences of muscular contraction and relaxation being absent or diminished; and, as a result of this, variations of temperature, and passive hyperemia and ischemia; hypertrophy of interstitial connective tissue, with subsequent cicatricial retraction, giving rise to contractures and atrophy of muscular fibers; formation of adipose tissue and fatty degeneration; in a word, vasomotor and trophic disturbances These are all rational indications for the use of massage, either as a preventive of such changes or as a palliative of them when they have occurred. But if the nerve centers are impaired beyond recovery, or secondary pathological changes have already taken place, the prospect of recovery cannot be encouraging. My own experience with massage in a number of cases of paralysis may be briefly stated by saying that in the absence of severe pain, obstinate contracture, or tonic spasm this agent has proved useful in improving the circulation, temperature, and comfort of the parts affected. When, in paralysis of spinal or cerebral origin, recovery has followed under manipulation, I have always hitherto assumed that the central disturbance had entirely passed away and that the force of habit was the main factor in perpetuating the external manifestations of inaction. But the more recent experiences and opinions of Zabludowski and others, well qualified to judge, teach us that it is possible by means of massage and gymnastics to educate other parts of the brain and spinal cord, by arousing psychomotor impulses in the formation of new associations and combinations, to take the place of the injured ones. It therefore seems no longer necessary to regard paralysis, of either central or peripheral origin, from the hopeless point of view that we formerly did.

However that may be, when the causative conditions have ceased, paralyzed muscles will not at once resume their former natural condition. Massage, passive and resistive movements, restore them to a sense of existence, enable them to recognize the power they still possess, and educate this to a higher degree, and at the same time such treatment affords the only means of judging of the capabilities of the patient and of telling him how to use them. Sometimes the patient will make better motion against resistance than without it. This seems to give a sense of support and consciousness of power. Interlocking the fingers of one hand with the other, so that the well arm can raise the paralyzed one, is a most excellent device, encourages the patient, and educates the unimpaired centers to supplement the deficiency of the injured ones.

Locomotor Ataxia.—Cases of locomotor ataxia are often benefited by a course of massage from time to time. There is early, frequently after the first massage, improvement in the tone of the muscles and later disturbances of sensibility, anesthesia and paresthesia, disappear and patients are apt to think that recovery will follow. Voluntary movements, such as the patients can make, and long continued have recently been advocated in locomotor ataxia and are called after the name of the man, Fränkel, who is said to have invented them. No doubt benefit has resulted by this method in combination with others

and it has been not inappropriately called compensatory exercise treatment. But its advocates, by cultivating the finer movements first, all seem to forget or ignore the fact that in the natural evolution of the human being from childhood up, the large and easy movements of trunk and upper parts of the limbs come first, the finer and more difficult later. Therefore this ought to be the plan in which to build and not the reverse. It is of great aid to the patient in the beginning to watch the movements and later do them without looking. But we do not think that this is sufficient reason for immortalizing a man or calling such a method by his name any more than we would say with Sancho Panza, "God bless the man who invented sleep." Compared with the efficacy of massage and resistive movements inspiring confidence and restoring these voluntary efforts alone fall far behind.

There seems to be no doubt as to the benefit that locomotor ataxic patients derive from suspension by the head and axillæ; but how this acts is still largely a matter of conjecture. That the spinal cord receives any stretching at all in this way is very doubtful, though the spinal nerve roots may receive some. The vertebral column is said to be elongated from two and one-half to four centimeters (1 inch to 1.6 inches), its muscles and ligaments are stretched. But this is accompanied with great danger in some cases. The same result can be attained much more safely and effectually by making extension and counterextension at both the head and feet simultaneously, with the patient in a horizontal or erect position or even on an inclined plane. Suspension from the elbows by the sides can act only upon the muscles of the trunk and chest, and in the same proportion take it off the spinal column, if suspension by the head be used at the same time. A better and more efficacious way than any of these is by passive or active flexion and extension of the trunk, preceded and followed by massage.

Acute Anterior Poliomyelitis.—In the treatment of infantile paralysis recent authorities give massage the highest place in all stages of this affection. It ought not to be used during the acute stage, until fever, pain, and tenderness have disappeared; as rest is of the utmost importance at this time. In such cases a warm bath is a good preparation for the massage; then friction and deep manipulation should follow; and when there is no motion in the parts, passive motion should be freely given; when there is slight motion left, but not enough to complete a movement, assistive movements will come into play; when there is returning motion and more than is necessary for simply moving the part to which the affected muscles are attached, resistive motion within their strength will be used; percussion when there is a languid state of sensation, motion, and circulation, and a sufficient substratum of muscles to strike upon, but when there is passive hyperemia, the less percussion is used the better. We often see cases where one group of muscles is paralyzed and atrophied, granting no response to the will or to the faradic or slowly interrupted galvanic current, as, for instance, the anterior tibiofibular group. Cultivating the extensibility of the opponent group with massage and passive flexion of the foot, together with resistive movements of the whole leg and thigh, made by opposing extension of the leg and thigh, with the opposing force at the ball of the foot, will here be productive of benefit; for in this manner the posterior tibiofibular muscles will be relieved from their continual state of contraction or retraction, the weak and elongated muscles will be shortened, and both groups will be simultaneously innervated. Medical gymnastics for weak, paretic, or paralyzed muscles are based on the fact that exercise of intact muscles stimulates innervation and nutrition of neighboring impaired muscles, and skill in directing these efforts consists in finding out what patients can do and contriving means for their performance. Massage will probably prove more serviceable in the prevention than in the cure of contractures, stiffness, and ankylosis, whether of central or peripheral origin. In conjunction with elastic muscles which supplement the loss of power in paralyzed muscles, to aid mechanical contrivances to overcome contractures and to make tissues more amenable to restraint, massage proves useful. After section of muscles, when repair has sufficiently progressed, massage is used to advantage for the restoration of mobility. A famous French surgeon, Malgaigne, long ago styled massage "the soul of orthopedic surgery," and now we should certainly say the body, also, judging from the number of masseuses exclusively employed in the offices of orthopedic surgeons.

There is a strong sentiment among the profession at present, which seems to be gaining ground, that massage when applied early in cases of anterior poliomyelitis will do much to prevent the loss of power and wasting of muscles which are so hard to overcome later. It evidently acts by maintaining the nutrition of the affected parts and supplementing the impaired functions of the nerve cells in the spinal cord.

The electrical reactions of degeneration, as shown by the response to the galvanic and faradic currents, are receiving much less attention than formerly; for even when these are present recovery may still take place. The power of voluntary motion and the contraction on being percussed are really much more useful tests.

Dry Symmetrical Gangrene.—This peculiar malady was first described by Maurice Raynaud, a medical student in Paris, in 1862. Observations since then have confirmed his description of this disease, the theory of which is that it is a neurosis characterized by great exaggeration of the excitomotor energy of the parts of the spinal cord that control vasomotor innervation—the posterior and lateral gray substance, according to Oppenheim.

The experience of myself and others would fully justify the following conclusions: (1) When massage is of benefit in Raynaud's disease, it shows its effects very quickly. (2) These effects are improvement of the circulation and an increased suppleness of the parts, with a corresponding increase of the sense of warmth and comfort. (3) Massage is competent not only to maintain and improve the vitality of the tissues, but it may even effect a complete restoration after destruction of tissue has begun. (4) As the beneficial effects of massage in Raynaud's disease are of a permanent character, this procedure must act, not only upon the vasomotor nerves of the affected parts, but also upon their central connections in the brain and spinal cord.

Sprains, Fractures, Displaced Semilunar Cartilages.—When massage is employed sprains of all degrees of severity get well in one-third of the time ordinarily required in cases of this nature. The sooner after the injury massage is begun the speedier is the recovery. Friction and manipulation should be used above and below the injured joint, which should be gradually approached in this manner, and finally worked upon at the same sitting. Fractures unite more quickly when the limb is *masséed* from the first. The immediate advantages are reduction of swelling, pain, and spasm; the remote are less weakness, pain, and stiffness after the bones have united.

Sprains of the knee are sometimes accompanied by derangement of its internal structures, known as displacement of the semilunar cartilages of the knee-joint. I could recite cases which have occurred either in my own practice or in that of others, which would seem to justify the following conclusions: That it is possible by carefully applied massage, resistive movements, home exercises, and electricity so to strengthen the muscles on the front of the thigh, the fasciæ, ligaments, and attachments of the knee-joint, that

they will safely hold a previously dislocated semilunar cartilage without artificial support.

These conclusions do not apply to cases which require surgical operations, although the above-mentioned combination of therapeutic procedures might be safely tried in some cases before cutting into a knee-joint. The adoption of massage and exercises, however, is more especially called for after the operation, its purpose being to restore motion and strength.

Hyperemia, Opsonic Index, and Massage.—The hyperemic treatment of Bier, which often does such wonders, whether brought about by compression, suction, or heat, accomplishes but one-half of what massage does. In the case of compression or suction it produces a venous stagnation; with dry or moist heat, an arterial hyperemia, either of which must be stopped in due time so as to allow the lymph and blood currents to flow in their natural direction. Massage brings more arterial blood to the parts worked upon and hastens the return of the venous and the flow of lymph at every lick; brings more oxygen and removes more carbon dioxide; acts as marketman and scavenger at one and the same time. In suitable cases it would, therefore, be most rational, to have massage follow the congestive treatment. Sir Almroth Wright discovered that the effect of massage on a variety of infected joints, by discharging an extra number of bacteria into the circulation temporarily depressed the opsonic index and then raised it. Massage would thus serve not only as a valuable aid to diagnosis but also in some cases as a highly beneficial method of treatment at the same time. In all probability the appetite and digestion of these leucocytes and other phagocytic cells are simultaneously increased and the stimulins also aroused to greater activity, the function of these latter, according to Metchnikoff, being to act upon the phagocytes so as to stimulate them to perform phagocytins.

So long ago as 1866, Professor Donders, of the University of Utrecht, was of the opinion that by friction against the walls of the capillaries the blood acquired more oxygen or became ozonized; and that this was greatly increased by external friction or massage, so that the blood became more active and "acquired teeth to bite the tissues." This theory apparently foreshadowed that of opsonins. It must be by the agency of autoinoculation that the machinery of immunization is set in motion in bacterial infections; and, it must be by the agency of immunizing response to such autoinoculations that spontaneous cures are achieved (Wright). That opsonin is not found in the blood, but is a product of muscular and subcutaneous activity, gives further evidence of the great value of massage in this connection. By stimulating this activity massage would undoubtedly increase the amount of opsonin.

Recent observations tend to show that the toxins of fatigue are not dialyzable, but remain where formed; and, that massage favors the union of the antitoxin with the toxin, resulting in recovery. The rapid recovery from fatigue by massage would thus receive an additional explanation. Still more light is thrown on this subject by Horath and Reinke who have shown by experiment that mechanical stimulations, such as vibration and shaking, inhibit and depress the growth of bacteria; and when regularly continued cause their death and disintegration.

Dr. H. F. Wolff of New York uses massage with great advantage in gonorrheal rheumatism. He considers that it is advisable to start this treatment about two or three weeks after the beginning of the disease as soon as the acute stage is over. He finds no danger of a general infection as the gonococci in the tissues are dead about one week after the disease has started. The massage should be given daily by the physician himself in the form of effleurage only. Immediately after the massage there should be relief from pain. Passive motion of the joint should be begun as soon as the patient can stand it.

Massage of the Head.—To most people massage of the head is highly delightful, more agreeable, indeed, than on any other part of the body to which it is applicable, and in various disturbances as beneficial as it is pleasant. To account in great part for this increased comfortable sensation we need only remember the acutely sensitive condition of the terminal filaments of the fifth pair of nerves, and that they will show signs of sensibility under circumstances in which spinal nerves would make no response. But massage of the head is seldom attempted, for manipulators are so accustomed to grasping muscular masses that, when they cannot do this, as on the skull, they are apt to think that nothing can be accomplished. When manipulation of the head is attempted, it is usually, I might say almost always, in a way that would be better described by the word shampooing than by any other

With the patient in a semi-recumbent position in an easy-chair that does not rock, the head inclined toward the side on which the operator sits or stands at a suitable distance to give his arms free play, one hand will be placed over the temporal fascia and muscle, and the other, if the manipulator be a novice, on the frontal region to steady the head, then the pressure of the hand on the temporal region is instinctively graduated to give the greatest movement of the scalp and underlying tissues between it and the bone, without gliding of the hand or such vigorous compression as hinders motion. Six to twelve manipulations will be made in this way and proceeded with step by step, the advance overlapping one-half of the region just worked upon, until the occiput is reached, and the whole can be repeated several times. After this the other hand can be trained to make similar movements in an opposite direction, proceeding from the superciliary ridges over the top of the head, upon the occipitofrontalis to the nape of the neck. A good *masseur* ought to be able to keep both hands going on these regions at the same time, one contracting as the other relaxes, without scraping, scuffing, shaking the head, or turning a hair. The manipulator, having done one side of the head and the region bounded by the occipitofrontalis on this side, will find it most convenient to step to the other side of the patient and proceed as before. The back of the head can be more thoroughly *masséed* with the head erect, one hand steadying it on the frontal region, while the other makes manipulations in an oval direction, the long diameter of which is horizontal. At the middle of the upper portion of the back of the head, the center from which the hair sheds off in all directions, a spiral, circular movement with the palm of the hand is agreeable, efficacious, and useful.

The Face.—In *masséeing* the face of a fat patient the tissues can only be rolled and stretched under the fingers and palm away from the corners of the eyes and alæ of the nose toward the angle of the lower jaw; but if the patient be moderately nourished or thin, the cheeks can be grasped between the thumb and fingers and more thoroughly squeezed and *masséed* in the same direction. The eyelids can be effectually and agreeably manipulated by pinching them up with a rolling grasp by means of the forefinger and thumb at right angles to the orbicularis palpebrarum, and stretching the enclosed fold away from the canthus to which it is nearer. With one thumb closely adapted to the inner portion of the supraorbital arch and the middle finger of the other hand a short distance below it on the upper and bony portion of the nose, useful stretching in opposite directions and away from the inner angle of the eye can be made and should be simultaneous. Moving the thumb one step farther along, so as to include the whole supraorbital arch, all the tissues upon and immediately beneath it can be advanta-

geously stretched upward and outward at the same time that the lower lid is pulled down by one or two fingers of the other hand by carefully graduated pressure upon the lower margin of the orbit. The alæ of the nose, one at a time, can be stretched and manipulated by covering the end of the finger introduced internally with a fold of soft handkerchief. By putting the index-finger, still covered by a fold of soft cloth, inside of the cheeks, these can be squeezed, manipulated, and stretched between the thumb and finger, observing carefully not to lacerate the bridles of mucous membrane.

The Eye.—Blepharospasm offers favorable opportunity for the use of massage and many cases have been reported of its successful employment. In 1890 Dr. Richard Kalish published in the *Medical Record* his method of hastening absorption of cataract with restoration of reading power. It consisted of instillation and massage. The mixture for instillation is composed of equal parts of glycerin and a one per cent. solution of boric acid in rose water. A few drops of this is put into the eye every day, after which it is *masséed* and this is continued for two, three, or four months as the case may require.

Massage has also been used for the ripening of cataract for operation. Forster's method consists of rubbing the cornea against the lens with a small blunt instrument, after first doing an iridectomy. As a result of this the lens undergoes a rapid degeneration, and in the course of a few weeks becomes completely opaque and suitable for removal (*Medical Record*, June 28, 1884).

Whereas a few years ago it was considered the rankest kind of quackery even to speak of massage of the eyes, now European oculists of the highest eminence have gone wild over the success of this method and are using it for every conceivable affection except acute conditions like iritis. Not content with massage of the globe over the lid, they have invented instruments for doing massage immediately on the eyeball as well as in its interior. A number of cases of embolism of the central artery of the retina have been suddenly restored from blindness to vision and the curative results in incipient cases of glaucoma are scarcely less remarkable, and would not be worthy of a moment's consideration if they were not vouched for by oculists of the highest eminence. By a circular movement of finger or thumb upon the upper lid the sclerocorneal canal is opened up and a more rapid drainage of the intraocular fluids is secured, with consequent diminution of tension. By the same means, sometimes in conjunction with instruments, massage has been used for affections of the cornea, conjunctiva, sclera, and ciliary body. (For a more full report on this subject, see Graham's Massage, Chapters xxvii and xxviii, Lippincott and Co., 1913.)

The Ear.—Stroking or effleurage of the neck in a downward direction is a good preliminary measure to deplete the head or any part of it that may be congested, and has even afforded relief in severe cases of cerebral hemorrhage. It should always precede more thorough massage of throat and ear. Good results have been reported from massage by Hommel and others: (1) in chronic catarrh of the middle ear; (2) in perforations of the membrane, the handle of the hammer still being in connection with the membrane; (3) in thickening and opacities of the membrane; (4) as a prophylactic measure against deafness developing in old age.

For this purpose a much more agreeable and efficacious method than that of Hommel is to apply the hand so that the muscles in front of the metacarpal bone of the thumb will fit accurately into and over the auricle, the right hand for the left ear, the left for the right, and by making moderately strong circular kneading upward, backward, and outward, powerful but pleasant compression and suction are created which have none of the disagreeable feeling of shooting peas into the ear that the "tragus press" of Hommel has. Indeed, Hommel's method makes no suction at all, for the compression of the air that it causes is so slight that its sudden liberation cannot produce any appreciable vacuum, as claimed by its advocates. That benefit has resulted from it there can be no doubt, but we must look for a reason other than that given, and it is undoubtedly this: that as the vessels of the cavity of the tympanum and drum membrane anastomose at the tragus, alternate compression and relaxation of the tragus produce a pump-like action on these vessels which draws the blood outward, thus making the circulation proceed more lively, bringing more nutritive material and removing more waste products, as massage does in any other part of the body. The more agreeable method which I advocate possesses the same advantages also and affords much more decided compression and suction of air in the external auditory canal. When desired the auricle also can be grasped at the same time by the fingers behind it, and a circular traction with the strongest pull upward, backward, and outward exerted; but this does not afford so much compression and suction as when the auricle is not grasped.

DOUGLAS GRAHAM.

Massaneta Springs.—Rockingham County, Virginia.

POST-OFFICE.—Harrisonburg. Modern brick hotel and cottages.

ACCESS.—Via Baltimore and Ohio Southern or Chesapeake Western Railroad to Harrisonburg, thence by automobile or carriage four miles southeast to the springs. This resort is located in the Shenandoah Valley, near the Massanutten Mountain, at an elevation of more than 2,000 feet above the sea-level. The waters of the spring have been in use for upward of fifty years, and are still extensively resorted to in the treatment of a variety of affections. They have been analyzed by Professor Mallet, of the Universty of Virginia, with the following results:

GASES ESCAPING IN BUBBLES

Nitrogen	86.67
Carbonic anhydrite	2.64
Oxygen	8.44
Marsh gas	2.25
	100.00

ONE IMPERIAL GALLON CONTAINS

Solids	Grains.
Calcium carbonate	14.778
Magnesium carbonate	6.949
Iron carbonate	0.375
Manganese carbonate	0.052
Sodium carbonate	1.128
Lithium	Trace
Ammonium chloride	0.012
Potassium chloride	0.163
Potassium sulphate	0.113
Calcium sulphate	0.414
Alumina	0.169
Arsenious oxide (in salt)	Trace
Phosphoric acid	Trace
Silica	1.134
Organic matter	0.480

Carbonic anhydrite united to carbonates as above to form acid carbonates. 10.576 grains.

Temperature of water, 55.9° F.

These waters are said to be valuable in the treatment of chronic malarial poisoning, kidney and stomach disorders, and nervous troubles, and the managers present numerous testimonials from physicians and others attesting their virtues. It is reasonable to believe, however, that the good effects observed have been in a large measure due to the excellent climatic and sanitary condition about the springs. The water is an excellent chalybeate tonic, and also has diuretic properties. It is used commer-

cially. Many points of interest are easy of access, the famous natural Bridge, the Luray caverns, the Weyer's and Pirkey's Caverns, the Massanutten Cavern, the Natural Chimneys the Battle Fields of Port Republic and Cross Keys, the Ashby monument, and a great many others.

EMMA E. WALKER.

Mastic.—MASTICHE. A concrete resinous exudation from *Pistacia lentiscus* L. (fam. *Anacardiaceæ*). This is a graceful little tree with slender, brownish-gray branches, and evergreen pinnate leaves. Its flowers are very small, diecious, in erect axillary spikes; its fruit consists of little, dry, red drupes, about as large as cubebs. Large resin canals exist just beneath the surface of the thin bark, from which a certain amount of turpentine exudes spontaneously or from incisions made for the purpose. It is widely distributed through the Mediterranean region.

Mastic is a drug of venerable antiquity, being mentioned by the early Greek and Latin writers upon medicine and natural history two thousand years or so ago. It has been kept in use ever since, and several hundred years ago it entered into the formation of numerous medicines and plasters, and was highly prized. It is now fast becoming obsolete, so far as medicine is concerned.

It is collected in the northern part of Scio, whose political fate for centuries depended upon its importance, from cultivated (male) trees planted for the purpose, by making light incisions in the bark, through which it flows in little rounded tears, and on which it slowly hardens in the same shape. Two or three weeks after the tapping, the collectors revisit the trees and collect the little tears from the bark, and from the ground, to which some of them have fallen. This product is afterward sorted, according to whiteness, cleanness, and shape, into several grades, and so sold. The best of that which reaches us is in lemon-yellow tears, of the size of a large pea and smaller. The surface is smooth and free from dust, by which it is distinguished from the dusty tears of sandarac, and the fracture is clear and glassy. Odor and taste pleasantly terebinthinous; texture brittle, but softening in the mouth. Mastic contains one to two per cent. of *essential oil*, about ninety per cent. of *resin*, soluble in alcohol, and ten of another *resin* soluble in ether, but not in alcohol. Mastic is superior when fresh, and this is determined by its degree of plasticity when chewed and by its higher solubility (up to ninety per cent.) in benzol.

The medicinal action of mastic is exactly that of other turpentines, although, perhaps, on a slightly milder scale than the most active of them; that is, it is a local and renal stimulant. It has been, and still is, in the East, employed as a sort of dentifrice, and as a temporary filling for carious and aching teeth. Out of respect to old tradition it is still used in the *Pilulæ Aloës et Mastiches* of the Pharmacopœia, which are one-sixth mastic. It is claimed that the addition of the mastic increases the certainty and promptness of action of the aloes, as of other catharties.

Oil of mastic, of a clear yellow color, having a specific gravity of 0.858 and the characteristic odor of mastic, is an article of commerce.

ALLIED PRODUCT.—*Pistache* or *Pistacia Nuts* are the seeds of *Pistacia vera* L., obtained chiefly from trees cultivated in the Mediterranean region. This product has no medicinal properties, but is extensively used as an article of food or flavoring by confectioners, in *bonbons* and ices. An emulsion may be made by pounding the seeds with sugar and water, after the manner employed with almonds. This can be used as a pleasant vehicle for active substances.

HENRY H. RUSBY.

Mastication.—This is the mechanical comminution and moistening of food for the purpose of rendering deglutition and the penetration of digestive secretions possible. Provision for this process is practically limited to mammals and is not found in all mammals. Analogous provisions are, however, found in certain animals of lower rank than mammals: *e.g.* the softening and trituration with gravel of grain in the crop of fowls; the stripping of seed coats by the mandibles of various insects; while various fish and reptilia have muscular control of the jaws and are armed with structures more or less analogous to teeth so that they perform the function of mastication at least as thoroughly as carnivorous mammals. The epithelial structures commonly known as whale bone are so arranged as to act as a sieve for the exclusion of large fish, masses of vegetation, and foreign bodies and thus, in a negative sense, may be considered as representing the masticatory function. Among terrestrial mammals, the muscular control of the maxilla and the dental armament correspond approximately to the food. Without entering into a discussion of the comparative anatomy of dentition, it may be pointed out that the masticatory anatomy and muscular physiology of man include in varying degrees the incisive and tearing functions of the carnivora which do not usually masticate at all in the strict sense; and the molar function developed to its highest degree in the ruminants which regurgitate, for the purpose of thorough comminution and moistening, leaves and stalks originally cropped and swallowed into a special stomach for preliminary storage and softening. In man, the rodent and nut-cracking functions are little developed and the teeth are not adapted to such uses without serious detriment.

The muscular action of mastication may be summarized as follows: Elevation (adduction) of mandible—temporal, masseter, internal pterygoid; depression (abduction) of mandible—digastric, mylohyoid, geniohyoid; anterior projection of mandible—external pterygoid; retraction of mandible—lower fibers of temporal; lateral and rotary (ruminant) motions—alternate and balanced successive action of external pterygoid and lower temporal fibers of the two sides in succession; guidance of food between opposing dentures—buccinator, orbicularis oris, supported by chin and facial muscles generally, without; intrinsic and basic muscles of tongue within.

Innervation of the above muscles is by the facial, except that the glossal muscles are supplied by the hypoglossal. Mastication is essentially a voluntary process but largely automatic, efferent impulses being mainly by the lower two branches of the trifacial, to some extent probably by the corresponding muscle sense fibers of the motor nerves, the gustatory nerves, etc.

It is commonly stated and is, to some degree, confirmed by palpation of the contracting muscles that molar adduction is due mainly to the masseters, incisive adduction by the upper fibers of the temporal. But the other muscles control the coordination to a considerable degree and, especially in syngnathic adduction of the incisors, the external pterygoid is brought into action along with the upper temporal fibers.

It must be admitted that, even for incision and tearing of tough foods such as raw meats and fibrous vegetable matter as well as for the attrition of dense foods, especially those rich in woody cellulose, and a fortiori for gnawing and rupture of dense seed coats as of nuts, the human dentition and even the musculature and osseous structures are relatively inadequate. This condition is the result of a cycle, not necessarily to be characterized as vicious, due to the gradually increasing use of selected, artificially comminuted and divided, cooked, and specially prepared foods. A considerable proportion of the average diet of civilized man is so soluble or at least pultaceous or readily forming a pultaceous mass in the presence of water, that very little mastication is required, for

mechanical purposes, to fit the food for subsequent penetration of digestive secretions. It may even be argued that persons whose diet is largely of meat have established a gastric secretion approaching in activity that of the carnivores which do not practise true mastication, especially as the human diet is usually artificially divided by table utensils and the food further softened by cooking. The main value of thorough mastication is to secure insalivation. Aside from the mechanical influence of insalivation to secure a pultaceous state, its chemical value is limited to the digestion of cooked starches for which there is abundant provision by the pancreatic juice.

While neither theory nor empiricism warrant the assumption that mastication is unnecessary, the protraction of this function to an unreasonable degree is equally to be condemned both empirically and for the following logical considerations: (1) The secretion of digestive juices, especially by the stomach depends largely on afferent stimuli of taste and on local mechanical stimuli of the wall of the stomach by dense masses of food. Both these stimuli are largely removed by protracted mastication. (2) The proper performance of the digestive function of the stomach requires that the process should proceed according to certain time limits, upon contents of approximately the same stage of digestion at any given time. Hence, while it is impracticable that the process should begin with a mass of material deposited in the stomach at a given moment, it is not desirable that it should be interrupted by the repeated deposit of raw food material at intervals for a considerable period. (3) It is questionable whether the diastatic function of the salivary glands should be developed to the virtual exclusion of that of the pancreas as, under ordinary dietetic conditions, prolonged mastication would insure the conversion of practically all starch into maltose by the ptyalin, the uncooked starch remaining for the pancreatic amylopsin being usually of very small amount. (4) Even with the aid of dental art, human dentition is barely able to supply the demands of a long lifetime such as is being secured to a greater and greater degree by sanitation and hygiene. Thus the actual wear of the teeth is a matter to be considered seriously. Contrary to opinions often expressed, it should be borne in mind that man in a state of savagery approaching a state of nature is by no means immune to dental caries, that his teeth show far more attrition by molar action than for corresponding ages of civilized man, and that, as among the women of basket-making tribes, an attempt to employ the teeth as by rodents, causes a pitiable and early interference with the dental armament. These statements are based on actual observation of Indian skulls.

A. L. Benedict.

Mastigophora.—Protozoans possessing one or more flagella in adult condition. This class is subdivided into three subclasses: Flagellata, Dinoflagellata, and Cystoflagellata. These animals are extremely abundant in fresh and salt water; many are parasites. See *Protozoa*. A. S. P.

Mastin, Claudius Henry.—Born at Huntsville, Alabama, June 4, 1826. He obtained his collegiate education at the University of Virginia, and began the study of medicine in 1846, under the preceptorship of Dr. George B. Wood, of Philadelphia, Pa. In 1849 he received the degree of Doctor of Medicine from the University of Pennsylvania. Soon afterward he went abroad and still further pursued his medical studies at the schools and hospitals of Paris, London, and Edinburgh. Finally, he settled in Mobile, Alabama, in 1854. During the next six years he held the following important positions in that city: Surgeon of the City Hospital, Surgeon in Charge of the United States Marine Hospital and Surgeon of Providence Infirmary. During the Civil War (1860–1865) he served in the Confederate States Army in different capacities: first, as Medical Director upon the Staff of Major-General Leonidas Polk, of the First Grand Division of the Western Department; then as Corps Surgeon of General Polk's Army of the Tennessee; and subsequently in still other capacities. In 1875 the University of Pennsylvania conferred upon him the honorary degree of Doctor of Laws. From 1890 to 1891 he was President of the American Surgical Association; he was one of the trustees of the Pan-American Medical Congress, and Honorary Chairman of its Surgical Section; he was the founder of the Congress of American Physicians and Surgeons; at one time President of the American Genito-Urinary Association; and he contributed largely to medical and surgical literature. He died at his home in Mobile on October 3, 1898. A. H. B.

Fig. 3918.—Claudius Henry Mastin.

Mastoid Operations.—Indications for Opening the Mastoid Cells.—In many cases there is no single symptom, local or general, which, considered by itself, will lead the surgeon to say positively that the mastoid cells ought to be explored. The decision to operate is reached in most cases by both a careful consideration of the history of the case and of the actual conditions revealed by the examination of the ear and of the surrounding tissues. The examination of the case should also include a bacteriological examination of the pus that escapes from the middle ear. Special care, however, is necessary in obtaining the material for bacteriological examination, as one may very easily contaminate it by contact with the germ life that is constantly present in the external auditory canal. The type of infection is a factor in determining the necessity or not of an operation.

With certain types of infection the virulency is so marked that the surgeon is not warranted in temporizing with the inflammation if the symptoms of a mastoiditis being present are at all suspicious, but should operate without delay. For example if such a bacteriological examination reveals the fact that the bacillus mucosus capsulatus is present in the discharge, which comes directly from the middle ear, the surgeon should consider an immediate operation well nigh imperative, for experience has demonstrated that this germ causes a rapid breaking down of all structures which it attacks, and yet at the same time produces little or no attendant physical signs indicative of the damage that is being done. The meningococcus is another organism which is capable of causing marked destruction of the tissues in a very short time, and in cases where the germ is found, unless positive evidences of improvement have already appeared, an early operation is advisable. Cases in which a pure streptococcus infection exists come to operation in over fifty per cent. of the total number of cases and if decided improvement does not take place within a week it is best in these cases to operate without any further delay, even if the physical signs of a mastoiditis are indefinite. It is estimated that over sixty per cent. of the cases, in which the pneumococcus is found to be present, recover with-

out operative interference upon the mastoid process; and in probably not more than fifteen per cent. of the cases, in which the staphylococcus is the infective agent, is it found necessary to open the mastoid cells. In doubtful cases the radiogram is most helpful in aiding the surgeon to come to a conclusion as to whether he should or should not operate. A patient with double acute purulent otitis media consulted me less than a year ago, where a scanty discharge from the tympanum, which had lasted for five weeks, was absolutely the only symptom present. To establish better drainage a double myringotomy was performed. After treatment for ten days the discharge was still present, so a radiogram was made, and it showed both mastoid processes to be very cloudy. A confrere also agreed with me that aside from the scanty discharge no sign was present to indicate any aural involvement let alone a mastoiditis. After studying the radiograms I decided to operate, and on opening the mastoid cells I found both to be markedly involved, full of granulation tissue and pus, and on one side a large area of the internal plate of the mastoid process was eroded and the underlying sinus wall covered with granulations and bathed in pus. This case well illustrates the value of the radiogram.

The most constant and the most trustworthy symptoms of the purulent involvement of the mastoid process are a *profuse discharge of creamy pus from the middle ear* and *a concurrent prolapse of the posterior and superior cutaneous wall of the external auditory canal near the drum membrane.* But there may be serious involvement of the mastoid cells even when these associated symptoms are entirely absent.

Thus, for example, I have seen a number of cases in which the discharge from the middle ear had stopped for a period of between two and three weeks, the perforations in the drum membrane had healed, and they were practically normal in appearance; and yet in all of these cases the mastoid portions of the temporal bones were found to be extensively diseased.

A very frequent and very prominent symptom is *tenderness on pressure* over a whole or a part of the mastoid process. The tip is the most frequent site of this tenderness and the area over the antrum comes next. When the tenderness is most marked over the posterior cells of the mastoid process it is quite likely we are dealing with a case complicated with a perisinus abscess or even with a sinus thrombosis. Another point where mastoid tenderness is to be detected is upon the posterior surface of the wall of the external auditory canal. If the case is a recent one this tenderness on pressure may not be very significant; but if it persists, without diminution in intensity for forty-eight hours, then it is time for the surgeon to invade the mastoid cells. The difficulty is, that this symptom is frequently absent even in a case of well-marked mastoiditis. A differentiation will have to be made between tenderness on pressure due to mastoiditis and tenderness due to a furunculosis of the external auditory canal. The history of the case will be of service in reaching a conclusion. If mastoiditis is present, there will generally be a history of pain followed by a discharge; the active pain then ceasing. Then besides, as the canal is generally found to be sufficiently open for the observer to obtain a view of the drum membrane, he will be able to see the pus oozing through a perforation. On the other hand, in a case of furunculosis of the external auditory canal the pain does not diminish but rather increases, the canal is stenosed, there is little or no discharge, and, with the aid of a probe, a localized area of tenderness may be detected at some point on the wall of the external auditory canal. The discharge from a case of furunculosis is free from any mucus while that from a middle-ear infection always contains some.

In using pressure as a means of detecting mastoid tenderness it is important that this pressure should be firm and steady. It is also advisable to test both mastoids—the presumably healthy one as well as the suspected one—as in some individuals hyperesthesia is marked, and one may find as much tenderness on pressure over the healthy mastoid as over that which appears to be involved.

Pain which is located in the mastoid process or its vicinity, and which persists despite free drainage, is another diagnostic symptom of mastoiditis. Still another is to be found in *hyperemia and edema of the skin covering the mastoid process.* When this is found in a case in which furuncular inflammation of the external auditory canal is not present it is time, in the vast majority of instances, to operate. The only exception is in those cases in which this symptom manifests itself very early in the disease (the second or the third day), when a delay of twenty-four to thirty-six hours is permissible, provided no other symptoms of mastoiditis are present. As a rule, however, hyperemia and edema develop at a relatively late stage of the disease, and when they are present the signification generally is that the case has progressed very rapidly, or that the mastoid cortex is quite thin. Extension of the inflammation into the soft parts of the neck generally means that a perforation through the inner table has taken place. It may also signify a similar perforation through an unusually thin body wall of one of the large cells at the tip of the mastoid process.

Cases of mastoid fistula demand immediate operation.

Torticollis occurring in cases of aural disease is suggestive of a mastoiditis with spontaneous perforation of the inner plate of the mastoid process and a burrowing of the pus into the muscles of the neck. It may occur, however, in lymphatic children because of the involvement of the lymphatics in this region in cases where there is only a mild otogenic infection.

If the *temperature* remains high or is of a septic type, the operation ought not to be delayed.

Finally, it must be remembered that there are cases of well-marked mastoiditis in which all of the symptoms mentioned above may be absent.

A good rule to follow, in all cases where the mastoid infection is not well defined, is when in doubt as to the necessity of an operation, take the less dangerous course and explore the mastoid process. Never wait for redness and swelling or fluctuation over the mastoid process. While the operation is one that requires skill and is not to be lightly undertaken, yet it is also one that if properly performed is practically devoid of danger. On the other hand, the disease itself is characterized by a decided tendency to spread beyond the limits of the mastoid process. It may force its way through the inner table of the skull, and the pyogenic organisms may reach the sigmoid sinus, dura mater, pia mater, cerebrum, or cerebellum, there to set up a septic sinus thrombosis, a pachymeningitis, an extradural abscess, a leptomeningitis, a cerebral or a cerebellar abscess. A disease which carries such deadly possibilities within itself is a disease not to be trifled with.

Preparation of the Patient.—If the exigencies of the situation are such that from twelve to eighteen hours may be allowed to elapse before the operation, the patient should be prepared as for any other major operation. The bowels should be thoroughly evacuated, the healthfulness of heart, lungs, and kidneys ascertained, and the patient should be without any food in the stomach for a period of, at least, six hours before the administration of the anesthetic.

The hair, for a considerable extent in the vicinity of the mastoid process, should be dry shaved (if a complicating brain abscess is suspected, the entire head should be shaved) and the underlying skin surface, as also the auricle, rendered aseptic by painting with tincture of iodine and then covered with a sterile dressing.

The external auditory canal, which is, as a rule,

serving as a drain for the pus flowing from the tympanic cavity, should be irrigated with a bichloride-of-mercury solution (1 to 3,000) sufficiently often, during the interval between the application of the dressing and the time of operation, to keep it fairly free of pus. After each irrigation a wick of sterile gauze should be inserted into the canal and a fresh external dressing applied.

In many cases the necessity for immediate operation will not permit the making of the preparations just described. In all cases, however, the patient, the surgeon, and his various assistants, as well as everything that may directly or indirectly come in contact with the wound, should be rendered as thoroughly aseptic as possible.

The patient should be placed upon the operating table with a hard cylindrical pillow under his head. (This pillow, however, should be of the same thickness as the other cushions which cover the table, as it is not desirable that the head should be elevated above the level of the shoulders.) A piece of india-rubber sheeting, large enough to extend well over the shoulders and chest of the patient and below the cushions of the table, should be securely fastened about his neck. Sterile towels should be fastened tightly about the head, leaving free only the operative field; sterile towels should be placed over the chest and shoulders and fastened together by means of safety pins or towel pins.

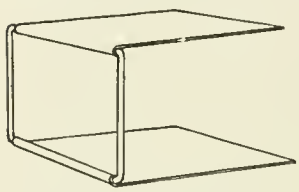


Fig. 3919. — Device through which the Anesthetist Works and which Shuts off the Operative Field from a Possible Source of Contamination.

Fig. 3919 shows a simple device made of a rectangle of nickel-plated iron wire, and to the bottom and top of this rectangle are hinged pieces of thin sheet metal. The bottom piece fits under the patient's head and the upper piece lies on the uppermost portion of the patient's face. A sterile towel is folded partially under and partially over this upper piece and thus protects the operative field from the anesthetist, who anesthetises through the rectangular opening and underneath the towels. Over this area and the rest of the patient is spread a sterile sheet with an opening in the upper portion. through which the operator works. The seat of the operation is again painted with iodine and washed with alcohol and the patient is then ready for the operation.

Instruments Needed.—It matters not how simple the case of mastoiditis about to be operated upon may appear, the surgeon should at all times be prepared, if such a step should be found necessary, to open the sinus and excise the internal jugular vein for a sinus thrombosis, or to trephine the skull and explore the brain for a cerebral or a cerebellar abscess, or to explore the structures of the internal ear. He should have for the operation the instruments shown in Fig. 3920.

It adds materially to the expeditiousness of the operation if the surgeon has some definite arrangement for placing the instruments on the table. After a short time he is able without hesitancy to place his hand directly on the instrument wanted. (Fig. 3920 shows the table in a measure so arranged.) The instruments enumerated above and shown in the figure are not required for every operation. For the simple mastoid operation many of them are superfluous. The instrument table is larger than the one shown here, and the space occupied by the syringe, gauze, cotton-carriers, encephaloscopes, and catgut is used for a tray of sterile water where the instruments are cleansed of blood as rapidly as put aside by the surgeon and again put in their designated places on the table. An infusion apparatus, an irrigation bottle, needles, catgut for ligatures, Horsley's wax to control hemorrhage from the bone, silkworm gut for sutures, iodoform gauze in bulk as also in strips one-half inch and one inch wide (cut so that the edges will not ravel), dry sterile gauze handkerchiefs and sterile cotton for dressings, bandages two inches wide, also dry sterile gauze sponges, should be provided.

The Simple Mastoid Operation.—Each surgeon will have his own preferences as to minor operative details. I prefer to stand at the head of the table, near its right-hand or left-hand side, according to whether it is the right or the left ear which is involved. The anesthetist stands in front of the patient's everted face; the second assistant, who manages the retractors and holds the artery forceps out of the way, stands between the anesthetist and the operator; while the first assistant, who sponges and seizes bleeding vessels, stands on the other side of the operator. The instrument table with the attendant nurse is within my convenient reach.

Narcosis.—My preference is for nitrous oxide gas followed by ether. In cases of suspected brain abscess in very young children, in kidney complications, or when edema of the lungs is to be feared, chloroform is to be preferred. Schiebe reports six cases in which local anesthesia (ethyl chloride) was employed, in five of which cases it gave good satisfaction. I have also used the combination of nitrous oxide gas and oxygen successfully.

As a preliminary step to the operation the drum membrane should be incised, if a free opening does not already exist in it, and a strip of iodoform, or of plain sterile gauze, should again be inserted into the auditory canal.

The Operation.—The first incision is made by inserting the point of the knife, held at right angles to the surface of the skin over the tip of the mastoid process and carrying it through the periosteum to the bone; the handle should then be lowered so that the curved edge of the blade does the cutting, and the incision itself should be carried, in a direction parallel to the insertion of the auricle and about five millimeters from it, to a point directly above the external auditory canal (see Fig. 3921, *A D B*). In adults the scalpel should cut through the periosteum with the first incision, but in the case of children it is not safe to do this, for the reason that in them the cortex of the mastoid process is so thin that the knife might easily pass through it and so wound the underlying sigmoid sinus or the dura mater. In cases in which the mastoid process is large, it will be necessary to make a second incision (Fig. 3921, *D E*), extending horizontally backward on a level with the external auditory canal and at right angles to the first one. In still another group of cases it may be necessary to extend the first incision horizontally forward (Fig. 3921, *B C*), a short distance in front of the anterior insertion of the auricle.

The next step is to push backward, with the periosteal elevator, the posterior flap including its periosteum, and thus expose the greater portion of the mastoid process. In a similar manner the anterior flap and its periosteum are to be pushed forward for the purpose of exposing the posterior and superior borders of the external auditory canal and the root of the zygomatic process. In separating the periosteum from the bone, great care should be taken to avoid wounding the membranous wall of the external auditory canal. If wounded it may give rise to a permanent opening behind the auricle or to atresia of the canal.

It is next necessary to control all bleeding by means of hemostatic clamps. When this has been accomplished a retractor is placed in position so as to hold forward the anterior flap, and another is placed to hold backward the posterior flap. It is generally necessary at this point in the operation to extend,

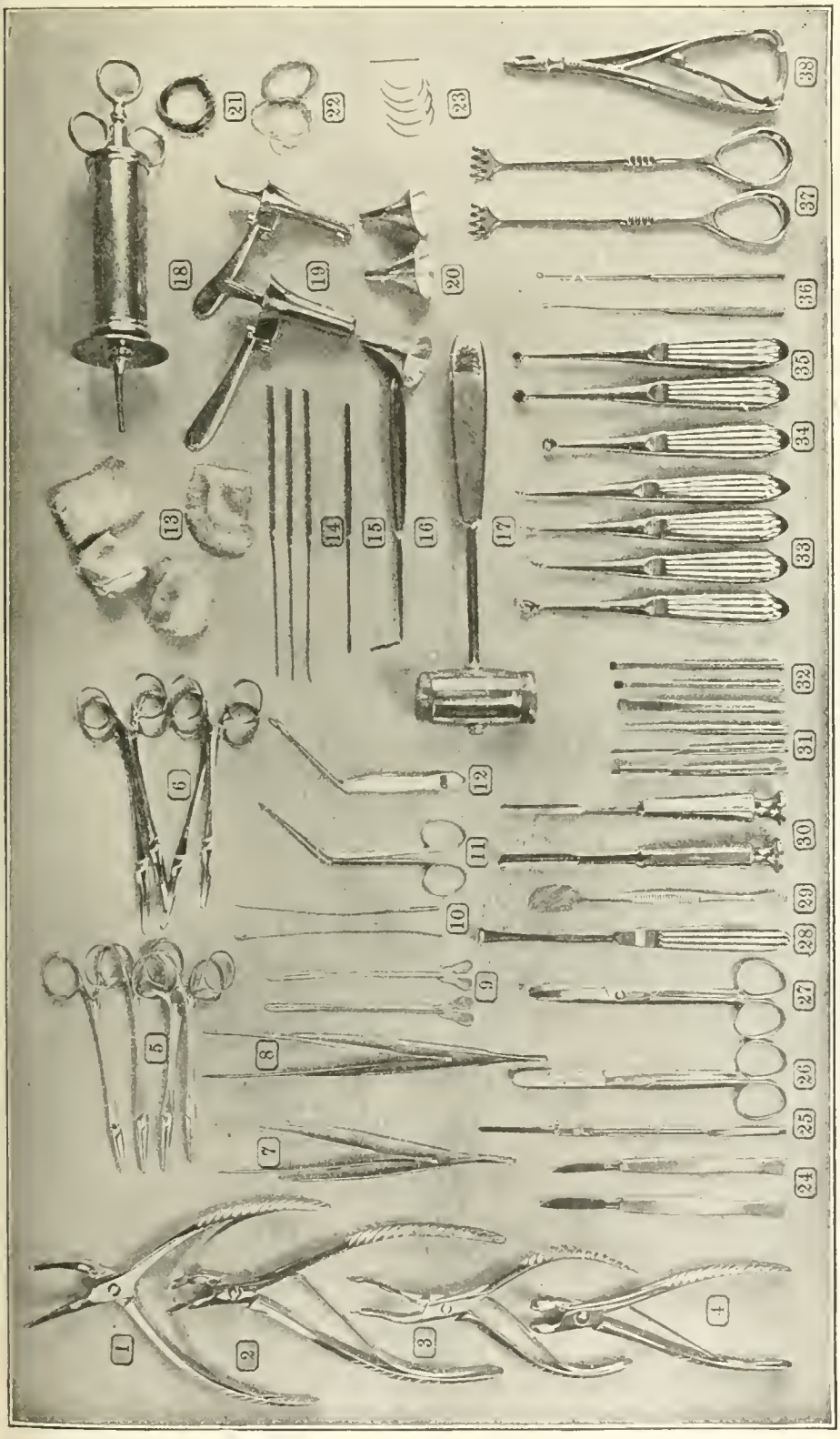


FIG. 3920.—Instruments Required in Operations upon the Mastoid Process.

1, Whiting's long-beaked bone forceps for working in the bottom of deep-seated cavities; 2, Whiting's short-beaked forceps for working in narrow but shallow cavities; 3, Jansen's forceps for the removal of the posterior and upper wall of the external auditory canal between its external surface and the exposed anterior boundary of the antrum and aditus ad antrum, thus making one cavity of the middle ear, and external auditory canal—the forceps is so fashioned that the desired piece of bone may readily be removed without at the same time wounding the facial canal; 4, Mathieu's forceps for rapid work in removing large pieces of bone; 5, straight and curved hemostatic clamps; 6, mouse-toothed dressing forceps; 7, 8, blunt dressing forceps; 9, grooved directors; 10, silver probes; 11, Hartmann's ear forceps; 12, Politzer's ear forceps; 13, gauze (iodoform and plain sterile) strips one inch wide; 14, cotton applicators; 15, myringotome; 16, aneurysm needle; 17, mallet; 18, Pomeroy's aural syringe; 19, Whiting's encephaloscopes, large and small; 20, aural specula, Boucheron's; 21, silkworm gut for sutures; 22, catgut for sutures and ligatures; 23, needles; 24, scalpels; 25, probe-pointed bistoury with extra long blade for making meatal flap in the radical mastoid operation; 26, scissors, straight; 27, scissors, curved on the flat; 28, periosteal elevator, Langenbeck's; 29, periosteal elevator; 30, bone gouges, large; 31, gouges, small; 32, chisels; 33, bone curettes, Buck's; 34, bone curette, fenestrated; 35, bone curettes, fenestrated, Richard's, for working chiefly with the handle at or nearly at right angle to the bone and toward the operator; 36, Buck's sharp ring curettes for working in the tympanic cavity; 37, retractors; 38, needle holder.

with the scissors, the first incision downward for a distance of about eight or ten millimeters. Then with the blunt-pointed scissors, curved on the flat, the operator separates the tendinous insertion of the sternocleidomastoid muscle from the top of the mastoid process. The point of the scissors is kept in close contact with the bone and the muscle is divided by small bites, so as to avoid wounding any of the vessels of the neck. The bony surface of the mastoid process having thus been fully exposed to view, the surgeon must take notice of the landmarks which are to guide him in his further operative procedures. First, the surgeon directs his attention to the *supramastoid fossa* at the juncture of the posterior and superior margins of the bony portion of the external auditory canal. This fossa in front of which is to be found a small spine (*spina supra meatum*, or the *spine of Henle*) presents a sieve-like appearance, due to the presence of several vascular foramina—the *vascular zone*, or, as it is called by some authors, the *spongy spot*. At times these vascular foramina dip down into the underlying cells, the lining mucous membrane of which comes almost in contact with the external periosteum, and they thus afford an easy passage of pus from these cells to the surface of the mastoid. A carious opening will occasionally be found at this spot. The antrum is situated exactly in the same horizontal and lateral planes as this fossa. From infancy to adult life its position changes. In infancy it is above

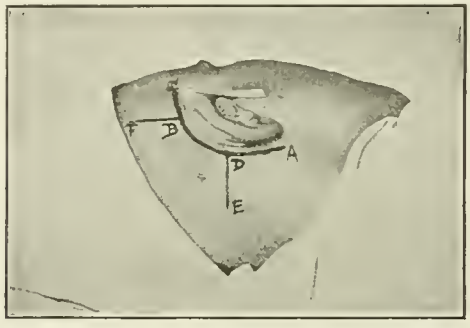


Fig. 3921.—Shows the Patient Prepared for Operation and the Various Incisions. *A D B*, Line of incision close to auricular fold—the only incision necessary in most cases of simple mastoiditis; *D E*, the posterior incision necessary in cases with a large mastoid process, in sigmoid sinus thrombosis, and in intracranial complications situated in the posterior fossa; *B C*, extension of first incision necessary in the radical operation, the Stacke operation, and in intracranial complications in the middle fossa; *B F*, additional vertical incision necessary in cases of intracranial complications in the middle fossa. (The strip of adhesive plaster is used merely to hold the auricle forward so as to show the line of incision.)

the meatus, from which point it gradually moves downward and backward in a circle concentric to the auditory meatus until, in adult life, it is to be found immediately behind the suprameatal spine. In infancy the center of the antrum is slightly above and behind this spine, but it then gradually passes downward and backward until at the age of ten it is directly back of the suprameatal spine. From this age onward the center of the antrum passes backward until, in the young adult, it is located at a distance of about five millimeters from the suprameatal spine. This fossa, therefore, is our most important guide to the antrum, as it is always present, whereas this is not true of the suprameatal spine. Macewen's guide is a triangle, which he terms the "suprameatal triangle," formed above by the posterior root of the zygomatic process, below by the superior and posterior wall of the bony external auditory canal, and behind by an imaginary line connecting the extremities of these two lines. In early life the non-existence of the posterior root of the zygomatic process renders this guide less positive than the one mentioned above. The spine of Henle also gives some idea as to the positions of the lateral sinus and the middle cranial fossa. If the spine is high up in the meatal wall the surgeon may expect to find a sinus situated well forward and a low-lying cranial fossa.

The next landmark to observe is the linea temporalis which is the extension backward of the posterior root of the zygomatic process. This is an important guide, as it indicates in a fairly accurate manner, the level of the floor of the middle cerebral fossa, the latter being more often a little below than a little above this line. In broad skulls the middle fossa will generally be lower than in long skulls. Before beginning the operation the surgeon will do well to call to mind the anatomical structures which are to be avoided. The floor of the middle cranial fossa is, as I have stated above, fairly easily avoided by not removing any bone and especially so near the cortex of the mastoid process above the line of the temporal ridge. Another very important structure which should be borne in mind is the lateral sinus. This structure is very variable in its relation to the mastoid antrum (see Figs. 3922, 3923, and 3924). According to Lake (*Journal of Laryngology, Rhinology, and Otology*, vol. xiii., p. 231), its distance from the antrum varies from 0.2 inch (5 millimeters) to 0.7 inch (about 17 millimeters). On an average it is situated at a distance of 0.48 inch (12 millimeters) from this cavity. The sinus is more superficially situated than the antrum. On the right side it extends, as a rule, further forward than it does on the left side and in broad skulls it will generally be found located farther forward than in long skulls. The location of the sinus may be mapped out to a large extent by noting the area of greatest convexity of the mastoid process. The sinus will be found beneath this area.

In infancy the distance of the antrum from the cortex of the mastoid process varies from 2 to 4 millimeters ($\frac{1}{2}$ to $\frac{1}{6}$ of an inch); in children it has been found at as great a depth as 10 millimeters ($\frac{2}{5}$ of an inch). In adults, on the other hand, it is much farther removed from the surface of the bone; the distance (measured from the suprameatal fossa to the outer wall of the antrum) being from 12 to 18 millimeters ($\frac{1}{2}$ to $\frac{4}{5}$ of an inch) (Kerrison, *Arehives of Otology*, vol. xxxii., No. 3), by the measurements of a number of temporal bones, concludes that the depth at which the antrum is situated is always less, by actual measurement, than the length of the posterior superior canal wall, and that the depth rarely exceeds 15 millimeters or about $\frac{5}{8}$ of an inch. (The average of all of his measurements was 11 millimeters (not quite $\frac{1}{2}$ inch); while the average length of the posterior superior canal wall was found by him to be 14.7 millimeters.) Broca states that he has found it in two very old subjects, at the extreme depth of 25 millimeters, in one case and 29 millimeters in the other. When the surgeon encounters a case in which the antrum is located at an unusual depth, he must persist in his efforts to reach his objective point, but at the same time he must proceed with caution. In pneumatic mastoids this is comparatively an easy thing to do, but in cases where chronic conditions have caused a sclerosis it is often necessary to chisel through a hard compact mass of bone to proceed through which requires the determination which comes alone from experience and from the knowledge that the antrum does exist and is to be found. The antrum is connected with the tympanic cavity by a canal—the *aditus ad antrum;* this canal is from 3 to 5 millimeters long, 3 millimeters high, and 3 or 4 millimeters deep. Its upper wall, the *tegmen tympani*, forms part of the thin plate which separates the tympanic cavity from the cranial cavity; at times it is wanting. The mucous membrane and endosteum lining the tympanum are in close contact with the underlying bone, and hence, in purulent inflammations of the tympanum, caries and necrosis readily occur. In view of the fact that the tegmen tympani and the tegmen antri are very thin, or may

even be wanting, it is a source of wonder that abscess of the middle or of the posterior portion of the temporo-sphenoidal lobe does not more often occur.

Two very important structures, it must be remembered, are in close relation to the aditus ad antrum, namely, the *facial nerve*, and the *horizontal semi-*

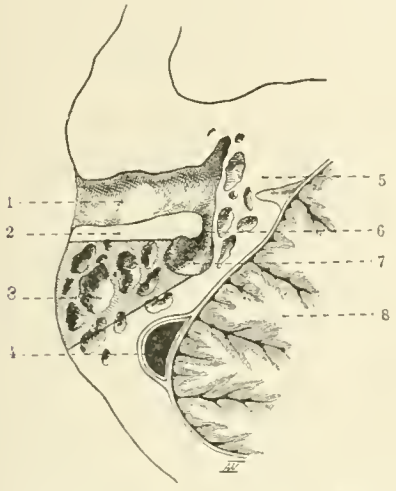


Fig. 3922.—Horizontal Section through the Mastoid Process, External Audtory Canal, etc., showing the limits of the bone removed in the classical mastoid operation, as well as the relations of the excavation to the lateral sinus, antrum, and posterior canal wall. (Laurens.) 1, The external auditory canal; 2, posterior wall of the external auditory canal; 3, that portion of the mastoid which is excavated in the operative procedure; 4, sinus; 5, internal ear; 6, aditus ad antrum; 7, antrum; 8, brain. (The shaded area, 3, in the diagram is too narrow; it should extend far enough back to include the cellular structure lying outside the shaded portion.)

circular canal, which lies at a distance of from 15 to 18 millimeters ($\frac{3}{5}$ to $\frac{3}{4}$ of an inch) beneath the cortex. The facial nerve is the structure which it is especially important to avoid in all mastoid operations. There are two places in its course where it is most likely to be exposed to injury in operative procedures upon the mastoid process. The first point is situated in the horizontal portion and elbow of the facial canal, where it passes under the aditus ad antrum. When the nerve is wounded here it is generally due to the careless use of the curette when employed for removing granulations from the epitympanic space. The second point where the nerve is liable to injury is near its exit from the stylomastoid foramen. It is apt to become involved at this point in those cases in which perforation of the inner table or anterior surface of the mastoid process takes place—the so-called Bezold's perforation. The nerve is also apt to receive damage at this point in infancy, because the undeveloped condition of the mastoid process leaves the stylomastoid foramen more exposed upon the lateral surface of the bone than is the case in adult life. The surgeon, in using his curette, in those cases in which the cells lying above and behind the jugular bulb are involved, will have to exercise care, so as to avoid wounding the facial nerve.

The only part of the internal ear which is apt to be encountered in operative work is the horizontal semicircular canal. This canal, which is surrounded by an eburnated sheet of bone and is situated just behind the inner wall of the aditus ad antrum, is rarely injured. In order to avoid injuring it, one needs only to be careful not to curette the inner wall of the antrum and of the aditus ad antrum.

The short process of the incus is another part which bears some relation to the aditus ad antrum; it rests upon the floor of this canal at its tympanic end.

The surgeon having recalled to memory the various landmarks and the relations between the structures which he expects to invade and those which he must avoid, is now ready to proceed with the bone operation. As the first step, the large bone gouge is placed in contact with the bone at the upper border of the suprameatal fossa, and with it the surgeon proceeds to remove a long narrow sliver of bone extending from this point to the extreme tip of the mastoid process; that is, he uncovers that portion of the mastoid process where the external surface curves over to form the anterior surface. In taking this step he will gain some idea of the character of the mastoid process—whether it is made up of pneumatic or of diploetic cellular structure, or whether it be sclerosed. He need have no fear of wounding the sinus, as it is almost impossible to do this unless it happen to lie immediately beneath the cortex of the mastoid process at the point where it curves in to form the external auditory canal—a position which it rarely occupies. However, if he is careful to hold the gouge firmly and at a very acute angle to the bone surface, he can scarcely injure the vessel even if it should occupy this very exceptional position, for the instrument would slip along its flexible surface and so in all likelihood would not wound it. From the vertical groove thus established he should proceed, with gouge or chisel and rongeur forceps (chiefly the latter), to remove the remaining cortex of the mastoid process. The chisel is used but little, except in sclerotic cases, after the cortex has been removed. The curette and the forceps are used to remove each of the cell partitions throughout the whole mastoid structure until the cells are entirely obliterated and the inner plate of the mastoid process is reached. This thin plate of bone, as will be remembered, is the only structure which separates the sinus and the dura of the posterior and middle cerebral fossæ from the pit made by the removal of the mastoid cells. If, upon careful examination, it shows evidences of being diseased, or if, though it should appear to be healthy, the history of the case should warrant the suspicion

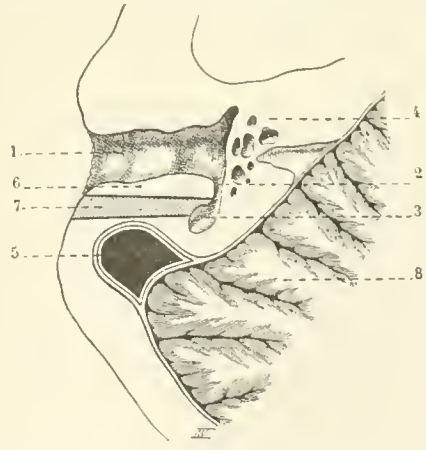


Fig. 3923.—This Diagram represents a Horizontal Section through the Mastoid Process, Antrum, Sinus, etc. In the picture the lateral sinus is situated very far forward, and the mastoid process is small and sclerosed. (Laurens.) 1, External auditory canal; 2, aditus ad antrum; 3, antrum; 4, labyrinth; 5, sinus; 6, posterior wall of the external auditory canal; 7, route by which the antrum may be entered; 8, brain. (Of course the excavated portion may be extended farther backward underneath the sinus.)

that pathological conditions exist in either of these fossæ, or that the lateral sinus is involved, this plate of bone must be removed to permit of a thorough examination of the parts lying underneath.

If it should appear to some that the plan here advocated, of removing all the mastoid cells, is unnecessarily thorough, their attention is called to the

fact that unless these structures are completely eradicated, some remote cell with its nidus of infection may be left behind, and then, weeks later, when the wound is still open, although apparently well on its way toward healing, it is necessary to conclude, from the unsatisfactory manner in which the case is progressing, that the operation was not thoroughly performed, and that it, with all the attendant dangers and worries, must be performed a second time. There are cases which occur even in the most thorough of operations, where some portion of bone will become necrotic after operation and will prevent healing and where it may be necessary to perform a second operation. It is surprising to note how often, in the course of a mastoid operation, one encounters—at some point quite remote from the antrum and separated from it by other cells which to the unaided eye appear to be fairly normal, or at all events free from the presence of anything like purulent material—a single cell filled

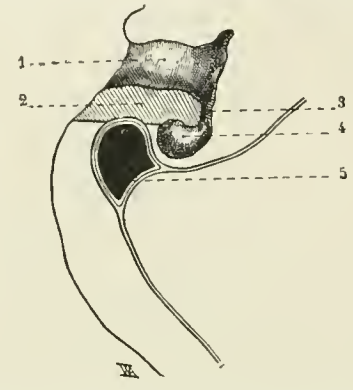


Fig. 3924.—Horizontal Section (Diagrammatic) through the Mastoid Process, External Auditory Canal, Antrum, Sinus, etc. In the picture the sinus is situated very far forward, in front of the antrum. In a case like this it would scarcely be possible to reach the antrum except by removing the external portion of the posterior wall of the external auditory canal. (Laurens.) 1, External auditory canal; 2, posterior wall of the external auditory canal removed in the search for the antrum; 3, aditus ad antrum; 4, antrum; 5, sinus.

with pus. Such a discovery is apt to be made among the cells situated in the posterior portion of the tip of the mastoid process, and occasionally also among those located in its upper and posterior portion.

As even the complete destruction of the distinctive mastoid cells cannot be trusted to eradicate all the sources of infection, it is advisable, in addition, to obliterate all the cellular structure located anteriorly to the antrum above the external auditory canal and at the root of the zygomatic process, as well as those cells in the petrous portion, which lie between the posterior boundary of the antrum and the anterior and superior border of the sigmoid sinus together with those other deeply situated cells, which lie above and posterior to the jugular bulb.

It will generally be found best to remove the entire tip of the mastoid process, instead of leaving, as is often done, its inner surface, which serves no useful purpose. In course of time the sternocleidomastoid muscle forms new attachments, and I have never seen a case in which the muscular movements of the head were at all interfered with as the result of the removal of this plate of bone. The aditus ad antrum ought to be gently curetted and freed of all granulations and carious bone, otherwise the products of inflammation in the tympanic cavity will be prevented from properly draining through the posterior wound.

If for any reason—as, for example, when a sinus is situated very far forward—the antrum cannot be reached in the usual way, it may be necessary to enter by way of the bony external auditory canal. By separating the soft tissues from their bony support the upper and posterior bony wall of the external auditory canal may be removed with the chisel and the antrum opened, care being taken to avoid breaking the tympanic ring and entering the tympanic cavity.

In carrying out the operation in the manner here described, the surgeon will always have before him a broad and open field in which there are no obscure pockets. If he chance to wound the sinus—an accident which is generally the result of undue haste—he will experience no difficulty in controlling the hemorrhage by the simple application of an iodoform gauze tampon; and afterward he may proceed with the operation by working around this tampon—a procedure which could not so readily be carried out if the sinus had been wounded while he was working at the bottom of a deep cavity.

It is important, as the operation proceeds, to ascertain whether or not the granulations are lining a bony cavity or are springing from the dura mater or sinus and protruding into the mastoid cells through an opening in the inner table. Unless this precaution is taken, it is easy, while using the curette, to wound the exposed dura mater or to plunge into the sinus. The existence of any possible sinus, which may lead through the inner table into either the middle or the posterior fossa, should be carefully searched for. If such a sinus is found to exist, it should be enlarged so as to permit of the easy examination of the underlying tissues. This careful investigation is absolutely necessary, so as to prevent the possibility of a case of unsuspected perisinous abscess, or of extradural abcess, remaining undiscovered.

In cases of perforation through the posterior wall of the external auditory canal this bony partition will have to be removed to a limited extent and the adjacent soft tissues carefully curetted. It is rarely necessary, in acute cases, to remove that portion of the posterior wall which includes the tympanic ring.

If the mastoid process is one that contains few pneumatic cells, the surgeon, in performing the operation, must adopt a course somewhat different from that which I have advocated above; he must first search for and find the antrum, and then from this point he should work toward the tip and posterior portion of the mastoid process until this process has been fully excavated. Such thorough excavation is as necessary in these cases of sclerosis as it is in those first described, for in this type of mastoid a large cell is often found remotely situated from the antrum, and yet filled with pus. In fact, cases occur in which, while the antrum and adjacent cells are apparently free from purulent matter, a cell located posteriorly and near the tip is found to be full of pus.

In cases in which a perforation has already taken place spontaneously in the cortex of the mastoid, the use of the chisel is unnecessary; the surgeon may begin at once with the curette and follow the fistulous tract which exists and which always leads into the antrum. After he has reached this cavity he may proceed with curettes and forceps as in the first type of cases. In following such a fistulous tract, however, considerable caution is needed if one wishes to avoid plunging into an uncovered lateral sinus.

When the surgeon is positive that every pneumatic cell of the mastoid process has been excavated, in other words, after he has performed thoroughly the work, which he sees before himself at the beginning, viz., that of removing from the mastoid region every vestige of infective material and after he has carefully smoothed down all the rough places both on the inner table of the mastoid process and along the edges of the excavation in the bone, he may either cleanse the cavity with a normal salt solution or simply mop the surface with dry sterile gauze. (In children particular care should be taken not to use such solutions as one of bichloride of mercury, on account of the ease with which solutions pass through the Eustachian

tube into the throat.) In syringing the wound no forcible effort ought ever to be made in an endeavor to have the solution pass through from the opened antrum into the tympanic cavity, and thence through the external auditory canal. If the operator can readily pass his probe into the tympanic cavity he has accomplished one of the important objects of the operation, viz., to establish tympanic drainage posteriorly, and it is not necessary to force fluids through the membrana tympani and external auditory canal after the cavity has been cleansed. The next step is to tie off any bleeding vessels, then to close with silkworm-gut sutures or metal clamps the posterior cutaneous incision, if one has been made, and, finally, to close in the same manner the upper angle of the auricular incision as far as the level of the external auditory canal. The remainder of the incision is left open. The cavity of the wound is lightly packed with iodoform gauze, and a small wick of sterile gauze is also inserted into the external meatus as far as the membrana tympani. This last measure provides for proper drainage and prevents the retention of any secretions in the tympanic cavity and also prevents collapse of the canal. The wound and the auricle are then covered with sterile gauze and a bandage is applied over all.

The outside dressing is changed the next day and the iodoform packing and clamps or sutures are removed on the fourth day (unless pain, or a rise of temperature, indicates the necessity for their earlier removal). In many cases a postoperative fever will occur the day after the operation, and in infants and young children the temperature is very likely to rise as high as 102° F. If the fever continues on the second and third days it may be due to wound infection or to some complication; under these circumstances the dressings should be removed and the parts examined. The cavity at each dressing is dry-cleansed, a sterile gauze dressing is very loosely placed in it, and the external dressings are applied as before. If the case has been one of simple mastoiditis, it is seldom requisite to keep the patient in bed more than from five to seven days. Care must be taken in all subsequent dressings that the granulations shall spring up evenly around the bottom of the wound, and that the superficial healing of the wound shall not occur before the cavity is filled with healthy granulation tissue.

In cases with a past history that is favorable, healing takes place in from four to six weeks; while in cases with a previous history of ill-health the healing may be delayed for as many months. The after-care of the case is one that requires much judgment. Irrigation, especially with a solution of bichloride of mercury, is injurious to the delicate granulations which are endeavoring to fill the cavity. For cleansing the latter, careful use should be made of pledgets of dry gauze or of pledgets of absorbent cotton moistened in sterile water. After the first few dressings the wound should be packed with simple sterile rather than with iodoform gauze, as the latter tends to promote exuberant granulations. The packing should be introduced somewhat loosely, the quantity of gauze used being simply sufficient to absorb the discharge and to prevent the superficial union of the tissues. The scissors or the curette may be used for the removal of exuberant granulations, which at times form along the edges of the wound. To stimulate the formation of granulations on the bone, in cases which are slow to heal, an application of pure carbolic acid, followed immediately by one of absolute alcohol, will be found advantageous. A solution of nitrate of silver, of a strength of from forty to sixty grains to the ounce of distilled water, or balsam of Peru, may also be used. Insufflations of boric acid, of subgallate of bismuth, or of xeroform, are of assistance in cases in which there is much discharge, as also toward the end of the healing process. After the first few dressings the gauze bandage (Johnson and Johnson manufacture a black gauze bandage which is less conspicuous than the white one) may give way to a black silk pad which is tied over the wound by means of tapes passed around the head. When the wound becomes small enough, the dressing may be fastened to the skin by means of flexible collodion.

In a few cases the otorrhea may persist. This is more likely to happen in neglected cases, where the operation has not been performed early enough, or in cases of a very virulent type. Under such circumstances one may expect to find the mucous membrane of the tympanic cavity covered with granulations, or some portion of its bony wall in a necrosed state, or one or more of the ossicles similarly affected. Systematic cleansing of the canal with sterile salt solution or a boric-acid solution may suffice in some of these cases to arrest the otorrhea; but if granulations have formed or if there be a limited necrosis of bone structure, it will be necessary to employ a Buck's sharp-edged curette or a Hartmann's cutting forceps. A bead of silver nitrate fused on the end of a slender probe may be used for destroying the granulations, and the instillation of a few drops of a saturated solution of iodoform or of boric acid in seventy-five per cent. alcohol may be found useful in effecting a cure. In some of the cases, however, no medication or simple surgical procedure will suffice to effect a cure, and an ossiculectomy or even a radical mastoid operation may be necessary.

The Blood-clot Method of Inducing Healing of the Mastoid Wound.—This method may be adopted in those cases in which the tissues, during the operation, have been subjected to very little bruising, and in which all granulations and all shreds of tissue have been carefully removed from the antrum and aditus. After the cavity has been irrigated with a sterile saline solution and then wiped dry, it is allowed to fill with blood. No chemical solutions are to be used. When the cavity is filled with blood the overlying soft parts are brought together and sutured subcutaneously with silver wire or silkworm gut. In carrying out this method it is necessary to employ the strictest asepsis; and when it proves successful this procedure shortens very materially the time of healing. Very little if any depression remains behind the auricle after the wound has healed, and the scar in a very short time is scarcely discernible. If the blood clot becomes infected the suture is removed and the case is dressed as an open wound, as described above.

The Radical Operation or the Schwartze-Stacke Operation.—This operation is undertaken for the purpose of curing cases of chronic purulent inflammation of the middle ear in which the actual disease is not confined to the lower portion of the tympanic cavity and the cells around the tympanic end of the Eustachian tube, but consists of a caries of one or more of the ossicles of some portion of the walls, of the epitympanic space of the mastoid antrum and of the adjacent cells. The disease may or may not be accompanied by a cholesteatomatous condition of these cavities.

By means of the operation the surgeon seeks to establish a single large cavity which shall consist of the excavated mastoid cells, the tympanic cavity, and the external auditory canal; this cavity eventually to be lined with a non-secreting epidermal membrane.

The question of operative or non-operative interference in cases of chronic purulent discharge from the middle ear is as yet a mooted question with otologists; that is, some surgeons naturally radical will operate where others more conservative will try the effects of locally applied remedies. Professor Macewen's rule is: "When a pyogenic lesion exists in the middle ear or its adnexa, which is either not accessible or which cannot be effectually eradicated through the external ear, the mastoid antrum and cells ought to be opened." This is, in a sense, a

good broad view, but it may be interpreted in different ways by different operators. For example, they are not likely to agree as to the accessibility of the diseased area; one class of men believing that an ossiculectomy, with removal of the diseased tissues of the tympanic cavity, will render accessible the necrotic area and will bring about the desired cure, while another class of men maintain with equal positiveness that the results of an ossiculectomy are unsatisfactory. Again, as to the possibility of effectually eradicating the disease by working through the external ear, some men, who have given the method a careful trial for a period of several months, claim that it is impossible, in a given case, to accomplish a cure in any other way than by a radical operation. Then, again, there are others who, in a similar case, persevere in this local method of treatment for a year or more and finally obtain a cure. Some believe that in those cases in which the discharge is intermittent the operative plan should be adopted, while others maintain that in these cases one may, without risk of jeopardizing the patient's health or life, advise against an operation provided he will be careful to have his ear examined at short intervals. Case upon case may be cited to support each one of these different views, and, as a still further enhancement of the difficulties of the question, all operators admit having opened mastoids in which the gross pathological lesions were insignificant and wholly out of harmony with the grave character of the symptoms which led to the performance of the operation. The reverse has also been the experience of these same men; they have found great destruction of tissue in cases in which there were but few and not very serious symptoms. Finally, cases are observed in which, within a few hours, the previously insignificant symptoms give place to others of the gravest import. Chronic purulent inflammation of the middle ear is the direct cause of from thirty (Pitt) to fifty (Barr) per cent. of the brain abscesses that occur. It is estimated that in this country about 4,000 cases of brain abscesses of otitic origin end in death annually. According to Körner the Prussian statistics for 1885 give a death rate for otitic brain abscess three times as great as this for each 10,000 of population, or 1.5 from this cause for each 10,000 of population. A fairly large percentage* of the cases of leptomeningitis, of pachymeningitis, of pyemic sinus thrombosis, and, to a less degree, of septic pneumonia, pleurisies, general septicemia, etc., are of otitic origin. To prevent the development of these most serious complications the aural surgeon must urge the necessity of dealing with every case of chronic purulent discharge from the middle ear as something not to be lightly regarded, but as a disease which must be eradicated, no matter how innocent a case it apparently may be. The disease is capable of advancing most insidiously, and frequently without any symptoms, until a very extensive destruction not alone of the tympanic cavity and its adnexa but of the brain tissues as well, has taken place. Brain abscesses have often been found at the autopsy to have been the cause of death when no such lesion was suspected in life. How many more cases of this and other pyemic complications of otitic disease are fatal annually, in which death is attributed to the complicating pyemic metastasis, or to apoplexy, or to heart disease, may only be suspected.

Macewen says "that one who has a chronic purulent otitis media is liable to have, with very little warning, a most serious or even a fatal illness." Acute or chronic disease of the middle ear is a disease that is fraught with much danger to life and should always be regarded most seriously.

Indications for the Performance of the Radical Mastoid Operation.—The question of operative or non-operative interference in prolonged suppuration from the middle ear is not a difficult one to decide if all the symptoms of an acute exacerbation of the inflammation in the mastoid antrum and vicinity are present. For example, if a fistula exists in the mastoid process; if it can be demonstrated that a cholesteatomatous mass occupies the region of the antrum or adjacent cells; if, after repeated removals, granulation tissue is still reproduced in the tympanic cavity; if facial paralysis is present; if, in consequence of a narrowing of the external auditory canal, the discharge from the deeper parts cannot escape freely; if vertigo is present or if there are recurring attacks of mastoid tenderness, there can be no question as to the need of operation, and this need becomes imperative if in addition there are headache, malaise, and elevated temperature. It is only in cases where, aside from an incurable discharge, there are no objective symptoms, that the surgeon hesitates; and even in these cases the consensus of opinion is in favor of operative interference, as the operation, although not devoid of danger, is less dangerous than the existing disease—or, as Grant states, "the responsibility is greater in deciding against than in deciding in favor of an operation."

The Steps of the Operation.—The patient is prepared as is described above for the simple mastoid operation.

The incision (Fig. 3925) is carried from the anteroinferior border of the tip of the mastoid process in a curvilinear direction upward, backward, and then forward to a point above the insertion of the anterosuperior angle of the auricle. The center of this incision should be about one inch behind the center of the posterior insertion of the auricle. This incision gives better results, especially from a cosmetic point of view, than does the incision made nearer the auricular insertion. In making the incision it is advisable to cut through all tissues down to the bone from the tip up to the temporal ridge, but from this point to the extreme end of the incision it is not necessary to cut any deeper than down to the aponeurosis which covers the temporal muscle. If a fistulous opening exists in the skin surface it is excised or the incision is made so as to include it. When the anterior flap is retracted it is pushed sufficiently far forward to expose the posterior bony wall of the external auditory canal. As the next step, the posterior wall of the membranous external auditory canal is separated from its bony support and made to lie flat

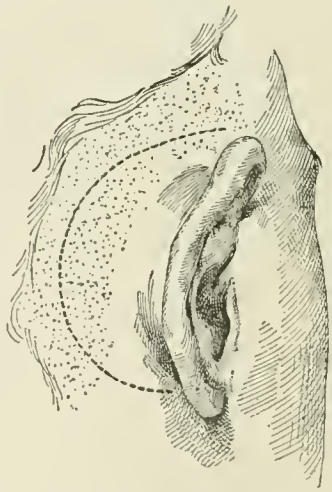


Fig. 3925.—The dotted line shows the line of incision required when the large anterior mastoid flap is to be used.

*About five per cent. of all cases of meningitis and two-thirds of all cases of sigmoid sinus-thrombosis are of otitic origin (Pitt). In 17,028 autopsies in London death was due in 102, or 1 in 167, to an otitic lesion. In 10,707 cases with tympanic suppuration 69 deaths occurred as the result of the aural lesion, or 1 in 155 (Körner). In 38,017 aural patients death occurred, as the result of the disease, in 119, or 1 in 319 (Bürkner's and Randall's individual statistics combined). Whitehead (*Arch. Otology*, vol. xxxv., p. 427) in an article based upon work performed at the General Infirmary at Leeds, England, states that "There was an antecedent history of chronic otorrhea in 2 out of 33 cases of meningitis; in 17 out of 20 cases of sinus thrombosis; in 20 out of 21 cases of cerebral abscess; in 13 out of 15 cases of cerebellar abscess; and in 1 out of 2 cases of combined cerebral and cerebellar abscess."

on the anterior wall of the canal, thus exposing the entire upper and posterior wall of the bony canal as far as the tympanic ring. This should be done with great care, so as to avoid bruising the periosteum, which eventually forms the outer boundary of the cavity to be created. With this object in view, and at the same time to keep the flap out of the operator's way, a strip of sterile gauze should be passed into the external auditory canal and brought around so as to lie against the exposed posterior surface of the flap. The latter may then be drawn well forward by pulling upon the ends of the gauze strip. There is no need of disturbing the posterior flap. The spurting vessels should merely be clamped; those which simply ooze may be controlled by pressure.

The operation upon the bone is performed in the same manner as is the operation described for simple mastoiditis, up to the stage at which the latter is considered complete. In the course of his work, however, the operator will almost surely encounter conditions which are appreciably different from those observed in the ordinary operation. In the first place, he will find, as a rule, that the mastoid process is sclerosed and possesses few if any cells or pneumatic spaces, and consequently he will have to chisel his way through an ivory-like bone before he reaches the antrum. This cavity, when reached, may be found to contain cholesteatomatous material, thickened granulations, or inspissated pus. Then, again, it may be found that the tympanic roof has been eroded and that the exposed dura is covered with necrotic granulation tissue; or the inner plate of the mastoid process may have been destroyed, thus laying bare the wall of the sinus or the dura covering the cerebellum from this point onward certain additional steps are required. The first of these consists in bending the tip of a pure silver probe at nearly a right angle (the bent portion measuring about six or seven millimeters in length) and then passing it along the posterior wall of the external auditory canal into the tympanic cavity until its tip projects into the antrum. This probe serves as a guide to show the position of the facial nerve, while the upper and posterior canal wall is being removed. The bony channel containing this nerve lies underneath the probe and under the floor of the aditus ad antrum. The mallet and chisel may be used in the removal of the major portion of this canal wall. When, however, the surgeon reaches the internal portion of this posterior wall he will have to remove a bridge of bone which has no support, and if, for the accomplishment of this, he employs the chisel, it may easily happen that he will remove a piece which is much larger than he intended to remove, and which may include the facial canal. On the other hand, with Jansen's forceps, Fig. 3920, No. 3, especially curved for this purpose, he will experience no great difficulty in controlling the size of the fragment removed at each seizure. The piece of bone which will have to be removed at this point extends, like a partition from the tympanic roof to the floor of the aditus ad antrum. The course taken by the facial canal is from the petrous process of the temporal bone across the upper portion of the inner wall of the tympanic cavity and above the oval window. Then, dipping down beneath the floor of the aditus ad antrum, the canal passes downward, through the hard compact plate of bone which forms the base of the posterior wall of the external auditory canal, and terminates immediately behind the base of the styloid process. The nerve, when injured, is generally wounded above the oval window or on the floor of the aditus ad antrum; it is also sometimes injured near its exit from the skull.

The horizontal or external semicircular canal may also be wounded if care is not exercised. It is to be found in the compact mass of bone which forms the floor of the aditus ad antrum, a little above and behind the facial nerve, and if care is used in working on the floor of the antrum and of the aditus ad antrum no damage will result.

The posterior wall of the external auditory canal should next be removed, by shaving, until the bottom of the newly excavated part represents a plane extending from the floor of the aditus ad antrum to the floor of the bony portion of the external auditory canal. After it has been removed, the next step is to remove the ossicles or such portions of them as may remain. The removal of the two larger ossicles or of the necrotic stumps which may still remain *in situ*, is easily accomplished by seizing the incus with a pair of forceps, care being taken not to disturb the stapes, and then with an angular knife cutting through the incudo-stapedial joint. After this has been done, the removal of the incus, malleus, and remnants of drum membrane is easily accomplished. All granulation tissue in the tympanic cavity, especially in the vicinity of the pharyngeal end of the Eustachian tube and on the floor of the cavity, must be removed. The removal of the granulation tissue is best accomplished with the curette, which should be used with great caution, as it is with this instrument that damage to the facial nerve is most often done. It is therefore safer, before curetting, to use the probe, in order to determine whether or not the facial nerve is exposed. When it is exposed, the pressure of the probe will cause the muscles of the face to twitch. In curetting the cavity of the tympanum care must be exercised not to dislodge the stapes or to wound either the oval or the round window and thus possibly open up avenues of infection into the labyrinthine structures and thence very readily to the base of the brain. Displacement of the stapes results in a further loss of the already impaired hearing. If a loss of hearing does not occur immediately as the result of the operation, it is among the possibilities that a fixation of the stapes, with displacement, will occur as the result of the formation and subsequent contraction of newly formed tissues about its foot-plate. On the other hand, a permanent improvement of the hearing has sometimes followed the operation.

In order that the lower portion of the tympanic cavity may be properly drained it is generally necessary to remove a small portion of the inner end of the inferior portion of the external auditory canal and thus bring it on a level with the floor of the tympanic cavity. There, again, it is important to remember that the jugular bulb lies under the floor of the tympanic cavity, and that consequently one may easily wound it if care be not exercised. The tympanic end of the Eustachian tube should be thoroughly curetted so that it may be obliterated by the process of cicatrization and that thus the possibility of infection extending from the posterior nares to the tympanic cavity may be removed. The carotid artery lies in its canal below and behind the Eustachian tube. Hence the necessity of proceeding cautiously, when one curettes the posterior and inferior surfaces of the tube, lest injury be done to the artery. If any pathological condition is found to exist in the nares or nasopharynx it should be attended to as soon as practicable, so that the middle ear may not be subjected to further infection or irritation from this source.

All portions of the tympanic cavity, as also of the mastoid cavity, should be smoothed down, and no projecting edges or points, which might impede the future epidermization of the cavities, should be allowed to remain.

Before proceeding to make the meatal flaps, the operator should carefully inspect the cavities for the possible existence of a sinus leading into the posterior or the middle cranial fossa. If such a sinus is discovered the bony structure through which it passes must all be removed and the underlying dura mater and sigmoid sinus inspected, so that, if any complicating lesions of the meninges, the sinus, or the brain itself, exist, it shall not escape discovery.

In those cases of chronic suppuration which are associated with cholesteatoma the bone should be thoroughly searched for the presence of any fistulous tract, and if one is found it should be thoroughly curetted. At no point should any but healthy bone denuded of membrane be left behind. Unless this is done a recurrence of the cholesteatoma is most likely to ensue.

When the surgeon has smoothed and rounded off all sharp edges of bone and is positive that he has removed all necrotic tissue, he may proceed to form, from the posterior portion of the membranous external auditory canal, the flaps which are to serve in large part as a lining membrane for the excavation in the bone. The process of repair is much influenced by the manner in which the meatal flap is applied to the

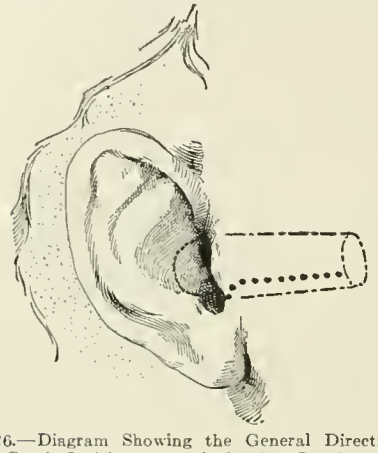


Fig. 3926.—Diagram Showing the General Direction of the Shepherd's Crook Incision aa made in the Concha and thence extended into the External Auditory Canal. The broken lines indicate the location of the external auditory canal; the dotted line the direction of the incision.

underlying surface of bone. This bone, it must be remembered, is frequently sclerosed and therefore scantily supplied with blood-vessels, and consequently it does not produce healthy granulations. The larger the flap and the more bone covered, the more rapid will be the reparative process; for the well-nourished flap rapidly unites with the bone and sends out granulations to cover the portion of bone left exposed. The meatal flap may be further aided by the employment of Thiersch's skin grafts to cover the exposed surfaces of bone. Before any incisions are made to give the flap its proper shape all the muscular, fibrous, and areolar tissues underlying that portion of the external auditory canal and concha of the auricle which is to form this flap should be removed until nothing remains but the skin, with its subcutaneous connective tissue.

The First Method of Forming the Meatal Flap.—The flap that is probably employed in the majority of cases, and that is known as the "Ballance or shepherd's-crook flap," is made in the following manner: First, the membranous external auditory canal is put on the stretch by introducing the blades of a slender artery clamp into the lumen of the canal and then separating the blades. Next, with straight, blunt-pointed scissors, the wall of the canal is slit, a little below the center of its posterior surface, as far as the concha. Then, by means of a probe-pointed bistoury, the incision is extended into the concha in a curved direction, at first downward and backward, then upward and slightly backward, and finally slightly forward and upward until the root of the helix is reached (Figs. 3926 and 3927).

It might seem as if the large opening made in the region of the external auditory canal would produce an unsightly deformity, but this is not the case. In the course of six months, contraction takes place to such an extent that the meatus is but slightly larger than it was before the operation, and during the process of healing this large opening serves to render the dressing of the cavity much easier, more thorough, and less painful than if it were done through a smaller one.

By the method which we are now considering, two flaps are provided—a large superior one, which will cover the upper portion of the excavated mastoid cavity, and a smaller one which will completely cover the ridge in which lies the facial nerve. Any cartilage contained within the flaps should next be removed; then they should be anchored to the anterior flap of the mastoid wound by means of a catgut suture passing through the conchal end of each flap. The internal ends of the meatal flaps are placed in position against the bone and held there by means of gauze packing. The posterior mastoid wound is then entirely closed by subcutaneous silkworm-gut suture, the wound cavity is packed through the enlarged meatus with gauze, and the outer dressings are applied as in the simple mastoid operation.

If the method of operating here advocated is adopted, the raw surface of the flap will be brought in contact with the raw surface of the flaps of the mastoid incision, and with the denuded bone of the excavation, and in due time firm union between them will take place. From the free edges of the deeper portions of these flaps a new growth of epithelium will take place, and gradually this new growth will extend over the granulating surface of the rest of the cavity. Thus, in the course of time, a non-

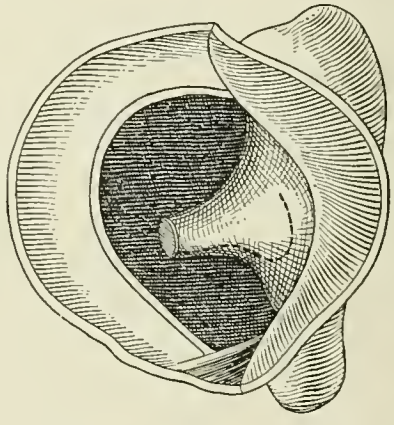


Fig. 3927.—Diagram Showing the Large Semicircular Anterior Mastoid Flap Everted. The more darkly shaded area represents the exenterated mastoid cavity. To the right of this are the inner surface of the posterior wall of the external auditory canal and the inner surface of the concha. The dotted line indicates the shepherd's-crook incision, made for the purpose of forming the meatal flaps.

secreting dermal lining will be supplied for the entire cavity which has been created by the breaking down of the partitions separating the mastoid cells, middle ear, and external auditory canal. After the healing is complete, a survey of the cavity will reveal the fact that a small ridge is located in its lower portion. This ridge, which is composed of the remainder of the posterior bony wall of the auditory canal, contains the facial nerve and divides the cavity into a posterior and an anterior half. Facial paralysis sometimes occurs at the end of a few hours, or even a day or two, after the operation. I have attributed the phenomenon, which was only transient in character, to the pressure exerted upon an exposed facial nerve by the saturated dressings which filled the cavity or to an inflammation extending from the severed and exposed chorda-tympani branch of the facial.

The Second Method of Forming the Meatal Flap.—In this method, which was devised by Koerner, the following steps are required: A pair of artery or dressing forceps is introduced into the external auditory canal and held open so as to render tense its posterior cutaneous wall; then, with a small scalpel, an incision is made in the membranous canal through the middle of its superior surface and extending from its freed extremity to the cavum conchæ. A similar and parallel incision is next made through the inferior surface of the canal. In this way there is formed, out of the posterior canal wall, a quadrilateral flap which is united to the anricle by a vertical line of union in the cavum conchæ (Fig. 3928). This flap is made thinner at its outer end, by removing some of the cartilage which enters into its composition. After it has thus been reduced in thickness the flap is turned backward into the mastoid wound (Fig. 3929) and united—by means of two catgut ligatures passed through its free extremity—to the posterior flap of the mastoid incision. The next step is to unite the edges of the mastoid incision as before described throughout its entire length. The excavated cavity in the mastoid is thoroughly dried and carefully packed with gauze through the meatal opening. Especial care should be taken to force the flap into close apposition with the periosteum of the mastoid flap and with as large a portion of the bony cavity as it can be made to cover.

Fig. 3928.—Lines of Incisions as Made in the Concha in forming of the Koerner Meatal Flap. (Laurens.)

The Third Method of Forming the Meatal Flap.—This method of providing a lining for the excavation in the bone was suggested by Panse. The first step in this procedure consists in carrying the incision through the middle of the posterior membranous wall of the external auditory canal as far outward as the cavum conchæ. From this point one incision is carried upward, at right angles to the first incision, as far as to the summit of the superior wall of the canal, while a second one is carried downward as far as the lowest point of the inferior wall, the two forming a T-shaped incision and as a result of these incisions there will be formed two flaps—an upper and a lower one (Fig. 3930). The superior flap is sutured to the periosteum at the upper anterior angle of the mastoid incision, and the inferior flap to the lower angle of the same incision. The extremities of the flap are held in apposition with the bone by gauze packing. These flaps are denuded of all underlying tissues, as was described in the making of the other flaps.

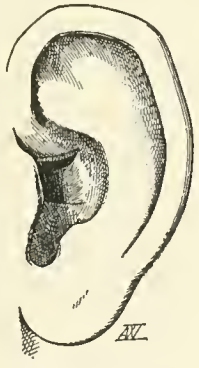


Fig. 3929.—Diagram Showing the Second Step in Koerner's Method—viz., the turning of the meatal flap backward in the mastoid wound—completed. (Laurens.)

The Fourth Method of Forming the Meatal Flap.—This method was suggested by Stacke. According to his plan, the flap is made by carrying an incision through the middle of the superior wall of the auditory canal as far outward as to the cavum conchæ, while from the termination of this first incision a second one is carried downward as far as to the lowest point of the inferior wall of the canal. The flap thus formed is pushed downward into the bony cavity and held in place by a gauze tampon and by a catgut ligature which unites its outer extremity with the mastoid flaps and the lower angle of the incision. This flap is of especial service in cases where the sinus or jugular bulb has been accidentally or intentionally exposed.

The Fifth Method of Forming the Meatal Flap.—In this method the flap is constructed by making the incision through the inferior cutaneous wall, instead of the superior cutaneous wall, and, in addition, a second incision is carried at right angles to the first upward to the superior wall of the canal. By means of gauze packing, the flap is held in apposition with the upper and posterior wall of the mastoid cavity rather than with the lower and posterior wall, as in the preceding method. This method of forming and managing a meatal flap should be used in cases where the dura in the middle fossa has been exposed.

The Sixth Method of Forming the Meatal Flap.—In this method the flap is constructed by making the incision through the middle of the posterior wall of the external auditory canal to the concha and then carrying this incision from this point upward at an angle of forty-five degrees into the concha of the auricle, and another incision from the same point downward at a similar angle into the concha, thus

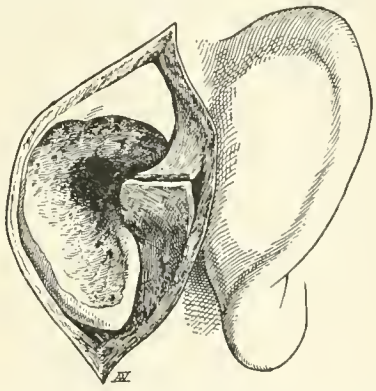


Fig. 3930.—Shows Line of Incision Made to Form the Panse Meatal Flaps.

making a Y-shaped incision which forms a superior, an inferior and a middle flap. The superior and inferior flaps are turned respectively upward and downward, as in the third method, and the middle flap is turned backward and covers over that portion of the auricle which in the other methods is left raw and which is oftentimes very long in healing; this method because of this point is one of the best to use.

After-treatment.—In the class of cases which we are here considering, the after-treatment requires much judgment. Irrigation should not be resorted to; as a substitute, very gentle cleansing with moist sterile cotton pledgets is to be preferred. The first dressing need not be disturbed for six or seven days unless the temperature denotes a septic disturbance. Subsequently, however, the wound will have to be dressed every day or every other day. The subcutaneous suture is generally removed at the time of the first dressing, when union will be found to have taken place between the external cutaneous flaps. As a protection a small dressing of sterile cotton is applied over the mastoid wound and fastened in place by means of flexible collodion. At the second or the third dressing this may be dispensed with. At each dressing, if much secretion is present, the cavity should be dusted with finely powdered boracic acid or with subgallate of bismuth, and a loose packing of sterile gauze should be inserted. The cavity must not be allowed to become obliterated by excessive granulations, and the strictest asepsis should be employed

so as to prevent the possibility of a perichondritis—an accident which is liable to occur on account of the cartilage of the auricle having been opened in the making of the flap. If perichondritis arises, marked deformity is sure to follow. It is well to apply carbolic acid to the edges of the cartilage, with the view of preventing such an unpleasant accident. If the case that has been operated upon is one in which an acute exacerbation had previously taken place, with the formation of a subperiosteal abscess and perforation through the skin, it may be impossible to obtain, from the immediate vicinity, enough healthy skin to cover the exposed portions of the mastoid. When this is found to be the case, the difficulty may be overcome by resorting, at some later date, to a plastic operation, or by transplanting small skin grafts and thus hasten healing.

The Mode of Procedure in Applying a Thiersch Skin Graft to the Exenterated Mastoid Cavity.—The majority of aurists seldom, if ever, resort to the use of Thiersch skin grafts. The writer has employed them in only a very limited number of cases, as the majority of cases thoroughly operated upon seem to do as well and heal as rapidly without as with the skin graft. Some aurists apply the graft at a secondary operation some days following the primary one, while others insert the graft at once. The graft is obtained from the patient's thigh; the operation should be done under general anesthesia.

The mastoid wound having been prepared for the reception of the graft, the spatula upon which it rests is introduced into the wound, the edge of the graft is gradually moved over with the teasing needle from the spatula to the innermost portion of the exposed surface to be grafted, and then, while it is held in position, the spatula is gradually removed, leaving the graft in the desired position. A glass pipette, with a bulb in the center of it for collecting the fluid, has attached to it a piece of rubber tubing. The end of the pipette is introduced under the graft while it is being placed in position, and the operator sucks on it so as to withdraw all fluids and air from under the graft and thus permit it to apply itself closely to the surface to be covered. The graft is held in position by means of small pledgets of sterile cotton dipped in subgallate of bismuth or in aristol. The edges of the mastoid wound are united and the necessary dressing is applied to the wound. A fresh dressing will have to be applied on the third or fourth day, and on every day following. At the time of the first dressing, there is likely to be considerable odor, the result of a necrosis of the superficial portions of the graft.

The Meato-mastoid Operation—Heath, Ballinger, and Bryant have described operations (for the cure of chronic purulent otitis media) which, while differing in minor details, are essentially the same in principle. Their claim is that in the majority of these cases the chief seat of the disease is in the mastoid antrum and adjacent cellular structures, and that if the necrosis in this vicinity is eradicated and the exposed surface of bone properly covered with an epithelial membrane, the Eustachian tube will be amply able to drain the middle-ear cavity, and that the latter, in time, unless there is necrosis of the ossicles, will resume a normal condition. The advantage of this method of operating over the radical operation lies, as they believe, in the facts that the drum membrane and the contents of the tympanic cavity are not interfered with, and that consequently the function of hearing is preserved. Indeed, in some cases, as they claim, the hearing, upon the subsidence of the disease in the middle ear, actually improves.

The operation proceeds along the same lines as those followed in the simple mastoid operation. As soon as the antrum has been opened, and after it and the aditus ad antrum have been freed from all granulations and areas of necrotic bone, and their surfaces have been smoothed down, a piece of sterile gauze is placed in the aditus ad antrum so as to prevent any bony débris or other material from falling into the middle-ear cavity. A piece of moistened gauze is also, for a similar reason, placed over the opening in the drum membrane. The posterior wall is then entirely removed as far as the annulus tympanicus. A portion of the external superior wall should also be removed at this time, so that as much room as possible may be obtained for the future treatment of the tympanic cavity and also for the purpose of securing the best possible drainage. Injury to the facial nerve is not so likely to occur as in the radical mastoid operation; nevertheless, the possibility of injuring the nerve must be kept in mind. At no time must any interference with the drum membrane and the contents of the middle ear, either by probe or otherwise, be permitted through the aditus ad antrum.

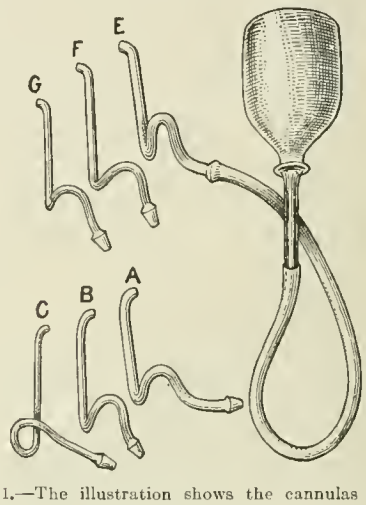


Fig. 3931.—The illustration shows the cannulas devised by Heath to be inserted into the aditus ad antrum, for the purpose of forcing a blast of air through it and the tympanic cavity, with the expectation that this blast will force out of both these cavities all débris and secretions. The cannulas are made in three different sizes and are so constructed that there are rights and lefts of each of the three sizes. Attached to one of the cannulas is the air-bag that may be employed with all of them. The cannulas may also be used in washing out the cavity with sterile solutions.

The next step is to remove any polypus or any granulation tissue that may protrude from the middle ear. If the perforation of the drum membrane is large enough, a small angular curette may be introduced for the purpose of removing any granulation tissues that may be present in the lower portion of the tympanic cavity. With a straight curette, the mouth of the Eustachian tube may be gently scraped. In these procedures extreme care must be taken to avoid dislocation of the ossicles.

The piece of gauze previously placed in the aditus ad antrum is now removed, and a specially devised cannula (Fig. 3931), with air bag attached, is inserted into the aditus ad antrum, and by means of the air bag a blast of air is blown through the tympanic cavity, for the purpose of cleansing it of all secretion. If at the same time any granulation tissue is forced through the drum membrane into the external auditory canal it should be removed. If the perforation in the drum membrane is not sufficiently large to drain the middle ear properly, the opening may be increased in size. Or, if the perforation is not well situated to afford satisfactory drainage, a new opening may be made. Following this, the tympanic cavity

is washed out with a physiological salt solution by attaching a syringe to the previously mentioned cannula.

The next step is to make the meatal flap according to one or other of the methods already described. In making this flap the operator should extend the incision further into the superior portion of the external auditory canal wall, so as to obtain a larger area of skin surface and at the same time more room for subsequent treatment. The flaps are sutured and held in position as described in the radical mastoid operation. The outer wound is entirely closed and the cavity packed through the meatal opening, care being taken not to press unduly upon the tympanic membrane.

After-treatment.—On the third, fourth, or fifth day following the operation, the dressings should be removed, the cavity carefully wiped out, the cannula (with air bag attached) introduced into the aditus ad antrum, and the tympanic cavity cleansed of all secretions by forcing a blast of air through it as at the time of operation. All granulations that may be found present should be removed.

After a few weeks the mastoid cavity will be covered with an epithelial lining, and the entrance from the aditus ad antrum into the tympanic cavity closed by new connective tissue. If this passage into the tympanic cavity threatens to close too early, that is, before all discharge has ceased, it should be kept open by means of a probe.

The Stacke Operation.—The patient is prepared as for the former operations. The first incision is made as in the radical operation described above. The anterior flap is reflected forward so as fully to expose the bony external auditory canal; the membranous canal is then completely shelled out of its bony support and the entire mass is held forward with a blunt retractor. This gives an unobstructed view of the tympanic cavity and of the bony structures to be operated upon. If any remnants of the tympanic membrane or of the ossicles, or any granulation tissue, be present, they should all be removed and the tympanic cavity cleaned. As the next step, the upper and posterior walls of the canal should be removed with the chisel to such an extent as will fully expose to view the epitympanic space and the antrum. Of course great care should be used to avoid wounding the facial nerve. As an extra precaution against this accident Stacke makes use of a hook-like instrument which he calls a "protector" and which is introduced from the tympanic cavity into the antrum, so that if by any chance the chisel should slip it will strike this protector. The posterior canal wall is removed as in the radical operation and all cells adjacent to the antrum are removed; in fact, the operation on the bony parts should, so far as circumstances will permit, be as radical as the so-called radical operation. The chief point of difference between the two is to be found in the fact that in the radical operation the mastoid cortex is first removed and the antrum entered from behind, while in the Stacke operation the antrum is entered from in front and the mastoid cells are excavated by work done wholly from the side of the external auditory canal—the mastoid cortex being left undisturbed. This operation must necessarily be less complete than the Schwartze-Stacke operation, for it is not possible, by way of the external auditory canal, to remove the mastoid cells at the tip, or even those situated at a higher level. Exposure of the middle or the posterior cerebral fossa often takes place in the Stacke as in the other operations, but under strict asepsis this occurrence need cause no anxiety. Stacke's, as well as the other methods of furnishing an epidermal lining for the excavation by means of a flap, has already been described above. The flap or flaps thus provided are to be pushed into place and sterile gauze packed in upon them to hold them in apposition with the bony wall after the external mastoid wound has been entirely closed. In the subsequent management of the case the same directions are to be followed as those which are mentioned in the description of the Schwartze-Stacke operation. So far as results are concerned this method of operating is not so satisfactory as the radical operation and is seldom employed. The operation, because of the small space in which to manipulate the necessary instruments, is much more difficult to perform than the Schwartze-Stacke operation, the danger of wounding the facial nerve is greater; neither from an operative cosmetic or resultant point of view has it any advantage over the Schwartze-Stacke operation.

Fig. 3932.—Incision Employed in Forming the Flap According to the Mosetig-Moorhof Method. (Laurens.)

Plastic Operations for the Closure of Postauricular Fistulæ.—Cases of mastoiditis occur in which the pus forces an outlet for itself through the anterior surface of the mastoid process and causes sloughing of the posterior membranous wall of the external auditory canal. In such cases it often happens that there is left a permanent fistulous channel leading from the posterior meatal wall backward to the postauricular groove. It is also not a rare occurrence for the mastoid flaps, after a radical mastoid operation, to fail entirely to unite. For cosmetic as well as for other reasons—*e.g.* to prevent the intrusion of dust and other foreign substances into the canal or to prevent

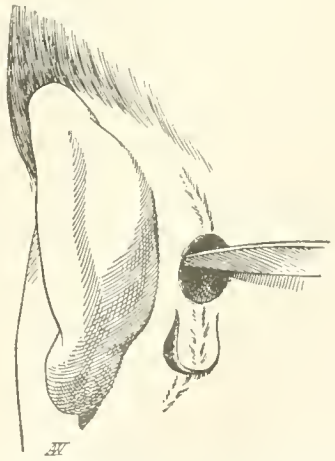


Fig. 3933.—In this illustration the flap has already been dissected loose from its underlying attachments, and the sharp-pointed bistoury is represented as cutting the grove in the opening. (Laurens.)

the too sudden and too direct impact of air upon the foot-plate of the stirrup or the membrane covering the round window—it may be necessary to close this opening by some plastic method. The closure of such an opening should not be attempted unless the cavity has been free from all evidences of inflammatory action for a period of several months.

Steps of the Operation.—General anesthesia is preferable; local anesthesia should be employed only in very simple cases.

The parts, both outside the auricle and within the canal or within the excavated mastoid cavity, should be rendered sterile by washing them with tincture of green soap and then applying freely seventy-five per cent. alcohol, or the tincture of iodine may be painted over the surfaces of the operative field.

The instruments and materials needed are: a sharp-pointed bistoury, two dissecting forceps (of the mouse-tooth variety), artery clamps, probes, scissors (sharp-pointed, blunt-pointed, and curved on the flat), a needle holder, small and delicate full-curved needles, catgut No. 0, silkworm gut, and sterile-gauze dressings.

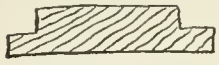


Fig. 3934.—Diagram Representing a Section through the Flap Employed in the Mosetig-Moorhof Method. The lower subcutaneous part, which projects like a ledge, is inserted into the groove or recess which is prepared for its reception in the sides of the opening behind the auricle.

The method of operating varies with the size of the opening to be closed and also with the condition of the cutaneous structures that surround the opening. When the openiug is small and the surrounding skin contains no cicatricial tissue and is freely movable over the underlying bone, it is only necessary to freshen the edges by cutting, with the bistoury, a strip along the entire margin of the opening. The edges may then be united with silkworm-gut sutures. If the skin is not as freely movable upon the underlying periosteum as it should be, it may be found necessary to loosen the attachments between the two by a subcutaneous incision.

In certain cases the procedures just described do not meet the requirements, and one may then employ either the Mosetig-Moorhof or the Passow-Trautmann method.

The Mosetig-Moorhof Method.—The flap is formed by making a U-shaped incision in the skin beneath the opening to be closed (Figs. 3932 and 3933). This incision should extend only through the superficial layer of skin. A second incision is made about one millimeter and a half beyond and parallel to the first. The skin lying between these two incisions is next dissected out, and the second incision is then deepened down to the level of the periosteum. Commencing along the line of the second incision the knife is used in dissecting the tongue-shaped flap, from below upward, loose from its attachments to the periosteum. The flap thus dissected free from its attachments (except at its broad base or pedicle) is wider on its under or subcutaneous surface than on its outer or epidermal surface because of the narrow rim or ledge of denuded tissue which surrounds it (Fig. 3934). The next step is to incise, with a sharp-pointed bistoury, a groove, two or three millimeters in depth, all around the upper two-thirds of the opening (Fig. 3933) and at a short distance (in depth) from its margin. The tongue-shaped flap is then inverted into the opening and its ledge-like margin is inserted into the groove prepared for its reception, in much the same manner as a watch crystal is held in its rim. Four or more rather long sutures are used for holding the flap in position. These sutures should be passed through the flap before it is inverted, and special care should be taken to carry them through the cutaneous part of the flap (Fig. 3935). The cutaneous surface of the flap, in its new position, faces inward or toward the region of the middle ear. The raw or external surface of the flap may be covered with a Thiersch skin graft or it may be allowed to heal by the process of granulation from the edges. The edges of the lower wound from which the flap was taken are brought together by suturing (Fig. 3936). A similar operation may be done by borrowing the flap from the posterior surface of the auricle.

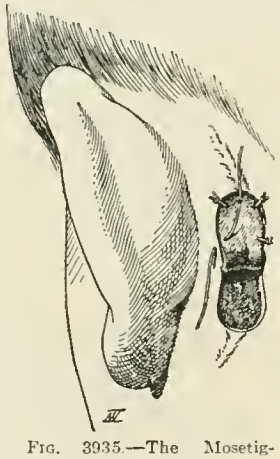


Fig. 3935.—The Mosetig-Moorhof Flap being Sutured in Position. (Laurens.)

The Passow-Trautmann Method.—Two vertical incisions, two or three millimeters in length, are made through the skin and subcutaneous tissues into the cavity of the mastoid in the longitudinal axis of the opening—one above and the other below it. The outer ends of these incisions are joined by an anterior and a posterior semicircular incision, both of which are parallel to the margins of the opening. The posterior incision is carried through to the periosteum, and the anterior one to the perichondrium. The flaps outlined by these incisions are dissected up from the underlying tissues so as to form an anterior and a posterior flap. Care must be taken not to cut through at the margin of the opening. The flaps are then inverted into the opening and are united, one to the other, by means of sutures introduced longitudinally through each flap. Finally, the margins of the external wound are united. It may be necessary, because of undue tension, to loosen the skin covering the mastoid process before the margins of the wound can be approximated.

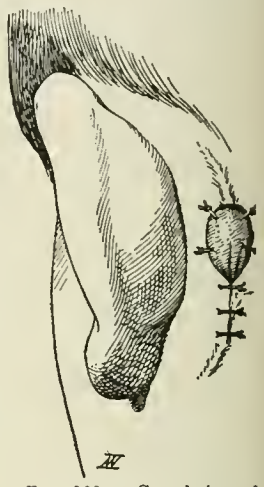


Fig. 3936.—Completion of the Closure of the Postauricular Opening According to the Method of Mosetig-Moorhof. (Laurens.)

In all these operations there will have to be both an external dressing of sterile gauze and an internal one placed within the cavity. On the sixth or seventh day the dressings may be changed and the sutures removed.

Operations for Meningitis, Extradural Abscess, Encephalic Abscess, and for Sinus-thrombosis of Otitic Origin.—Several of these intracranial lesions are often to be found in the same case, the most frequent being an extradural abscess, which is a localized pachymeningitis, walled off by adhesions from the rest of the dura mater. In cases of sinus thrombosis a complicating encephalic abscess is more apt to be cerebellar than cerebral. As a rule, the intracranial lesion is most often found in the vicinity of the most necrotic portion of the causal focus of the aural disease.

I. *Extradural and Encephalic Abscess.*—Extradural abscesses in the middle fossa generally lie just external to that portion of the dura which covers the lower and posterior portion of the temporo-sphenoidal lobe, while those occurring in the posterior fossa are in contact with that portion of the dura which covers the anterior portion of the occipital lobe. Of encephalic abscesses the majority are to be found in the cerebrum, and of these the larger proportion are to be found in the temporo-sphenoidal lobe where they generally occupy the inferior and posterior portion of this lobe, above and behind the tympanic roof and the petrous portion of the temporal bone. In cases of cerebellar abscess the most usual site is at a point close to the anterior and lateral surface of the cerebellum, behind the petrous portion of the temporal bone.

In cases in which the surgeon, although convinced that an abscess exists in some part of the encephalon, is nevertheless unable to decide whether it is located in the cerebrum or in the cerebellum, it is his duty to explore first the most likely sites in the cerebrum, and then, if he fails to find the abscess in this part of the brain, to explore the cerebellum.

Meningitis of otitic origin is sometimes non-suppurative (meningitis serosa). Usually, however, it is purulent in character and limited to a comparatively small area by a preceding adhesive inflammation. In cases of serous meningitis the early recognition of the presence of the disease and the drainage of the affected region—by the establishment of an opening in the bony wall of the cranial cavity, by incising the dura, and finally by inserting a gauze drain—has in some few cases been the means of saving a patient's life. As a preliminary to these steps the operator may, according to the acuteness or the chronicity of the causal ear disease, perform either the simple or the radical mastoid operation. The tympanic roof must be removed and the dura incised and drained. Lumbar puncture, repeated as often as is necessary to reduce the intracranial pressure, is indicated. Solutions of urotropine have been injected into the spinal canal following the withdrawal of the spinal fluid. In cases of meningitis serosa it may be wise to tap the ventricle as well as to make a lumbar puncture; it may be necessary to introduce the director for all of two inches to accomplish this. The director should be introduced through the middle temporal convolution.

In all cases of intracranial complications of otitic origin, the mastoid cells and the antrum—and, in chronic cases, the tympanic cavity as well—are first to be opened into. Then the surgeon, bearing in mind that in the large majority of instances the intracranial complication lies nearest the focus of infection in the ear, and realizing also that it is desirable to enter the cranial cavity by that route which is at once the easiest as well as the one which admits of the best drainage, proceeds—in the case of a lesion which he believes to be located in the middle fossa or vicinity—to remove the thin plate of bone which separates the tympanum, antrum, and adjacent cells from the cranial cavity. One surface of this plate of bone—it should be remembered—forms the tympanic roof, the other the floor of the middle fossa. The first opening through the bone is to be made with the chisel, but afterward the curette and rongeur forceps are to be employed for the purpose of enlarging it. Either of these instruments is much to be preferred to the chisel, the trephine, or the dental burr. They are not only fully as effective as these, but they possess in addition the great advantage of not being likely, as are the other instruments, which have to work from without inward, of wounding the deeper-lying soft structures. In the removal of bone by means of the curette or the rongeur forceps the tip of the former or the beak of the latter is inserted between the dura and the bone, and a portion of the latter of the size desired is then easily broken or bitten off; the force applied always working in the direction away from the soft parts. If the cortex is unusually thick and sclerosed at any one point it may be best to employ the chisel for the purpose of removing the more superficial portions, and thus gradually to reduce the bone to the desired degree of thinness. It is surprising, however, how thick a mass of bone a pair of forceps, such as Mathieu's, is capable of biting off. After the tympanic roof has been removed it is easy to extend the opening in any given direction—as may be indicated by the route taken by the infection—by removing the lateral wall of the middle fossa (the squamous plate of the temporal bone). In removing this plate care must be taken to avoid the middle meningeal artery, as the wounding of this vessel is likely to cause a hemorrhage which it is difficult to control. As has been said above, the larger number of intracranial complications are seated in the lower and posterior portion of the temporal lobe, and consequently, as soon as the plate of bone above the excavated mastoid cells has been removed, it is most likely that the nature of the lesion will then be revealed. Furthermore, the affected area will by this mode of procedure be exposed at its most dependent point. When once the diseased tissues are exposed, bone must be removed until normal tissue shows around the diseased area. If a localized pachymeningitis (an extradural abscess) is present, the simple laying bare of the site of the disease and establishing good drainage, after carefully cleansing the parts, will result in a cure. It is best not to curette any granulations that may be present. If, after they have thus been exposed, they do not soon disappear, cauterization by means of the nitrate-of-silver stick may be resorted to. The wound should be left widely open and antiseptic or sterilized dressings applied.

When an encephalic abscess is suspected but not located, the best way of searching for it is first to incise the dura in the center of the bone opening so that hemorrhage from any bleeding vessels may be readily controlled. (The reason why the bleeding may more easily be controlled at this part of the wound becomes apparent if we consider the fact that these vessels have a tendency to retract, and if the opening is made near the bony edge the vessels may retract under this bone and so make it difficult for the surgeon to seize them with the artery clamp.) Horsley's wax is useful to control hemorrhage from the bone, compression of the edge of the bone by forceps will as a rule arrest the bleeding; also small pledgets of iodoform gauze forced into the opening in the bone works well. In incising the dura, it should be lifted up and incised with a knife, care being taken to avoid wounding the cortex of the brain, the incision should then be completed with a blunt pair of scissors. The incision should be made so as to form a horseshoe dural flap. For the purpose of locating the pus, a double-bladed grooved director (Fig. 3937), the blades of which may be separated, the latter is the most satisfactory instrument to employ. A trocar and cannula do not answer equally well, as the former readily becomes clogged, and, besides, it is easily possible to pass the two instruments directly through a pus cavity into sound brain tissue beyond and thus fail to obtain any pus when the suction syringe is applied to the cannula after the withdrawal of the trocar. But when the above-mentioned director is employed in exploring the brain, especially if a little downward pressure is exerted upon the brain tissue at the same time, the pus—if any has been encountered in the track of the instrument—will almost surely escape by way of the pathway opened up by the separation of the blades of the director. When the brain is exposed in the manner described care must be exercised to prevent the director from penetrating to a vertical depth of more than three centimeters. It may be necessary to introduce the instrument several times before the abscess is located. It should first be introduced in a direction upward, inward, and backward, in the temporo-sphenoidal lobe; then, if the abscess is not found in this direction, the director may next be passed directly inward, and upward. If here too no pus should be dis-

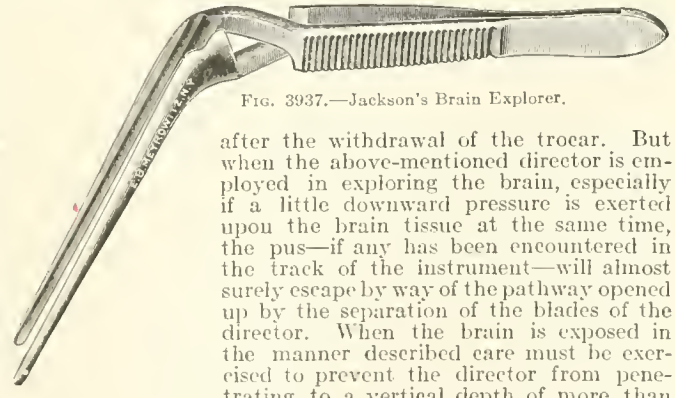


Fig. 3937.—Jackson's Brain Explorer.

covered, it will be well to introduce the director inward, upward, and forward. During the exploration the director should be advanced slowly for a short distance and then withdrawn for a part of this distance; then it should be pushed in a second time to a still greater depth and again withdrawn as in the first instance; and so on. When the pus is encountered, the track made by the director should be enlarged, and the pus allowed to flow out. The finger, if the abscess is of a sufficiently large size to permit of it, should then be introduced to explore the wall of the cavity and the latter should be gently cleansed with cotton wipes. This procedure is preferable to even gentle syringing with a saline solution and the employment of the double catheter; it is less likely to force the pus into the loose open cerebral structures. A cigarette gauze drain is preferable to one of rubber or bone; for these tubes are more unyielding and therefore more irritating to the soft cerebral tissues. A wick formed of a number of strands of catgut or silkworm gut make a good drain. In the subsequent care of the wound it will be found advisable to dry out the cavity in the brain every other day, and sometimes even daily, and on each occasion a shorter drain should be inserted, until the cavity finally closes. When, as occasionally happens, a hernia cerebri develops after the evacuation of the abscess, moderate pressure and the cicatrization of the tissues will have to be depended upon for the reduction and eventual obliteration of the protruding mass.

When the lesion exists in the posterior fossa or in the cerebellum, the sinus is first uncovered and the bone gradually removed backward and upward throughout the entire area invaded by the infection. Such removal of bone should not stop until normal tissues appear on every side of the bone opening. It is easy to explore the cerebellum posteriorly to the sinus, the point of entrance being in the angle formed by the junction of the horizontal portion of the lateral sinus with its sigmoid portion. The exploring director is introduced at first inward and forward toward the petrous portion of the temporal bone. If pus is not found here, the director, in the subsequent explorations, should be turned more and more in a backward direction. It is a much more delicate task to enter the cerebellum anteriorly to the sinus. If the director is introduced at this point, it should be kept on a level with the aditus ad antrum, and the surgeon should be cautious about pushing the instrument in a downward direction in the vicinity of the jugular bulb.

The route from the excavated mastoid cells to the seat of the intracranial lesion is of course the only route to be followed by the surgeon in cases in which the infection has clearly spread along a pathway leading from necrotic tissue in the mastoid region to the deeper-lying area of disease within the cranial cavity.

There are those who claim, with some show of reason, that the removal of the tympanic roof exposes the cranial contents to a greater danger from infection than if a separate opening were to be made, by means of a trephine or chisel, into the middle or posterior fossa, the floor of the middle fossa or the anterior wall of the posterior fossa being allowed to serve as a barrier between the infected mastoid cells and the contents of the cranial cavity. But, as I have already stated above, this method of operating does not afford the best drainage (especially when the middle fossa is involved), and furthermore if one or the other of the cavities is already infected—as is presumably the case—additional infection is not likely to augment the danger. On the other hand, if the cranial contents are found to be normal, it is easy to prevent an extension of the infection from the middle ear by means of proper dressings. Then again, there is ample evidence to show that, when provision has been made for good drainage, infection does not so readily pass from the antrum or the tympanum to the soft parts within the cranial cavity when the latter are deprived of the wall of bone that separates them from the middle ear. In a number of instances which have come under my direct observation an opening has been inadvertently established in the middle or posterior fossa, during the course of the operation for a simple uncomplicated mastoiditis, and yet in not a single one of these cases have I known any symptoms to develop which would justify the belief that any infection had spread to these deeper structures after the establishment of this opening. However, there are some cases when it may be necessary to explore the brain through an opening not in juxtaposition with the mastoid cavity. To accomplish this a horseshoe-shaped incision is made through the skin and subcutaneous tissues immediately above the auricle; the flap is then turned down, a vertical incision is then made in the temporal muscle and its fibers retracted so as to expose a sufficient area of the squamous plate of the temporal bone. The center pin of one-inch trephine is then placed one inch directly above the suprameatal spine and a button of bone removed; this opening may be enlarged by means of the bone forceps to the desired extent. If the posterior part of the superior and middle temporal convolutions are to be exposed, as in cases when aphasic symptoms are present, the center of the trephine opening should be at a point an inch and a quarter above and the same distance behind the suprameatal spine. After enlarging these openings the operation is proceeded with as described above.

In operations for suspected intracranial lesions the preference should be given to chloroform as an anesthetic, owing to the fact that it produces less congestion of the cerebral vessels, hence less hemorrhage, less secretion of mucus in the respiratory tract and, in the postoperative stage less headache, vomiting, and excitement. It possesses the greater danger of paralyzing the respiratory centers, but if only used in a two per cent. mixture with the inspired air this danger is lessened and oxygen may be mixed with the anesthetic if necessity arises.

The course of events after the evacuation of a brain abscess by operative interference can perhaps best be shown by the report of a case: A child, four years of age, was admitted to my service in the New York Eye and Ear Infirmary on March 29, 1902. The history of a long-continued, foul-smelling discharge from the right ear, with the development, some ten days previously, of a swelling behind and above the ear, was obtained. The child was prepared for immediate operation. The mastoid incision was extended upward, to, and above the parietal eminence. This unusually long incision was rendered necessary by the existence of a large subperiosteal abscess, filled with a most foul-smelling pus and occupying a space extending upward, from the mastoid tip, over three inches and from an inch to an inch and a half in width. The periosteal walls were found to be gangrenous. The bone, over a small area immediately below the parietal eminence, was of a purple-red color (evidently a beginning necrosis). The mastoid cells were opened and much cholesteatomatous material was evacuated; the posterior canal wall was removed and the tympanic cavity cleared of all granulations by means of the curette; the usual flap was made from the membranous external auditory canal. The dura was exposed above the tympanic roof and found to be normal. Owing to the necrotic condition of the periosteum the wound was left open throughout its entire extent.

Notwithstanding the fact that the child was a puny specimen of humanity and did not possess much recuperative power, the wound made fair progress toward healing. Suddenly, while she was sitting up in bed, on the morning of April 22, the child collapsed. When I reached the patient, a few hours later, she was unconscious, with a pulse of 120 and a temperature of 106° F. The resident surgeon reported that, before she became unconscious, he had failed to find any

evidence of paralysis or of anesthesia. The patient was prepared for another operation. The opening in the tympanic roof, made at the first operation, was enlarged, a portion of the squamous plate of the temporal bone was removed, and the dura mater was exposed from the tympanic roof to the parietal eminence a distance of about three inches; its width measured about one inch. The dura mater immediately above the tympanic roof, which had been exposed at the first operation, was covered with healthy granulations, and the dura mater, on further exposure, was found to be healthy for a distance of from half an inch to three-quarters of an inch beyond. As the work of removing the bone advanced in an upward direction, it was found that the portion of the skull which at the time of the first operation had presented a purple-red color, was now noticeably softer and more friable, and immediately under the center of this area was found a perforation in the dura mater. Granulations covered all this portion of the dura mater, but they were most exuberant in the immediate vicinity of the perforation. Pus exuded from the opening. A grooved director, introduced into this opening and pushed on toward the center of the brain, met with no resistance until it had reached a depth of about two inches. As the next step an incision was made through the dura mater at this point. This liberated a small amount of odorless pus and some clotted blood. On introducing an encephaloscope into the abscess cavity its bottom was found to be filled with a blood clot. This clot, it was inferred, was the result of a recent hemorrhage and the cause of the collapse which had occurred a few hours previously; it was therefore not disturbed.

During the period that followed the operation the wound was dressed daily up to the fifth day, when, as very little pus was present, the blood clot, with the aid of the encephaloscope, was removed. Upon taking away the last piece of this clot I was surprised to see that the lumen of the encephaloscope filled up with a clear fluid. I introduced cotton-tipped applicators in quick succession and in this way I was able to stop the flow for a sufficiently long time to obtain a view of the bottom of the cavity. It presented a smooth surface of a pinkish-white color, and I noted the fact that the fluid rose and fell with each inspiration and expiration. There can scarcely be any doubt that the descending horn of the lateral ventricle constituted the floor of the cavity into which I was looking.

A week later, as only cerebral fluid was exuding from the cavity, the gauze drain was removed, and on the next day I found that the cavity had closed. From this time onward the patient improved steadily, both as regards her general health and as regards the condition of the wound. In fact, at the end of four months she had visibly gained in flesh and I had every reason to expect a favorable result. But at about the beginning of the fifth month after the operation, the patient developed a slight paresis of the left hand and leg; two weeks later the body temperature suddenly rose to 106° F. Further operative interference revealed a softening of the superficial brain structure, near the outer wound, but no abscess was discovered. The patient sank gradually, and at the end of another two weeks died. No autopsy was allowed, but the brain was explored through the wound of the operation. No abscess was found, but the lining of the lateral ventricle was covered with a purulent exudate; in all likelihood this condition extended throughout the whole ventricular system of the brain.

In all probability the abscess, in the case just narrated, was situated in the posterior portion of the first temporo-sphenoidal convolution.

The infection, in this case, evidently spread from the middle ear to the antrum, and thence to the cortex of the mastoid process, where it caused the formation of a subperiosteal abscess which extended upward as far as to the parietal eminence and even a short distance above it; it then spread to the bone in the region situated below the parietal eminence, causing a necrosis which extended from the outer table of the bone to and through its inner table; it then finally invaded the dura mater (pachymeningitis and an extradural abscess), causing necrosis of the portion invaded, and eventually involving the cerebral structures themselves (abscess of the brain).

II. *Septic Sigmoid Sinus Thrombosis.*—In cases of septic sigmoid sinus thrombosis the surgical measures required are the following: The mastoid operation having been completed in the manner already described in the earlier part of this article, the sinus wall is to be carefully separated from its bony covering either by means of the smooth surface of a curette or a director and the separated portion of this bony covering either removed by the curette or the rongeur forceps. Great care should be taken not to tear the vessel wall, as to do so greatly complicates the operation. This procedure should be carried out until the sinus is fully exposed beyond the limits of the inflammatory area, both toward the torcular and toward the jugular bulb. It is better to expose as much of the sinus as is necessary to get beyond the limits of the contained clot before the vein is opened, as otherwise it is more difficult to proceed with the removal of more bone after the vein is opened and unnecessary delay is fraught with danger. In other words the sinus should be uncovered from a point well beyond the knee to well down toward the jugular bulb, and the width of the exposure should include a strip of healthy dura on both sides of the vessel. Near the bulb the operator must proceed cautiously, in order that he may avoid wounding the facial nerve in front of it; he must also remember that the foramen lacerum posterius does not give exit, from the skull, to the jugular vein alone, but that it also affords a passage, through its anterior portion, to the glossopharyngeal, the pneumogastric, and the spinal accessory nerves. The inferior petrosal enters the sigmoid sinus immediately above the jugular bulb.

As soon as the wall of the sinus has been fully exposed to view the question at once presents itself, Does it or does it not contain a thrombus? Unless the clot is large enough to occupy the entire lumen of the sinus canal, this question is a very difficult one to answer. From palpation alone it may be impossible to determine whether fluid blood is present or not; and it is practically useless to endeavor to make a diagnosis by aspiration of the sinus; for if the clot is centrally located the trocar will be likely to push it to one side, or if it hugs the wall of the vein the instrument will pass entirely through it. In either case, therefore, only fluid blood is likely to be obtained. It is, therefore, generally necessary to make the diagnosis from the general and the local symptoms alone. In some cases, however, the symptoms are not sufficiently marked to enable the surgeon to make a positive diagnosis. When this is the case he will be compelled to make an incision in the sinus wall while an assistant with small rolls of iodoform gauze is ready to control the bleeding, either above or below the incision. In making the incision the knife should be held with the back of the blade directed toward the inner surface of the vessel and great care must be taken not to go through this inner wall and thus probably infect the underlying brain tissue. Pressure should not be exerted over the sinus before it is opened, because to do so might dislodge a portion of the septic clot into the blood current. If hemorrhage occurs following the incision pressure should first be exerted over the torcular end of the sinus and then if the hemorrhage continues exert pressure over the lower end of the sinus. If bleeding still continues it may come from the emissary vein. When the bleeding is under control the incision may be extended in both directions and allow for inspection of the sinus walls to make certain whether or not a

parietal clot, which would permit of hemorrhage from either or both ends, exists. After the thrombus has been removed, by very gentle curettage or by the force of the blood stream, the free edges of the vessel wall should be cut away. Free bleeding is allowed for a few seconds so that the blood current may wash out any small particles of clot that may have escaped the curette. An iodoform gauze tampon (placed *over*, not *in* the sinus) is used to control the hemorrhage; if it should be inserted into the lumen of the canal it would hold it open, and when it became necessary to remove it the withdrawal of the tent would be likely to pull the clot out with it and so cause a recurrence of the hemorrhage. If the jugular bulb is occluded no attempt should be made to remove it by means of a curette for the reason that it may extend into the jugular vein or, if not, portions of the septic thrombus may be loosened and find their way into the general circulation and possibly cause a septic pneumonia, or endocarditis, or synovitis, or abscess in some other of the organs or tissues of the body. In these cases the jugular vein must be ligated and exsected, and then the clot removed from the bulb and upper end of the jugular vein. It requires but little pressure to control the bleeding; that exerted by the usual packing of gauze and by the outer dressings is all that is required.

It is better surgery, as soon as the sinus is fully exposed and a diagnosis of septic thrombosis is made, to leave the sinus unopened until the internal jugular vein is ligated and excised, and then return to the sigmoid sinus, open it, and remove the clot and cut away the anterior wall of the sinus.

III. *Ligation and Exsection of the Internal Jugular.*—The patient is placed on the operating table with the shoulders raised and the head turned to the opposite side; this sharply defines the anterior border of the sternocleidomastoid muscle, which is the guide to be followed by the surgeon in cutting down on the vein. The neck should of course be thoroughly cleansed and the field of operation rendered aseptic. The incision in the skin extends from the sternoclavicular articulation to a point midway between the angle of the jaw and the mastoid process. It is carried through the superficial fasciæ and the platysma myoides muscle. On reaching the deep cervical fasciæ the surgeon should do whatever further dissecting may be needed, with the handle of the scalpel, or with some other blunt instrument, rather than with the cutting edge of the knife. The latter is to be used only where the tissues are too firm to be torn apart. The branches of the superficial cervical nerve and of the external jugular vein are encountered in the course of the operation. About two-thirds of the way down the neck, and beneath the sternocleidomastoid muscle, is the omohyoid muscle, which must be drawn down out of the way or severed. Some small vessels are encountered, and if they get in the way, they should be ligated and divided. The jugular vein lies in the same sheath with the internal carotid artery and the pneumogastric nerve, and is covered by a fibrous sheath which also constitutes the posterior wall of the sheath of the sternocleidomastoid muscle. The muscle is retracted and this sheath is divided and then opened throughout its entire length. The vein, it must be remembered, is very thin and easily punctured, especially if distended. It usually lies to the outside of the artery, the nerve lying between the two. At times the vein is collapsed and so small that it is difficult to find.

When the vein has been freed throughout this entire length its branches are next to be tied off (*i.e.* the facial, the superior and middle thyroid, and the lingual veins). The internal jugular is then to be tied at two different points—one a little above its union with the subclavian vein, and the other at its upper end. At each of these two points two separate ligatures are to be placed around the vein, which is then to be divided by means of a pair of scissors at each of these points. The division is to be made at the lower point of ligation first, and the vessel is to be carefully dissected out from its bed until the upper point of ligation is reached. At this point the vein is again to be divided and the exsected portion entirely removed. Under no circumstances should this infected part of the vein be allowed to remain behind. Many surgeons do not consider it necessary to remove the vein, but consider the ligation of it sufficient, but even if it does not contain a septic clot, its walls are generally found to be the seat of a septic infection, so it is better surgery to tie off its branches and resect it and so remove so much infective material. The wound, if there is no sloughing of the tissues of the neck, may be partially closed leaving an opening at the lower end for the insertion of a cigarette or gauze wick drain. Dressings are then applied and kept in place by a bandage made by folding a piece of gauze four or five times, so as to form a bandage of four or five inches in width and some six or seven yards long. This bandage first encircles the neck, then passes over the chest under the opposite axilla over the back, again around the neck over the mastoid wound and auricle over the forehead around the occiput, again over the chest, and repeat. An ordinary bandage may then be used to reinforce this dressing. A dressing applied in this manner will prevent exposure of the wound.

Randall (*University Medical Journal*, October, 1900), in an article entitled "A Review of Surgery, with Special Reference to Operation for Phlebothrombosis of the Lateral Sinus" and containing a most excellent summary, draws the following conclusions: Shock should be forestalled by avoiding loss of blood, by maintaining the body temperature, by the injection of a hot saline solution, and by the rapid use of the chisel, curette, and the rongeur with the minimum use of the mallet.* Metastases already formed, even in the lungs, are not necessarily contraindications for operation, since the secondary foci are generally less virulent and may heal. Brain abscess, especially in the cerebellum, should be constantly watched for, and may yield to prompt evacuation. Leptomeningitis alone seems to preclude recovery; and yet, in some cases, the symptoms of this serious complication may promptly disappear after operation.

The *carotid artery* and the *bulb of the jugular vein* because of their displacement forward into the tympanic cavity, have, in a few rare cases, been wounded in operations upon the drum membrane or in the middle ear. Bruhl mentions a case in which the carotid canal almost reached to the promontory of the middle ear. If this accident should occur, packing with iodoform gauze may control the hemorrhage, and continued pressure over the carotid will assist in the formation of a clot. ROBERT LEWIS.

Masturbation.—See *Neuroses, Sexual.*

Maté.—YERBA MATE, *Paraguay Tea.* The dried leaves of *Ilex paraguensis* St. Hil. (fam. *Ilicineæ*). The plant yielding this important article is a shrub or small tree, growing both wild and cultivated in the country for which it is named, and in other parts of South America. The leaves are evergreen, lanceolate or oblong, blunt, and sparsely serrate. For use they are collected, dried, and generally broken into fine fragments.

It is not a drug in the proper sense of the term, but a beverage substance, being drunk in South America as a substitute for tea, for the sake of its one-half to one and one-half per cent. of caffeine. With this there occur about fifteen per cent. of tannin and a trace of volatile oil, so that the resemblance to tea is very close. It is the staple beverage of millions of people, who are quite as fond of it as any people are of other beverages, and it has the advantage of being

* The inhalation of oxygen, especially in septic cases or in those in which the lungs are involved, is an excellent sustaining measure.

very cheap. Various spasmodic attempts have been made to introduce it abroad, as a cheap substitute for tea, for the poorer classes, and these are now (1914) beginning to meet with some success. In doses about double those of tea, the characteristic action of theine or caffeine is to be obtained. HENRY H. RUSBY.

Maternal Impressions.—The influence which a mother may have by her impressions and emotions in modifying the structure of her unborn child is a subject which has been wrangled over and investigated and written about for ages, and still remains unsettled. Those who believe in the effectiveness of such impressions and those who do not, fail in either case to convince the others. The embryologists, anatomists, and clinicians have all taken a hand in this discussion and none of them has succeeded in bringing forward evidence which shall once and forever settle the controversy. It is said by the embryologist that since the form and outlines of the fetus are "mapped out" or developed in miniature by the end of the second month, any extensive modification of structure which could be produced by maternal impression must occur prior to that time, and that therefore the birthmarks and deformities and defects in the fetus which have a later origin cannot be due to maternal impressions. The anatomists seek to find some structural relation between the nervous system of the mother and that of the fetus along which impressions could pass which might modify fetal structure, but no less an authority than Virchow says that such a relation does not exist, and that there is no connection between the nervous system of the mother and that of the fetus.

But what about the circulation of the blood between the mother and the fetus? Here again we are met by the assertion that the capillary structure in the maternal portion of the placenta does not coalesce with the fetal capillary structure. The blood current in the fetus is derived from the yolk sac, and the maternal and fetal blood do not intermingle. Oxygen and nutriment are transuded through the maternal capillaries and are taken up by osmosis by the fetal capillaries.

The clinicians of one party follow the anatomists and embryologists, and while they do not deny the existence of the defects and deformities, they say that their occurrence is merely a coincidence, when the supposed causative influence is quoted, which is an explanation that does not explain.

The other party of clinicians say that the maternal impression causes the deformity. Neither party can bring forward conclusive evidence to establish its position. That being the case, the position of one is as good as the other and either can say to the other "not proven." In the absence of anatomical evidence the best we can do is to reason on the theory of probabilities, and to that end we can refer either to the blood or the nervous system or to both.

That parental, ancestral, and racial peculiarities are transmitted there can be no doubt. That syphilis and perhaps other diseases can be transmitted, though there is no structural connection between the vascular system of the mother and the fetus, is equally certain.

The mother when suffering from profound nervous excitement can cause uterine contractions and can even cause the death of her fetus. Analogous is the influence of nervous impressions upon the milk of a nursing woman which may become poisonous to her infant.

A clean and well-healed amputation of a limb or member may be explained by the mechanical action of the umbilical cord or of amniotic bands or by some other mechanical influence, but this will not explain supernumerary fingers in connection with fright or some other profound experience. In one of Blondel's cases a pregnant woman saw a child chop off its middle, ring, and little fingers, and when her baby was born it lacked just these members.

Profound nervous experience of the mother is often accepted as a modifying or controlling influence upon the mental or psychic development of her offspring, and it does not wrench the imagination to believe this. A case is reported by Blondel in which a woman was told she had a serious disease of the heart, and the child which she was then carrying proved to be an imbecile. In another case a woman in the early months of pregnancy was terribly frightened by seeing a frog and developed an anencephalic fetus. In another case a pregnant woman was struck by a deaf and dumb pedlar whose wares she refused to buy and bore a deaf and dumb infant.

McEvoy tells of a three months' pregnant Filipino woman who in 1901 saw her husband after the top of his head had been blown off by a rifle shot. She fainted and when her child was born the upper part of its head was disfigured, the eyes being absent.

In a case of my own, a young woman who had been under my professional care for some time, while pregnant with her first child in the third month, was riding with her husband when the horse stumbled and fell. She was greatly excited, rubbing one hand with the other at the time, and wondered whether it would affect her baby. The baby was born with two thumbs on the left hand.

The belief in the influence of maternal impressions upon the fetus, is as old as human history, and it applies to animals as well as to man. In fact, the instances of monstrosities and defects in animals are more numerous than in man.

The Bible gives us an example of this ancient belief in the story of Jacob, who got the better of his father-in-law by the way in which he caused the ewes to bring forth ring-streaked and speckled lambs. The advocates and believers in this influence are by no means limited to the visionary and superficial, but include such great names as Van Swieten, Boerhaave, Morgagni, Rokitansky, Burdach, and Stolz. Among our American obstetricians are such eminent men as Fordyce Barker, Busey, and Parvin. Of the recent American obstetrical writers Hirst brings forward numerous reasons for the plausibility of the theory without committing himself to positive enunciation of it. Edgar thinks there is need of much more, and more reliable, evidence than we have yet had, before an opinion or a belief could be ventured. DeLee, while admitting the somewhat astonishing character of some of the evidence, is inclined to explain it by coincidence or invention, and he does not believe there is a teratological connection between the nervous shock and the deformity.

My own belief is that while many of the opinions and theories that have been handed down to us from the ancients are fanciful and imaginative, we are not obliged to throw them all overboard if we find in some of them the characteristics of reason and truth. Suppose there is no nervous connection between the mother and fetus, there is a connection between the nerves and the blood-vessels of the mother, and by that means, or some other which we do not understand, her blood is affected by a great variety of impressions and much more intensely during the period of pregnancy than at any other time. Without considering the influence of parental elements at the time of conception, it seems to me that it is enough to admit that oxygen and nutriment charged with maternal influence pass from mother to fetus. It is impossible just yet to say how that influence takes place, but if it can, according to its quality and peculiarities, modify ordinary development and cause a child to become large or small, thick or thin, transmit syphilis, ichthyosis, and various other morbid conditions, why is it not possible that it may modify

structure in the anomalies and deformities which we know exist but for which no rule or law of development has yet been found.

ANDREW F. CURRIER.

Matico.—"The leaves of *Piper angustifolium* R. et P. (fam. *Piperaceæ*)" (U. S. P.). This plant is a large shrub or small tree, growing upon the eastern slope of the Bolivian Andes, and probably in Peru, at an elevation of 4,000 to 6,000 feet, the belt inhabited by the cinchona and coca plants. It is said to grow also in southeastern Brazil, but this is a distinct species. Several other species are collected and sold for it. The illustration correctly represents the genuine leaf. The following is the description of the plant:

Leaf from twelve to twenty centimeters (five to inches) in length, very shortly and stoutly petioled, oblong-lanceolate, with obliquely cordate base, its lobes rounded, and a long acuminate, acute summit; margin entire or obsoletely crenate; bullate above, finely cancellate underneath, the veins densely brownish-hairy; odor faint; taste aromatic, pungent and bitterish. The flower spikes, which are frequently present, are about a fourth of an inch in diameter and two-thirds as long as the leaves. This distinguishes it from a spurious species often sold for it, the leaves being decidedly shorter and relatively broader and the spikes only about half as long and relatively thicker.

Matico contains from two to three per cent. of an essential oil, which is distilled for the market. It is yellowish brown, of characteristic odor, and has a specific gravity of about 0.93. Its important constituent is the stearopten, which has been called "matico camphor" ($C_{12}H_{20}O$). The oil of the flowers is similar but has a specific gravity of 1.13. With the oil, there are considerable resin and tannin and an amaroid, as well as *artanthic acid*.

The essential oil is a powerful abdominal stimulant, contracting the vessels in serous diarrhea and in intestinal hemorrhage, in which action it is aided by the tannin. It has also been used locally as a hemostatic, and as an ordinary vulnerary. It also possesses the ordinary properties of a bitter tonic. Its chief use, especially in France, has been as a substitute for cubeb and copaiba in the treatment of gonorrhea and cystitis, but it is inferior to them, especially to the latter. We have official the fluid extract, dose, fl. ʒ ss.–iss. (2.0–6.0). The best use of the ten per cent. tincture is as a stomachic, in doses of ʒ ss.–i. (15.0–30.0).

HENRY H. RUSBY.

Matricaria.—GERMAN CHAMOMILE. "The dried flower-heads of *Matricaria Chamomilla* L. (fam. *Compositæ*)" (U. S. P.). This drug is the product of a daisy-like plant, one to two feet in height, native of Europe and western Asia, and introduced, as a roadside weed, into many countries. The reflexed rays are about fifteen in number, nearly half an inch long, white, three-toothed. These rays, together with its elongated, conical, and hollow receptacle, which bears no scales, distinguish it from all drugs or substitutes which might be mistaken for it.

Its active constituents are its anthemic acid, which is very bitter, and less than half of one per cent. of a dark blue volatile oil. There are also a small amount of tannin and some anthemidin.

The drug is very largely used as an ingredient of proprietary "teas" and other herb mixtures, but possesses only ordinary aromatic-bitter properties of the *Compositæ*, which see. The ordinary dose is gr. xv. to lx. (1.0–4.0), and it is commonly given in infusion or fluid extract.

HENRY H. RUSBY.

Maturation.—In this article the term maturation is applied to that process by which germ cells are prepared for fertilization (see article *Impregnation*). In its essential features the process appears to be identical in all multicellular animals and plants. Its result is the formation of ripe ova and spermatozoa in animals or the equivalent cells in plants.

In his famous Treatise on Comparative Embryology, published in 1880, Balfour applied the term maturation to the ovum only. In its superficial aspects the maturation of the ovum consists in the budding off of two minute cells called *polar bodies*, one after the other at one pole of the egg (Fig. 3938). The first polar body may divide into two. It is now known that the polar bodies are formed by mitotic cell division (see article *Cell*), and that as first pointed

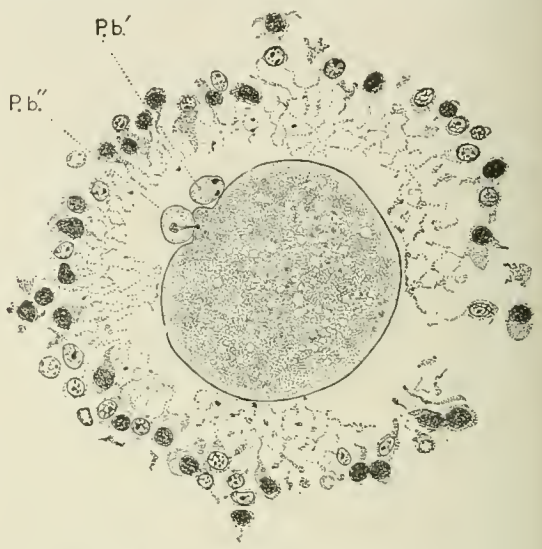


FIG. 3938.—Section of a Fertilized Egg in the Fallopian Tube of the Cat. *Pb'*, first polar body; *Pb"* second polar body just formed. The zona radiata is disintegrating. × 40. (After Longley.)

out by Mark, they are equivalent to ova, differing from the ripe egg only in the amount of their cytoplasmic contents.

It was first suggested by Platner in 1889 that the last two cell divisions leading to the formation of spermatozoa are equivalent to the formation of polar bodies. This conclusion was confirmed by O. Hertwig in 1890, and subsequently by many observers. The maturation of the ovum is part of the process called *oögenesis;* the corresponding process in the male is called *spermatogenesis*.

The identity of the two processes is shown by certain peculiar changes in the nuclei that occur in both cases. These changes are (1) *synapsis* and (2) a *reducing division*. Maturation is, therefore, essentially a change in the constitution of the nucleus of the cell; more especially a change in the number and distribution of the nuclear elements called chromosomes (see article *Chromosomes*). In order to understand the significance of these phenomena in the germ cells, it is necessary to consider certain events in the history of biology.

HISTORICAL.—Roux in 1884 published an elaborate review of the whole subject of mitotic cell division, so far as it had been developed at that time, and his conclusion was that the *longitudinal splitting* of the chromosomes and the whole mechanism by which the two halves of an originally single chromosome are always carried to opposite poles of the spindle, has for its object the distribution of the chromatin, both as to quantity and as to quality, in exactly equal proportions to the two daughter cells (see *Chromosome*).

If we suppose that the physical basis of heredity

consists of distinct units in the chromatin material of the nuclei of the germ cells, then at each union of two germ cells in sexual reproduction the number of ancestral units, or ancestral germ plasms, will be doubled. And, unless prevented in some way, this doubling will continue with each successive sexual union, until either the germ cells will be increased to an enormous size, or else the units will be reduced in size so much that they are smaller than the proteid molecule.

A study of the phenomena of heredity led Weismann to suppose the chromatin to be made up of elements as indicated in the previous paragraph (see also article *Heredity*) and that these ancestral germ plasms maintain their individuality through successive generations. And this led to the further supposition that sexual reproduction can be continued only in case there is a reduction in the number of ancestral germ plasms, a reduction that must be repeated in every generation. But Roux's conclusions would seem to make such a reduction improbable so long as the division takes place by the ordinary method accompanied by a longitudinal splitting of the chromosomes.

Writing in 1887, Weismann says: "This is the only kind of karyokinesis which has been observed until recently; but if the supposed nuclear division leading to a reduction in the number of ancestral germ plasms has any real existence, there must be yet another kind of karyokinesis in which the primary equatorial loops are not split longitudinally, but are separated without division into two groups, each of which forms one of the two daughter nuclei. In such a case the required reduction in the number of ancestral germ plasms would take place, for each daughter nucleus would receive only half the number which was contained in the mother nucleus." After discussing the work of van Beneden (1883) and Carnoy (1886), then recently published, Weismann defines the terms "reducing division" and "equal division," and then adds the following explanation of his prediction: "The 'reducing division' must be always accompanied by a reduction of the loops to half their original number, or by a transverse division of the loops (if such division ever occurs); although reduction can only occur when the loops are not made up of identical pairs. And it will not always be easy to decide whether this is the case. On the other hand, the form of karyokinesis in which a longitudinal splitting of the loops takes place *before* they separate to form the daughter nuclei must always as far as I can see, be considered as an 'equal division.'"

This propheey is one of the most famous in the annals of science, because it has furnished the stimulus for a large number of very careful investigations that have produced results of the greatest importance, especially for the understanding of the phenomena of heredity and of sex. The reducing division predicted by Weismann has been found to be of universal occurrence, and to be preceded by a process called synapsis, first described by J. E. S. Moore in 1895.

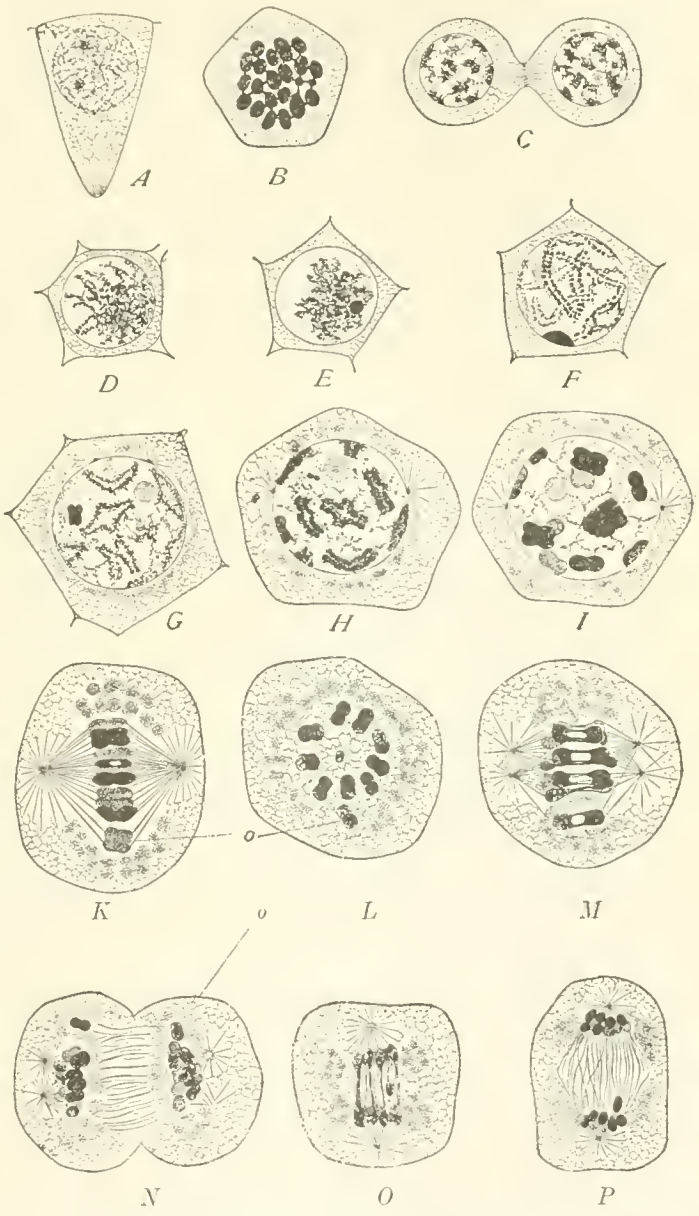


Fig. 3939.—Various Stages in Spermatogenesis from Sections of the Testis of the Squash Bug. *A*, Spermatogonium; *B*, spermatogonium preparing for division, cross-section of equatorial plate showing twenty-two chromosomes; *C*, division of spermatogonium nearly completed; *D* and *E*, primary spermatocyte in synapsis; *F*, *G*, *H*, and *I*, stages in the formation of tetrads; *K*, *L*, *M* and *N*, division of primary spermatocyte; *O* and *P*, division of secondary spermatocyte; *o*, accessory chromosome. (From Wilson, after Paulmier.)

The Time of Maturation.—The history of the development of the germ cells may be divided into three periods (see article *Germ Cells*). During the third period the germ cells undergo two kinds of cell division: multiplicative and maturation divisions. The multiplicative divisions (Fig. 3939 *A–C*) are indefinite in number, and the germ cells in this phase are called, if in the ovary, *oögonia;* if in the testis, *spermatogonia*. The maturation divisions are definite in number, and each generation of cells in this phase is given a name. The generations in the female are *primary oöcyte*, *secondary oöcyte*, and ripe *ovum;* in the male (Fig. 3939, *D–P*) they are *primary spermatocyte*, *secondary spermatocyte*, and *spermatid*. The last develops directly by metamorphosis into a spermatozoon (see article *Spermatozoa*). The ovarian ova,

or unripe eggs seen in sections of an ovary, may be either oögonia or primary oöcytes.

Nuclear Changes.—The chromosomes appear as discrete bodies usually only when the cell is about to divide (compare *A* and *B*, Fig. 3939). As a rule, at such times their number is a definite one for each species and sex. When the sexes differ in this respect, the female usually has the larger number. The number found in the oögonia or spermatogonia is the same generally as that in the somatic cells of the same individual. This is known as the *diploid number*. Synapsis is followed by an apparent reduction, and the reducing division, by a real reduction, to the *haploid* number, which is approximately half the diploid number.

The use of these terms has been made necessary by the discovery that there are two principal kinds of chromosomes, which behave differently in the process of maturation. These are (1) the ordinary chromosomes, or *autosomes* and (2) the *idiochromosomes*. The former are present in equal number in both sexes, are normally an even number in the somatic cells and just half that number in the mature germ cells. The idiochromosomes differ in the two sexes, frequently being twice as numerous in the female as in the male and absent in half of the spermatozoa.

In 1902 Sutton showed that the chromosomes of the spermatogonia in a grasshopper are of many shapes and sizes but that they may be grouped in pairs (Fig. 3940). Since then this has been found to

Fig. 3940.—Polar View of Equatorial Plate of Spermatogonium in the Lubber Grasshopper, showing twenty-two chromosomes and accessory, *x*; *i*, *j*, *k*, three pairs of small chromosomes. From a section. (After Sutton.)

be true of the autosomes of many animals, and in the oögonia the idiochromosomes usually are paired also. In the spermatogonium of many species there is a single unpaired idiochromosome, known as the *X-chromosome*. In other species two, three, four, and five X-chromosomes have been found. When multiple they act alike and form together the *X-element*, which may or may not be paired with a chromosome of different size or shape, called the *Y-element*.

It is now generally believed that synapsis consists in the union of similar chromosomes in pairs, and the reducing division is the separation of these *synaptic mates* into opposite daughter cells.

Synapsis.—The last spermatogonial or oögonial division is like an ordinary cell division, and the diploid number of chromosomes unite to form the daughter nuclei of the resulting primary spermatocytes or oöcytes. This division is followed by the period of growth; the increase in the size of spermatocytes is small, but of oöcytes may be very great, as in the hen's egg. Usually at the beginning of this period, sometimes in spermatogenesis toward its end, the nucleus takes on a peculiar appearance, the chromatin being massed in a thick tangle at one side of the nucleus, leaving the rest of the space within the nuclear membrane clear (Figs. 3941 *B* and 3939 *E*). This condition has been called *synizesis*.

Preparatory to synizesis the chromatin may take the form of a thin spireme or of chromosomes in the diploid number (Fig. 3941 *A*). When emerging from this condition it is seen to be composed of chromosomes in the haploid number, and where the chromosomes differ in shape it has been observed that now there is but one of each form, instead of two (Figs. 3941, *C*, *D*, 3942, and 3943). In other words, during synizesis each pair of like chromosomes has united to form a single bivalent chromosome. This is *synapsis*. If the union has been end to end, as in Peripatus (Montgomery, 1900), it is called *telosynapsis*, if side by side, it is *parasynapsis*.

In the oöcyte, as a rule, all the chromosomes undergo synapsis. But in spermatocytes with unpaired X-chromosomes, these having no mates take no part in synapsis. They remain univalent throughout and appear as dense chromatin nucleoli (Figs. 3939 *E* and *F*, and 3942). If a Y-element be present it unites with the X-element in synapsis.

In the human female all ova are oöcytes at the time of birth, or soon after, and synapsis occurs for the most part during fetal life. Von Winiwarter observed synapsis in a fetus of seven months (Fig. 3941). In the male the multiplicative divisions of the spermatogonia continue indefinitely and synapsis may be observed in the testis during the greater part of adult life.

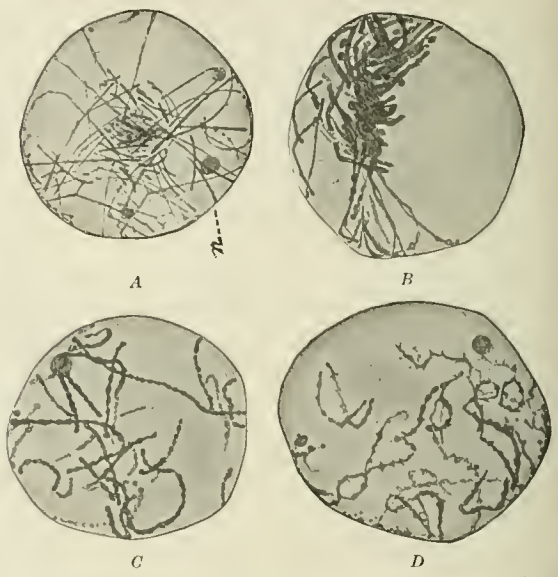


Fig. 3941.—Nuclei from the Ovary of a Human Fetus of about Seven Months, showing consecutive stages in the development of the oöcyte. *B*, Synapsis; *n*, nucleolus. × 1,700. (After Winiwarter.)

The First Maturation Division.—The maturation divisions are of two kinds—*equational*, as in ordinary cell division, when the chromosomes split longitudinally and the two halves are quantitatively and qualitatively alike; and *reducing* when a bivalent chromosome is divided so that each of the two synaptic mates goes to the opposite pole of the spindle (Fig. 3944). Synapsis is a necessary preparation for the reducing division, which in turn is the most essential feature of maturation. Two whole chromosomes having joined in synapsis, they may be pulled apart to opposite poles of the spindle, just as half chromosomes are in ordinary mitosis. In synapsis the diploid number of univalent chromosomes is reduced to the haploid number of double chromosomes. In the reducing division the double chromosomes are divided into two groups of single ones of the same number.

Corresponding to the two kinds of division, there

are two forms of chromosomes: *homotypical*, the usual rods, straight or bent into U- or V-shapes; and *heterotypical*, of which there is a great variety of form—rings, twisted rings, crosses, tetrads, etc. (Figs. 3939 *H* and *I*, and 3943). The tetrad is a group of four little, round balls, and is explained as due to the

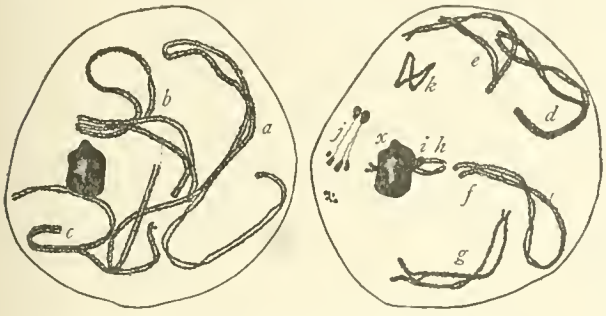


Fig. 3942.—Spiremes, or Chromosomes, from a Primary Spermatocyte in the Lubber Grasshopper in Early Prophase. Drawn in two groups to avoid confusion. From a smear preparation. (After Sutton.)

division of a bivalent chromosome in two planes, one plane between the synaptic pair and the other dividing each member longitudinally (Fig. 3945).

It is generally assumed that heterotypical chromosomes indicate the reducing division. This being so, the first maturation division is usually the reducing division, and the daughter cells receive the haploid number of chromosomes, one member of each of the pairs that joined in synapsis (Fig. 3946). In the female this is the division of the primary oöcyte to

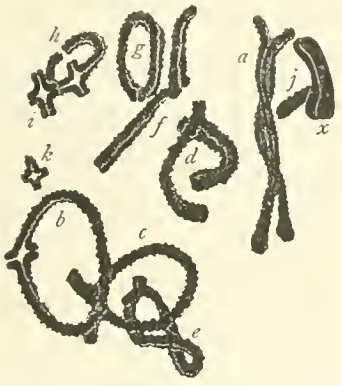


Fig. 3943.—Chromosomes from Primary Spermatocyte in Middle Prophase, showing Longitudinal Split. *a*, *b*, *c*, etc., same as in Fig. 3942. (After Sutton.)

form the first polar body and the secondary oöcyte; in the male it is the division of the primary spermatocyte to form two secondary spermatocytes.

In man the maturation of the ovum is unknown. In other mammals the first polar body is extruded in the Graafian follicle, just before ovulation. If the nucleus of the primary oöcyte contains paired X-chromosomes, as is usually the case, the egg and first polar body will have similar nuclei.

In the male, on the other hand, the X-element is usually unpaired, and at this division goes to one daughter cell, while the other receives no idiochromosome or the Y-element, if it be present. In man, according to Guyer (1910), there is no Y-element and the X-element consists of two chromosomes that go together to one pole of the spindle (Fig. 3947). The haploid number of autosomes is ten. There result two kinds of secondary spermatocytes, one with ten, the other with twelve chromosomes. These observations have been confirmed by Montgomery (1912) who found also interesting variations.

The Second Maturation Division.—At this division the secondary oöcyte gives off the second polar body and becomes a mature ovum; the secondary spermatocytes divide each into two spermatids. In mammals, so far as observed, the second polar body is extruded in the Fallopian tube. But the spindle is formed before ovulation and remains in the equatorial plate stage until the head of the spermatozoon enters the egg.

Usually this division is equational in both sexes, the idiochromosomes dividing longitudinally like the others. Where there are two kinds of spermatocytes, as in man, each produces two spermatids like itself. In some animals, however, the X-chromosome divides in the first division and goes undivided to one cell only in the second. In this case the secondary spermatocytes are alike but each produces two kinds of spermatids (Fig. 3939).

The net results of these processes, as usually observed, is to change unripe germ cells with two sets of chromosomes (diploid number) into ripe germ

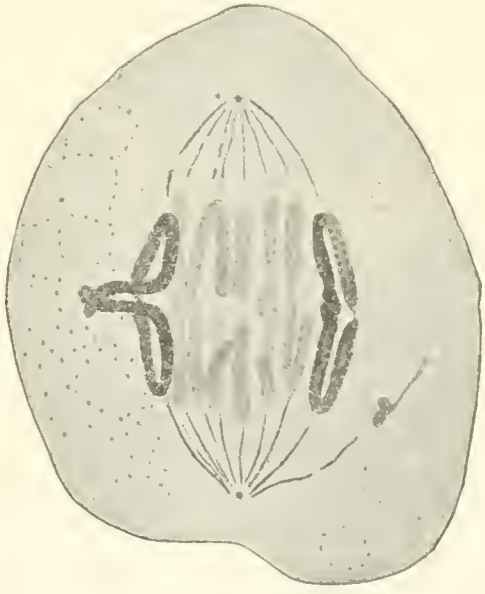


Fig. 3944.—Primary Spermatocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

cells with a single set of chromosomes (haploid number). The eggs are all alike, containing both autosomes and X-elements. The spermatozoa are of two kinds in equal numbers. One kind lacks the

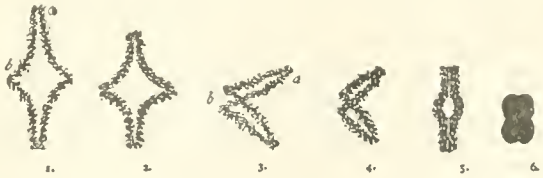


Fig. 3945.—Chromosomes from Primary Spermatocytes of the Squash Bug, showing changes of shape leading to the formation of tetrad. *a*, Distal end; *b*, central end; 6, completed tetrad with long axis corresponding to the longitudinal split. (After Paulmier.)

X-element, but may have in its place a Y-element (absent in the female).

In fertilization there is no fusion of chromosomes,

and the diploid number is restored by the union of the nuclei of egg and sperm. There being two kinds of spermatozoa, it is evident that there may be two kinds of fertilized eggs, differing in the number of X-chromosomes in their nuclei. It is believed that this difference has an important relation to the determination of sex (see articles *Impregnation* and *Sex*).

Special Cases.—There are certain special cases of maturation that deserve notice because of their theoretical importance.

In the prophase of the reducing division, the bivalent, heterotypical chromosomes are composed of a pair of synaptic mates united in various ways. It is quite probable that when they separate during the metaphase, the plane of division may not coincide exactly with the surfaces that united. Thus an interchange of material may take place. In fact Janssens has described such a condition, and Morgan has offered it as an explanation for certain exceptions to the Mendelian theory of heredity (see Figs. 3142 and 3143 in the article on *Heredity*).

Fig. 3946.—Polar View of Equatorial Plate of Secondary Spermatocyte in Grasshopper, showing eleven chromosomes and the idiochromosome, *x*. (After Sutton.)

Parthenogenesis offers many interesting examples of modification of the usual course of maturation. In most cases but one polar body is formed and in some cases the stage of synapsis is omitted. So the egg receives the full number of chromosomes. Such eggs probably always produce females. In the gall-fly, Neuroterus, Doncaster has found that some females produce parthenogenetic eggs which give off two polar bodies and contain the haploid number of chromosomes. These develop into males. In the honeybee a similar condition exists, except that any egg may be caused to develop into either a male or a female. Two polar bodies are produced as usual. If

A *B*

Fig. 3947.—Cells from a Human Testis. *A*, Polar view of prophase of spermatogonial division with twenty autosomes in a circle and two idiochromosomes in a vacuole at one side; *B*, Side view of metaphase in division of a primary spermatocyte, with autosomes massed in the equatorial plate and the idiochromosomes nearer one pole of the spindle. (After Guyer, 1910.)

the egg is fertilized it develops into a female with the diploid number of chromosomes, if unfertilized it develops into a male with the haploid number.

In these cases where fertilization results in the production of one sex only, there is only one kind of spermatozoa. The process of maturation in these cases is of great interest in connection with the theories of the determination of sex, and will be discussed more fully in the article on *Sex*.

Similar interest attaches to cases of hermaphroditism. Boveri and Schleip have studied a nematode worm in which an hermaphrodite generation alternates with a bisexual one. The somatic cells of the hermaphrodite have twelve chromosomes, the ripe egg has six and so does the primary spermatocyte. In the division of the secondary spermatocyte one chromosome is lost in the plane of division between the daughter cells. So there are two kinds of spermatozoa, one with five and one with six chromosomes, producing males and females respectively.

The whole subject of maturation is now under discussion, and in relation to these and other special cases there are many unsolved problems that offer a rich field for future investigation.

Robert Payne Bigelow.

Bibliographical References.

Guyer, M. F., 1910: Accessory Chromosomes in Man. Biol. Bull., vol. xix., pp. 219–234.

Hegner, R. W., 1914: The Germ-cell Cycle in Animals. New York.

Kirkham, W. B., and Burr, H. S., 1913: Breeding Habits, Maturation of Eggs and Ovulation of the Albino Rat. Amer. Jour. Anat., vol. xv., pp. 291–318.

Longley, W. H., 1911: Maturation of the Egg and Ovulation in the Domestic Cat. Amer. Jour. Anat., vol. xii., pp. 139–172.

Montgomery, T. H., Jr.: Spermatogenesis in Pentatoma up to the Formation of the Spermatid. Zool. Jahrb. Anat., vol. xii., 1898, pp. 1–88. Spermatogenesis of Peripatus (Peripatopsis) balfouri up to the Formation of the Spermatid, *l.c.*, vol. xiv., 1900, pp. 275–368. A Study of the Chromosomes of the Germ Cells of Metazoa. Trans. Amer. Phil. Soc., Phila., N. S., vol. xxii., 1901, pp. 154–236.

Montgomery, T. H., Jr., 1912: Human Spermatogenesis. Jour. Acad. Nat. Sci., Phila., Ser. 2., vol. xv., pp. 1–22.

Moore, J. E. S.: On the Structural Changes in the Reproductive Cells during Spermatogenesis of Elasmobranchs. Quart. Jour. Mic. Sci., N. S., vol. xxxviii., 1895, pp. 275–314.

Paulmier, F. C.: The Spermatogenesis of Anasa tristis. Jour. Morph., vol. xv., suppl., 1899, pp. 223–272.

Sutton, W. S.: The Spermatogonial Divisions in Brachystola magna. Kansas Univ. Quart., vol. ix., 1900, pp. 135–160. On the Morphology of the Chromosome Group in Brachystola magna. Biol. Bull., vol. iv., 1902, pp. 24–39.

Weismann, A.: On the Number of Polar Bodies and their Significance in Heredity, 1887. Essays upon Heredity, Oxford, 1889, pp. 333–384.

Winiwarter, H. von, 1912: Études sur la spermatogenèse humaine. Arch. d. Biol., vol. xvii.

Mauriceau, François.—The most celebrated accoucheur of the seventeenth century. He was born in Paris in 1637 and practised surgery in all its branches during the first part of his active career, but was soon compelled, by his great popularity as an obstetrician, to devote himself exclusively to this department of surgery. For many years he held the position of *Accoucheur-en-Chef* at Hôtel-Dieu. He died October 17, 1709.

Great credit is due to Mauriceau, not for having discovered any new methods of procedure nor for having invented any new instruments, but for having been the first to formulate in a methodical and precise manner the science and art of midwifery, and for having published a large treatise in which all the more important facts relating to obstetrics are set forth in great detail. The work here referred to bears the following title: "Traité des maladies des femmes grosses et de celles qui sont nouvellement accouchées, enseignant la bonne et véritable méthode pour bien aider les femmes en leurs accouchements; ouvrage très utile aux chirurgiens et nécessaire à toutes les sages-femmes pour apprendre à bien pratiquer l'art des accouchements," Paris, 1668 (with illustrations). During the period from 1668 to 1740 many editions were published, both in French and in the different European languages.

A. H. B.

Mauthner, Ludwig.—Born in Vienna, Austria, April 13, 1840. He received his doctor's degree in 1861. After he had been well trained as an ophthalmologist by Edward von Jaeger he was given the position of Dozent in Ophthalmology in 1864, in the University of Vienna. In 1869 he was called to Innsbruck to fill the regular chair of this branch of science, and he continued to hold this position until 1877, when he again established his residence in Vienna. In 1894, when Stelwag von Carion retired from practice and from his position as a teacher, Mauthner was chosen his successor. He died, however, October 20, 1894, a very short time after he had received the appointment.

The following are some of the more important of Mauthner's published writings: "Lehrbuch der Ophthalmoskopie," Vienna, 1868; "Die optischen Fehler des Auges," Vienna, 1872–1876; "Die sympathischen Augenleiden," Wiesbaden, 1879; "Die Functionsprüfung des Auges," 1880; "Gehirn und Auge," 1881; and "Die Lehre vom Glaucom," 1882.

A. H. B.

Mayer, Karl Wilhelm.—Born in Berlin, Germany, June 25, 1795. In 1821 he received his doctor's degree, and soon afterward began practising in his native city. He devoted himself particularly to gynecology, and soon built up a large private practice. In 1840 the new title of *Sanitätsrat* was established by Friedrich Wilhelm IV., and Dr. Mayer was made the first recipient of the title. In 1846 he was made a *Geheimer Sanitätsrat*. In 1844, in association with others, he founded the Berlin Obstetrical Society—the very first organization of its kind. He died February 12, 1868.

Mayer, according to Pagel, should be considered the founder of gynecology (the term being used in its modern sense), for he was certainly one of the first to cultivate the modern methods of making examinations and of operating in cases of disease of the uterus, and also one of the first to attach a special value to pathologico-anatomical and microscopical examinations. Aside from two articles which he published in the *Berliner medizinische Zeitung*, in 1834, he made only the following contributions to medical literature: "Geschichte des Blumenkohlgewächses;" "Ueber die Natur und Bekandlung der Flexionen des Uterus;" "Beiträge zur Behandlung des Prolapsus uteri et vaginæ;" "Klinische Mittheilungen aus dem Gebiet der Gynekologie," 1. Heft, Berlin, 1861 (with beautiful illustrations painted by himself); and "Ueber Erosionen, Excoriationen und Geschwürsformen der Schleimhaut des Cervicalcanals und der Muttermundslippen."

A. H. B.

Mayerne, Théodore Turquet de.—Born in the vicinity of Geneva, Switzerland, in 1573. He received his doctor's degree from the University of Montpellier, in the southern part of France, in 1597. In 1602 he settled in Paris and soon began giving courses of instruction to young surgeons. The Parisian physicians, who were very jealous of his success, managed to secure from the Faculty of Medicine—on the ground that Mayerne employed antimony as a remedy—a decree forbidding its members to consult with him. Just about this time he was induced by an English gentleman, who had at one time been under his professional care, to visit England; and, soon after his arrival in London, he received the appointment of Physician to King James. The same office was conferred upon him by Charles I. when he came to the throne. He died March 15, 1655.

Presumably one or the other of his royal patrons conferred knighthood on him, as Wootton, in his *Chronicles of Pharmacy*, says that "calomel was introduced into practice by Sir Theodore Turquet de Mayerne about the year 1698;" and the same author states that he was also one of the most active promoters of the publication of the London Pharmacopœia.

Of his published writings the following two alone deserve to receive notice here: "Apologia in qua videre est, inviolatis Hippocratis et Galeni legibus, remedia chymice præparata tuto usurpari posse, etc," La Rochelle, 1603; and "De gonorrheæ inveteratæ et carcunculæ ac ulceris in meatu urinario curatione epistola," Oppenheim, 1619. A. H. B.

McBurney, Charles.—Born in Roxbury, Mass., on February 17, 1845. He received his early education at private schools in Boston. He entered Harvard University, received the degree of A. B. in 1866. His medical degree was conferred by the College of Physicians and Surgeons, Columbia University, New York, in 1870. After serving as surgical interne at Bellevue Hospital, Dr. McBurney studied in Europe, returning in 1872 to New York City to establish himself in the practice of his profession. In 1873 he was appointed assistant demonstrator of anatomy at the College of Physicians and Surgeons, and later served for several years as demonstrator. In 1874 was appointed attending surgeon at St. Luke's Hospital, and in 1880 assistant surgeon at Bellevue Hospital. In 1882 he was made lecturer on operative

Fig. 3948.—Charles McBurney.

surgery at the College of Physicians, and professor of surgery in 1889. 1886 found him consulting surgeon to the Presbyterian Hospital and in 1888 he was given the entire surgical service of Roosevelt Hospital as the successor of Dr. Sands, a position which he held for twelve years.

On account of ill health, he retired from practice in 1908. He died in Brookline, Mass., on November 7, 1913.

Dr. McBurney's professional career stands for the greater development of the science and art of surgery in America. He was among the first to adopt, improve and simplify aseptic methods, such as sterilization of operating materials and instruments by means of the modern steam sterilizer, and the use of sterilized rubber gloves in operative work. His fame rests largely on his treatment of appendicitis by the operative method. He insisted that one attack of appendicitis demanded an operation for the removal of the appendix. His location of "McBurney's point," a point one and a half to two inches above the anterior superior spine of the ilium between that process and the umbilicus, where finger pressure elicits tenderness, and his method of incision for the operation of appendicitis, called "McBurney's incision" which was made parallel with the course of the external oblique muscle, one to two inches from the anterior superior spine of the ilium, brought him well-earned fame. He also used on selected cases, his intermuscular incision for this operation. Among

his other contributions to surgical technique may be mentioned McBurney's transduodenal method of removing stone from the common bile duct in certain cases; a small transperitoneal incision for the purpose of compression of the common iliac artery by the fingers of an assistant during disarticulation at the hip-joint; McBurney's hooks for skin grafting; McBurney's tractor or hook for the reduction of fracture at the shoulder-joint; McBurney's staff, with a combined gorget and knife for rapid perineal section.

While he contributed at various times to current medical literature, his now famous paper on "Experience with Early Operative Interference in Cases of Diseases of the Vermiform Appendix," published in the *New York Medical Journal* in 1887, has set forth principles which are the basis of modern surgery of this disease. E. L. J.

Mead, Richard.—Born at Stepney, near London, England, August 2, 1673. He began the study of medicine at the University of Leyden, Holland, in 1693, and received the doctor's degree from the University of Padua, Italy on August 26, 1696. Upon his return to England he settled at his native village and practised his profession there very successfully for a few years. As his reputation increased he was made a member of the Royal Society of London, and in 1703 he received the appointment of Attending Physician at the principal hospital of that city. In 1707 the University of Oxford presented him with its degree of Doctor of Medicine. Mead possessed a most generous nature and a keen sense of what is right. When Dr. John Freind, who was also a member of Parliament, was imprisoned in the Tower, in 1723, on the suspicion that he was an accomplice of Bishop Atterbury, Mead took charge of his private practice; and on the day when he was set free Mead turned over to him the sum of nearly 5,000 guineas which he had collected in fees from Freind's patients during the period of his imprisonment.

For nearly half a century Mead had one of the most extensive and brilliant practices in London. It is said that, although his earnings were very large (from 7,000 to 8,000 guineas per annum), he was not a rich man at the time of his death. He invested largely in books and works of art of all sorts, and he was always ready to give employment to artists and scientific men. It is well-known that it was through his influence that Guy, the rich bookseller, was induced to devote large sums of money to the construction and equipment of the fine hospital which bears his name; and it was Mead also who presented to the College of Physicians the statue of Harvey. He died February 16, 1754.

Of Mead's published writings, the following deserve to receive special mention: "Mechanical Account of Poisons," London, 1702 (in the edition of 1750 the author made many important changes; he admitted that his views on the action of various poisons had, during the intervening period, undergone a very decided change); "A short discourse concerning contagion and the method to be used to prevent it," London, 1720 (seven editions of this book were published during a single year); "Dissertation on the Scurry," London, 1749; "Monita et præcepta medica," London, 1751; and "Pharmacopœia Medica," London, 1756, 1757, and 1758. A. H. B.

Measles.—*Synonyms:* morbilli, rubeola; *Masern, Flecken* (German); *rougeole* (French); *rosalia* (Italian); *sarampion* (Spanish).

Definition.—Measles is an acute, highly contagious disease, characterized by fever and other constitutional symptoms, and specific manifestations in the skin and mucous membranes.

Description.—Measles is the most common of the exanthemata, and like the other members of this group, it consists of periods of incubation; of prodromi or invasion; of efflorescence or eruption; and of desquamation, decline, or convalescence. (See *Exanthemata.*)

History.—Rhazes, an Arabian physician, was apparently the first to describe this disease (A. D. 900), but he regarded it as a mild form of smallpox. Similarly measles and scarlatina were thought to be the same disease until Sydenham and Morton in the latter part of the seventeenth century differentiated these from each other and from smallpox.

Distribution.—This disease has spread to all parts of the world close on the heels of civilization. When introduced for the first time into any new territory it would attack almost the entire population with marked virulence and would be accompanied by a high mortality. These facts have been recorded by a number of explorers in the arctic and antarctic regions. From 1834 to 1836 and from 1842 to 1843 marked epidemics spread over the continent of Europe. In America the disease did not reach Oregon until 1829, and California and Hudson's Bay Territory until 1846. Greenland, as late as 1864, had not been invaded by it.

Etiology.—Measles is conspicuously a disease of childhood. Infants under three months of age have a relative immunity. The period of greatest susceptibility is between the ages of three and seven years, during which period 90 per cent. of all children exposed contract the disease. It may be transmitted to the fetus *in utero;* and the infant may be born with the disease or manifest the first signs a few days after birth. Under the age of six months the disease is exceedingly mild, and during the second year of life it is apt to be particularly severe. Unprotected adults may contract the disease and constitute a large percentage of all those attacked when the disease visits a region in which it has hitherto been unknown. This was the experience in the case of the epidemics in the Farroe and the Fiji Islands. Among the exanthemata measles is accompanied by the greatest mortality. This is highest during the second year of life. Natural immunity is very rare; probably ten per cent. of individuals escape the disease. As a rule one attack confers a lasting immunity. Some individuals may, however, be attacked by the disease a second, and even a third, time.

The cause of the disease is probably a microorganism, but this has not yet been isolated. In 1905 Borini cultivated a small bacillus from the blood in cases of measles. Lesage believed he discovered the morbid factor in a micrococcus. In 1758 Home, of Edinburgh, successfully inoculated individuals with the blood of measles patients, and others have since demonstrated the inoculability of the disease through the medium of secretions from infected individuals. Anderson and Goldberger have recently produced the disease in Rhesus monkeys by inoculating them with the blood of measles patients. They have shown that the virus is present in the blood and in the secretions of the mouth and nose; that the blood is infected before the appearance of the rash and that the infectivity of the blood decreases twenty-four hours after the rash has appeared. The buccal and nasal secretions are infective coincident with the appearance of the rash and for twenty-four hours afterward. The desquamating scales are not infective. The virus has as yet eluded discovery; it is filterable through a Berkefeld filter, resists drying for twenty-four hours, and becomes inert after fifteen minutes' exposure to 55° C. The infectivity of the disease is almost entirely confined to the catarrhal stage and is brought about by direct contact between individuals. The aerial conveyance of infection beyond the range of droplets from the mouth and nose of infected persons is practically negligible, although dried dust and fomites may contain

the virus. The disease may be carried by a third party, but this mode of conveyance is extremely rare. Kerley, whose experience is extensive, has not known a proved case. A relapse may occur in rare instances from ten to forty days after the original infection.

Morbid Anatomy.—There is nothing characteristic in the postmortem appearances in measles. The blood is said to be of a bluish or brownish-red color and seldom completely coagulated. In most of the fatal cases there are evidences of intense bronchitis and of bronchopneumonia. There is an enlargement of all the lymphatic structures of the body. A large number of conflicting observations have been made as to the changes in the skin. Mayr describes the eruption as the result of an exudation about the mouths of the hair follicles and sebaceous glands; Simon alludes to a slight swelling of the epidermis over the papillæ; Neumann detects a round-celled infiltration in the walls of the superficial vessels of the skin and chiefly of the papillary loops; Slawyk finds a thickening and in some instances a fatty degeneration in the epithelial cells of the buccal lesions; Traube describes a catarrhal interstitial pneumonia characteristic of measles; and Corneil and Babes report that they have observed a special form of pneumonia beginning as an interstitial pneumonia and later giving rise to an effusion into the alveoli. Aronson and Sommerfeld have found an increased toxicity of the urine in measles. Recent investigations have shown that there is a close analogy if not an identity between the catarrhal and cutaneous manifestations of measles and those of anaphylaxis. During an attack of measles the result of the von Pirquet cutaneous tuberculin reaction is negative in individuals who before and after the attack give a positive reaction.

Symptoms.—*Period of Incubation.*—This has been variously estimated as from seven to eighteen days; it is most commonly from eight to fourteen days and usually ten days. Although the disease cannot be detected during this period there are definite constitutional changes accompanying it. Recently attention has been called to a slight enlargement of the superficial lymph-nodes of the body, but this is a feature shared in common by all the exanthemata. In 1898 Meunier described a loss of weight occurring during the incubation period of measles: in a series of thirty cases he found an average loss of about ten ounces. This diminution in weight begins on the third to the fifth day after exposure. Another characteristic of the incubation period is a polynuclear leucocytosis which reaches its maximum six days before the rash appears.

Prodromal Period or *Period of Invasion.*—The duration of this stage is usually three or four days, but in rare instances as many as nine days may elapse before the appearance of the eruption. The symptoms of this stage may appear gradually, consisting of fever, malaise, anorexia, vomiting, diarrhea, and catarrhal manifestations in the nose, pharynx, larynx, bronchi, and conjunctivæ. The symptoms may be ushered in abruptly with a convulsion. The usual first signs of this stage are sneezing, running at the nose, soreness of the eyes and lids, and a harsh cough. The nasal discharge is serous, but may become purulent. Vomiting may occur any time up to the appearance of the rash. There is as a rule an absolute loss of appetite. Diarrhea is quite common, and in severe cases is accompanied by abdominal pain. There is considerable irritability and restlessness. The rise of temperature which varies between 100° F. and 104° F., is not characteristic; it is usually remittent and may even drop to normal on the second day of the disease. The fever may rise abruptly on the first day but usually attains its maximum on the second or third day. The pulse-rate increases with the fever. The catarrhal symptoms may be so slight as to be overlooked; they may even be delayed until the third or fourth day. The cough is dry, harsh, and paroxysmal. Sometimes the invasion is ushered in with a laryngitis that is so severe as to necessitate intubation. Headache, nocturnal delirium, and convulsions, according to Cautley, are, in the order named, symptoms of increased severity of the disease. Prodromal rashes may occur during the period of invasion. According to Goodall the most common one is a punctate erythema, general or patchy, limited to the trunk. It may, however, consist of macules, papules, irregular blotches, or urticaria.

The period of invasion is characterized by the appearance of the so-called *buccal spots* which are generally recognized as pathognomonic of measles. These constitute the enanthem or eruption on the mucous membrane of the mouth and are now widely known as Koplik's spots, after Koplik of New York, who in 1896 first popularized them as an important sign of measles although they had been recognized as such for a long time. They had been noted by William, in 1806; by Hein, in 1812; in Dunglison's "Cyclopedia of Practical Medicine," in 1854; by Trousseau, in 1866; by Rilliet and Barthez, in 1854; by Monti, in 1873; by Flindt, in 1884; and by Filatow, in 1895. The following is part of Koplik's original description of these spots. "If we look in the mouth at this period (first twenty-four or forty-eight hours of the invasion), we see a redness of the fauces; perhaps, not in all cases, a few spots on the soft palate. On the buccal mucous membrane and the inside of the lips we invariably see a distinct eruption. It consists of small, irregular spots, of a bright red color. In the center of each spot there is noted, in strong daylight, a minute, bluish-white speck. These red spots, with accompanying specks of a bluish-white color, are absolutely pathognomonic of beginning measles, and when seen can be relied upon as the forerunner of the skin eruption . . . . They cannot be mistaken for sprue because they are not as large nor as white as sprue spots. These specks of bluish-white, surrounded by a red area, are seen in the buccal mucous membrane and on the inside of the lips, not on the soft or hard palate. Sometimes only a few red spots, with the central bluish point, may exist, six or more, and in marked cases they may cover the whole inside of the buccal mucous membrane. If these bluish-white specks, on a red spotted background, are at the height of their development, they never become white opaque as in sprue, and in this respect, when once seen, are diagnostic, nor do they ever coalesce to become plaque-like in form. They retain the punctate character. I have noted and demonstrated these spots on the buccal mucous membrane when the other symptoms were so slight that physicians have doubted the diagnosis . . . . The eruption just described is of the greatest value at the very outset of the disease, *the invasion.* As the skin eruption begins to appear and spreads, the eruption on the mucous membrane becomes diffuse, and the characters of a discrete eruption disappear and lose themselves in an intense general redness. When the skin eruption is at the efflorescence the eruption on the buccal mucous membrane has lost the characters of a discrete spotting and has become a diffuse red background with innumerable bluish-white specks scattered on its surface. The buccal eruption begins to fade even while the skin exanthema is at its height, or at least while it is running a late course. The mucous membrane retrogrades to the normal appearances long before the eruption on the skin has disappeared. This being the case, it will be seen that the buccal eruption is of the greatest diagnostic value at the outset of the disease, before the appearance of the skin eruption and at the outset and height of the skin eruption."

Heubner found the above spots present in six-sevenths of all cases, and Balme in 97.7 per cent. of 214 cases studied. Cautley states that in infants under

six months the spots are seldom present until the rash comes out; that if they are absent or few in number the attack is usually mild; and that the orifices of buccal glands, bubbles of air, or tiny particles of milk, food, and inspissated mucus may cause confusion. On the day before the rash there appears a blotchy discoloration on the palate, particularly marked on the hard palate, and consisting of dark or purple, triangular or oval patches. Combe describes an erythematopultaceous stomatitis which may precede the rash by two days or accompany it. "The gums," says Cautley, "are covered with an opalescent or whitish epithelial coating, thin and easily detachable, but they do not bleed nor fungate. The fauces and soft palate are infected. Petechial hemorrhages in the mouth at an early stage indicate severity. They may develop with ulceration of the mucosa, in the course of the disease. The postcervical and, more frequently, the submaxillary glands are often enlarged before the rash appears. Occasionally there is found a general glandular enlargement and splenic hyperplasia." The diazo reaction may appear in the urine from twenty-four to forty-eight hours before the eruption.

The rash appears first on the forehead at the scalp margin and behind the ears, and then spreads over the temples, chin and face, neck, upper arms, trunk, forearms and hands, thighs, legs, and feet. The eruption consists of maculopapules, not quite round and with ill-defined edges, varying in color from a pale pink to a bright red, set more or less closely together, and arranged somewhat in crescentic clusters. In severe cases the rash may be confluent and may be livid in color. The elevation of the papules above the skin gives to the latter a shotty feel. The rash is hyperemic, disappearing on pressure; it is less intense and less uniform on the trunk and extremities on which also the swelling of the skin is not so pronounced as on the face. Interspersed among the papules there may be miliary vesicles and petechiæ, the latter of which may be quite numerous in cases of so-called hemorrhagic measles. Rhazes, as quoted by Osler, wrote that when the "measles sink in suddenly after they have begun to come out, and then the patient is seized with anxiety and a swooning comes on, it is a sign of speedy death." The "sinking in" of the rash so frequently looked upon as an ominous sign by the laity, is really an indication of a failing circulation. The rash reaches its full development in three to five days, and then fades in the same order as its appearance, being followed by little or no desquamation, which, if present, is of a branny character and noticeable on the trunk while the hands and feet are free. There may be a slight pigmentation of the skin for two weeks following the disappearance of the rash.

The constitutional symptoms become more severe with the appearance of the rash. The temperature rises and reaches its fastigium with the full development of the exanthem and then falls rapidly by crisis. The temperature chart shows two marked pinnacles with an intervening remission. Cautley points out that this remission may last for from twelve hours to four days, and that in some instances, particularly in breast-fed babies, the disease may run an afebrile course. Coincident with the development and spreading of the rash the patient looks and feels extremely ill; the cough, thirst, anorexia, swelling of the face, delirium, and drowsiness become more pronounced. If the temperature remains high four or five days after the appearance of the eruption one may have good reason to suspect the presence of bronchopneumonia.

Period of Desquamation or Decline.—With the fading of the eruption the symptoms gradually abate but the cough is the last symptom to disappear. Within seven or eight days after the onset of the invasion the temperature is normal and desquamation is completed in another week.

Varieties.—All grades of severity in this disease may occur from the very mild cases with few or no constitutional symptoms or little or no rash, to the very severe cases with marked constitutional symptoms, and with a profuse rash. The following distinct varieties are delineated by Cautley. (1) *Apyrexial measles.* This is usually mild and is the type seen in athreptic infants in whom it is not necessarily mild. (2) *Morbilli sine morbillis*, measles without eruption, occasionally seen during epidemics, usually mild, but sometimes fatal. (3) *Rubeola sine catarrho* of Willan, in which there is a rash without catarrh, conjunctivitis or fever. (4) *Black measles* in which the rash is purpuric, the result of a malignant type of infection or of heart or lung complications. (5). The *gastrointestinal* type in which diarrhea and less frequently bilious vomiting are the predominant symptoms, and in which ulceration of the colon may occur with mucopurulent or hemorrhagic stools. (6) *Septic measles*, with marked prostration and high fever from secondary streptococcal invasion of the blood, and fatal in a few days. (7) *Pulmonary measles*, occurring usually in the first year of life and characterized by a livid, rapidly fading rash; general cyanosis, restlessness, and collapse; acute necrosis of the lung; and death. (8) *Hemorrhagic measles* is the type in which the rash is brownish livid in color, the temperature is high, and the constitutional symptoms are severe. Goodhart and Still allude to a type of measles accompanied by an amount of cyanosis out of all proportion to the severity of the disease and of no sinister significance.

Diagnosis.—Measles may be confused with the other exanthemata (See Table of Exanthemata under article *Exanthemata.*) Little difficulty need arise in this respect if one take into account the characteristic catarrhal symptoms and the nature and distribution of the rash. From German measles and erythema infectiosum the differential diagnosis may not be so easy. (See *Erythema infectiosum* and accompanying table of differential diagnosis.) The most important diagnostic signs of measles are the prodromal rashes, the remission of temperature, the buccal spots, the conjunctivitis and early laryngitis, and the diazo reaction. The last is present in measles, but not in German measles. The conjunctivitis of measles is distinguished from simple catarrhal conjunctivitis by the fact that in the former the injection begins on the bulbar conjunctiva. Examination of the blood in measles shows a leucocytosis during the period of incubation with a leucopenia during the period of invasion. Tileston states that myelocytes are often present in small numbers during the latter stage. A leucocytosis during the period of invasion points to the presence of some complication. Typhus fever frequently simulates measles, but is usually marked by an absence of the catarrhal symptoms and by the presence of severe cerebral manifestations. The phenomenon of anaphylaxis sometimes resulting from the ingestion of certain foods or the injection of horse serum may be associated with an eruption resembling that of measles. Drug rashes, such as the copaiba rash, and the rash following an enema (enema rash) may also be confused with the rash of measles. (See *Exanthemata.*)

Complications.—Measles may be followed by a chronic inflammation of the tonsils and the lymphoid structures of the nasopharynx with the production of hypertrophied tonsils and adenoid growths. Laryngitis is a frequent complication: It may be spasmodic, phlegmonous, or membranous. The last is much more serious than the primary laryngitis and begins usually on the third or fourth day of the eruptive period. It is more apt to occur among institutional children. Edema of the glottis is a rare complication. Bronchopneumonia is the most frequent and fatal complication of measles. An extensive bronchitis of the smaller tubes and bronchopneumonia occur in

from ten to twenty-five per cent. of all cases of measles. The high mortality among the measles patients in children's hospitals is attributed to bronchopneumonia. Holt observed it in forty per cent. of all cases of measles in the Nursery and Child's Hospital of New York. It is the result of a mixed infection or an infection with streptococci or staphylococci, and is occasionally followed by necrosis of the lung, bronchiectasis, or empyema. Lobar pneumonia occurs less frequently than bronchopneumonia. Stomatitis of various degrees of severity may occur; the gangrenous type, cancrum oris, or noma is seen to-day less commonly than formerly. Vincent's angina is not a rare complication. Parotitis, enteritis, and colitis are sometimes observed. Osler states that nephritis is less rare than commonly understood, noting that many cases of chronic Bright's disease date from an attack of measles. Noma of the vulva and dry gangrene of the prepuce are sometimes observed. Otitis is a common complication of measles and may be of the serous or purulent type. Mastoiditis, sinus thrombosis, or meningitis may ensue, particularly if early paracentesis of the drum membrane is not practised when pus or infected serum is present in the middle ear. In all cases of measles the tympanic membrane should be examined at least every other day. Endocarditis is rare. Arthritis may accompany or follow measles. The nervous complications of measles include encephalitis, hemiplegia, multiple sclerosis, polyneuritis, acute disseminated myelitis, acute mania, meningitis, and abscess of the brain. The ocular complications include chronic conjunctivitis, blepharitis, hordeolum, palpebral abscess, phlyctenules, and haziness or ulceration of the cornea. According to Cautley, stomatitis is present in fifteen per cent. and diarrhea in ten per cent. of all cases. Enlargement of the lymphatic glands, particularly those surrounding the root of the bronchi, may occur during measles and may be an important sequel with or without secondary tuberculous involvement.

Prognosis.—In uncomplicated cases recovery occurs rapidly. "The general indications of severity," says Cautley "are a short incubation period, laryngitis at the onset, vomiting during the course, diarrhea and abdominal pain, epistaxis, livid rash, and cerebral symptoms..... In the first three years of life the mortality is about 10 per cent., possibly as much as 20 per cent. In the next two years it falls to 5 per cent.; and from five to ten years it is only 1 per cent." The mortality in this disease is largely due to the pulmonary complications. It is greater in hospitals than in private practice; according to Osler, in the former being from 6 to 10 per cent. and in the latter from 2 to 3 per cent. In 1875 measles was brought to the Fiji Islands by H. M. S. Dido from Sydney, and in the course of four months, 40,000 out of 150,000 inhabitants died from the disease. Children who have recently recovered from measles are susceptible to infection with whooping-cough, influenza, diphtheria, and tuberculosis.

Prophylaxis.—Considering the large mortality from this disease in early life the subject of its prevention is an important problem in sanitary science. Unfortunately the infection is contracted in many instances from patients in the catarrhal stage of the disease, before the eruption has appeared, and before isolation has been enforced. Moreover, there are many mild cases, particularly in the schools, which cases are unrecognized and become potent sources of contagion. Careful examination of all children presenting catarrhal manifestations should be carried out with the view of discovering the earliest manifestation of measles and of enforcing strict isolation.

The recent experimental evidence of the fact that the contagion of measles is disseminated by the patients almost exclusively during the catarrhal stage of the disease has caused a decided change in public health methods of dealing with the disease. Thus in New York City the child with measles is excluded from the schools until five days after the appearance of the rash at which time he may return if he is otherwise well, if all catarrhal discharges have ceased and if there is no cough. Children and other members of the family may continue at school if they have already had the disease and if isolation at home is properly observed. Children and other members of the family who have not had the disease and are immediately removed to another residence may return to school at the end of fourteen days, the usual limit of the period of incubation. This method of dealing with the disease largely removes one factor that in the past has played havoc with school attendance. Moreover, terminal disinfection of the premises of the measles patient is no longer required, reliance being placed rather upon the liberal use of soap and water, and the disinfectant action of sunlight and fresh air.

Treatment.—Measles is a self-limited disease and there is no specific in its treatment. The avoidance of complications should be the chief consideration in addition to relieving the discomfort of the patient. He should be confined to bed in a well-ventilated room. The old practice of keeping him in a very warm and dark room has been largely discarded. The temperature of the room should be no higher than 68° to 70° F. Fresh air and sunlight are valuable therapeutic aids. If there is photophobia the patient's eyes should be shielded from the direct rays of the sun. The fever is rarely so high as to demand any special treatment. If high the temperature may be combated with the use of the tepid bath gradually cooled, or tepid sponging, or the administration of a diaphoretic mixture containing sweet spirit of niter and the solution of ammonium acetate; or small doses of one of the coal-tar products, preferably, acetphenetidin, should be given. If the appearance of the rash is delayed hot drinks and a warm bath serve to bring it out. Restlessness may be relieved with the use of the bromides, and excessive cough responds to small doses of codeine or paregoric, or to the use of a warm compress to the chest, or of inhalations of water vapor containing compound tincture of benzoin. At the beginning of the attack the bowels should be freely opened, and care should be taken that the patient has an evacuation daily, an enema being ordered if necessary. During the continuance of the fever the diet should consist of milk diluted with a cereal decoction in the case of young infants that are not breast fed; and in the case of older children, of milk, cereal gruels, and broths. If there is diarrhea milk should be withheld until this is controlled. Careful attention should be paid to the cleansing of the mouth and nose, particularly with the view of preventing complications. For the conjunctivitis irrigation of the conjunctival sac with a three per cent. solution of boric acid usually suffices. If the conjunctivitis is severe instillation of mild solutions of the silver salts may be necessary. During the period of desquamation the skin should be washed daily with warm water and then oiled. The patient should be kept in bed for three or four days after the temperature reaches normal, and during the entire period of convalescence he should be protected from undue exposure. Careful attention should be paid to his nutrition. As an aid in this direction iron tonics, codliver oil, etc., are of appreciable value.

Alexander Spingarn.

Meat Extract.—By extracting meat with water and then concentrating this fluid to a thick consistency commercial meat extract is prepared. From its manner of preparation it is obvious that the final product contains little or no protein. A large number of substances have been isolated from such preparations the significance of some of which is by no means clear. The introduction of meat extract into the

body acts as a stimulant to the secretion of gastric juice and probably also by augmenting other metabolic processes. Some of the substances that may be contained in meat extract are the so-called "extractives" creatine, the purine bases as hypoxanthine, xanthine, adenine and guanine, carnine, carnosine, carnitine, ignotine, novaine, neosine, vitiatine, oblitine, choline, neurine, inosite, lactic acid beside a relatively large quantity of inorganic salts.

F. P. U.

Meckel, Johann Friedrich.—Born at Wetzlar, Germany, July 31, 1724. He began his medical studies at Goettingen, and continued them at Berlin, where he soon succeeded in obtaining the position of prosector. At the end of two years he left Berlin and returned to Goettingen, where, under the direction of Haller, he resumed with untiring energy his anatomical labors. In 1748 he received from the University of Goettingen the degree of Doctor of Medicine. In 1751 he was called to Berlin to fill the positions of Prosector of Anatomy and Demonstrator of Obstetrics in the recently established School of Obstetrics; and in a short time he became the successor of Buddeus, who had held the two Chairs of Anatomy and of Obstetrics. His death occurred on September 18, 1774.

The name of this celebrated anatomist has come down to us in connection with a variety of anatomical terms—Meckel's band, Meckel's cavity, Meckel's diverticulum, Meckel's ganglion, Meckel's ligament and Meckel's space. The following represent some of the more important of his published writings: "Diss. inaug. de quinto pare nervorum cerebri, duabus figurarum tabulis illustrata," Goettingen, 1748; "Tractus de morbo hernioso congenito singulari et complicato feliciter curato," Berlin, 1772; and "Obs. anat. sur un noeud ou ganglion du second rameau de la cinquième paire des nerfs du cerveau nouvellement découvert; etc., Mémoires de l'Académie des sciences de Berlin, 1749. A. H. B.

Mediastinum, Diseases of the.—The mediastinum as a whole may be described as that portion of the chest cavity not occupied by the lungs and their pleuræ. It is bounded in front by the sternum and behind by the vertebral column; the lateral boundaries are formed by the pleural sacs on each side. This cavity is described by Piersol in four parts. The superior mediastinum is that portion above a plane extending from the intervertebral disc below the fourth dorsal vertebra to the junction point between the two upper portions of the sternum. The lower portion is divided into three sections by the anterior and posterior layers of the pericardium. The middle mediastinum lies between these two layers and is occupied by the heart; the anterior lies in front of the anterior layer and the posterior behind the posterior layer of the pericardium.

The superior mediastinum is occupied by the upper portion of the thymus gland, by the arch of the aorta and its branches, and by the superior vena cava and the innominate veins emptying into it. The trachea, esophagus, and thoracic duct pass through it accompanied by the pneumogastric, phrenic, and sympathetic nerves. The roots of the lungs are in the lower portion of this division and the upper portion of the middle division.

The shallow anterior division is occupied by the thymus gland, a few lymph-nodes and the rest is fat and fibrous tissue.

The posterior division is occupied by the continuation of structures from the superior division, the descending aorta, esophagus, pneumogastric, and sympathetic nerves and by the azygos veins and thoracic duct from below. The structures named are, of course, bound together by areolar tissue and have lymph-nodes and their vessels scattered among them. The grouping of these nodes will be considered later.

In this article we are not concerned with diseases of the thymus, pericardium, heart and great vessels, nor of the trachea, esophagus, and nerves, except as they are secondarily involved. On the other hand, the affections of the lymphatic structures and of the connective tissues make up the bulk of the subject matter to be considered. These affections consist of hyperplasia of the lymph-nodes, which may be simple, suppurative, tuberculous, or syphilitic, inflammation, abscess formation, hemorrhage or emphysema in the connective tissue, and new growths of any of these structures.

Affections of the Lymph-nodes.—The lymph-nodes of the mediastinum have been described by Barèty in distinct groups. A group in front of each main bronchus where it comes off from the trachea called respectively the right pretracheobronchial group and the left pretracheobronchial group. A group below the bifurcation of the trachea, the intertracheobronchial group and one accompanying each bronchus, the bronchial groups. There is also a small group in the anterior mediastinum and a chain along the esophagus in the posterior mediastinum.

Any acute inflammation in the lungs or air passages may give rise to hyperplasia of these glands. It frequently follows pneumonia especially bronchopneumonia in children, and bronchitis, particularly that form associated with pertussis, measles, and influenza. The glands often become much enlarged due to congestion, edema and at times even effusion of blood into their tissues. They become much reddened and the cut surface bulges from the capsule, if there has been hemorrhage the appearance is that of liver.

At times the inflammation goes on to suppuration, but this is much more common in the tuberculous form.

Often the inflammatory tissue is replaced by fibrous tissue giving rise to chronic hyperplasia; this often shows large amounts of carbon pigment and it has been suggested that the carbon may be the primary cause of the production of fibrous tissue in some instances. This productive inflammation in the glands may cause pressure on surrounding organs, or later as the new tissue contracts cause diverticula in the esophagus, bronchi, pleura, or pericardium.

Tuberculous disease of these glands especially the tracheobronchial groups may be primary or secondary to disease of the lung. It is common particularly in childhood. These glands are often found to be the only portion of the body affected. Steiner and Neuretter found tuberculosis of the bronchial glands in 275 out of 302 children, and in thirty-six the glands were the only organs affected.

The bacilli follow the route taken by carbon pigment entering through the bronchial walls and passing through the lymphatics to the lymph-nodes. That they may be latent here has been proved by Pizzini, who has found tubercle bacilli in the bronchial glands of forty-two per cent. of non-tuberculous patients, dying from acute causes and by Loomis who found them in six out of fifteen cases. When conditions are right for their growth they develop miliary tubercles in the glands, which sooner or later undergo fatty change and when they are confluent the gland becomes caseous.

Postmortem examination may show glands somewhat enlarged, with tuberculous areas, or even caseous degeneration, in which there have been no symptoms; but usually the gland, or group of glands is large enough to cause pressure symptoms of some sort, or by contraction and adhesion to surrounding organs, to give notice of their presence.

Suppuration, as has been stated, may occur in con-

nection with simple adenitis but is much more common in the tuberculous form. The liquid contents may be gradually absorbed and the remnant of the gland become calcified, or the abscess may open into the pleura, pericardium, esophagus, bronchus, or large vessel, or more rarely perforation into the mediastinum may occur.

Phillips reports a case of simultaneous perforation into the aorta and a bronchus.

Gulliver, Parker, and Goodhart all report cases of sudden suffocation from perforation into the trachea or a bronchus and Powell reports finding the scar where such a perforation had taken place into the trachea.

Secondary infection from these glands may involve the lung, pleura, pericardium, and perhaps most frequently the meninges.

Syphilitic hyperplasia of the mediastinal glands may occur in late syphilis, especially in the presence of syphilis of the lung. Macroscopically and clinically the resemblance to tuberculous adenitis is very great.

New growths in the glands will be considered later in connection with mediastinal new growths in general.

Symptomatology.—The acute simple hyperplasia of the lymph-nodes gives rise to no definite symptoms, except at times adding a spasmodic character to the cough. In fact Mussy attributes the spasmodic cough of pertussis to the enlargement of certain mediastinal glands, causing pressure upon the bronchi and trachea. When a true productive inflammation occurs, pressure symptoms become more marked and will be considered under tuberculous hyperplasia of the glands.

The symptoms of suppuration of the glands will be considered under the heading of abscess of the mediastinum.

Tuberculosis of the glands causes pain or a feeling of pressure under the sternum, or in the "pit of the stomach," or more commonly on one or both sides of the fourth dorsal vertebra. There is often some tenderness on pressure over these areas. The cough is one of the most characteristic symptoms, being spasmodic, as in whooping cough, but more prolonged, often lasting with exacerbations and remissions, for months and even years. This is probably the result of pressure upon the bifurcation of the trachea, or on the bronchi, or irritation of the recurrent laryngeal nerves.

Dyspnea may be extreme, sometimes paroxysmal, giving rise to attacks resembling asthma. This is probably due to pressure upon the vagus, as in cases referred to by Baréty and by Dieulafoy, or to pressure upon the recurrent laryngeal nerves.

Dysphagia if present is usually slight and the sound gives no definite information. Vomiting occurs as the result of vagus pressure probably. The voice may be affected by pressure upon the recurrent laryngeal nerves. Hoarseness or even complete aphonia may result.

Vascular compression usually of the veins, may result in prominence of the veins of the neck, face, and thorax, often associated with frequent nose bleed and sometimes with bloody expectoration. Edema is rarely present or is slight in extent. Clubbing of the finger ends has been noted.

All of these symptoms may disappear if the process goes on to softening with rupture or contraction of the glands.

The characteristic fever chart of tuberculosis elsewhere may be a prominent feature or fever may be absent altogether.

Inspection may show the prominent veins already referred to and it may show a fullness or diminished expansion over one chest due to compression of a bronchus; this is rare.

Palpation will usually show enlargement of the cervical chains of glands, especially deep in the neck, and at times the mesenteric glands can also be felt to be enlarged. The trachea may be felt to be displaced to one side in some cases and at times can be felt to be unusually rigid on inspiration and expiration. Vocal fremitus may be increased over certain areas.

Percussion may be entirely negative but sometimes areas of dulness can be made out to either side of the spine between the second and sixth dorsal vertebra, this is apt to be more marked on the right, as the glands are more numerous in this situation. Kronig and others claim that there may be slight dulness of the right apex due to partial collapse from pressure on the right bronchus. Sometimes areas of dulness can be made out anteriorly corresponding to that in the interscapular region. Arnoux places importance on the finding of dulness under the right sternoclavicular joint.

Auscultation may show prolonged expiration and rough blowing breathing over the interscapular space with decided differences, at times, between the two sides. D'Espine describes a bronchial ring in the whispered voice sounds heard at the junction of the last cervical with the first dorsal vertebra. When a bronchus is compressed there may be stridor and sucking in.

Syphilitic enlargement of the glands produce pressure symptoms identical with those of tuberculosis.

Diagnosis.—In children because of the frequency of the condition and because of the thin chest wall and small size of chest, the diagnosis is usually comparatively easy. The onset of any of the pressure symptoms especially the spasmodic cough after bronchitis, measles, influenza, etc., is very suggestive and should lead to a careful physical examination. The same is true if the cough is unusually prolonged after whooping cough. The presence of enlarged cervical or mesenteric glands would also aid in the diagnosis. The history of syphilis, hereditary in childhood or acquired in later life, should always lead to the employment of the therapeutic test. In an adult, dysphagia with enlargement of the cervical glands would make such a diagnosis probable but it would be necessary to rule out malignant or other growths; this will be taken up later. The Röntgen ray is of extreme value in this diagnosis as the shadow cast is believed to be pathognomonic.

Treatment.—The acute forms usually yield to the treatment applied to the primary condition, but guaiacol in the form of an ointment with lanolin (one dram to an ounce) is a valuable aid when applied as an inunction to the chest.

If there is any suspicion of syphilis specific treatment should be used and often is remarkably successful.

For the chronic and tuberculous forms supportive measures are indicated good wholesome and easily assimilated food and out-of-door life. When practicable a change of climate is to be desired, especially a change where continuous out-door life is possible. Bathing, massage, gently applied, and inunction with lanolin, cod-liver oil, or the guaiacol ointment above referred to are often useful. Internally codliver oil is often very useful and can be combined with arsenic, hypophosphites, or malt preparations.

Mediastinitis.—Inflammation of the mediastinal tissues may be considered under the head of proliferative mediastinitis and suppurative mediastinitis or abscess of the mediastinum.

Proliferative mediastinitis is a slow productive inflammation which starts from chronic pericarditis, chronic pleurisy, chronic bronchitis, chronic adenitis in the tracheobronchial glands, or a chronic pneumonia. It is most frequently associated with chronic adhesive pericarditis, in which case it is known as indurative mediastinopericarditis.

These causes give rise to a plastic exudate which later contracts and forms dense fibrous bands about the structures of the mediastinum causing constriction of veins, arteries, trachea, bronchi, and nerves at times.

Symptoms.—At times this condition is completely masked by the primary disease and is found only postmortem. Often, however, pressure signs appear which make the diagnosis fairly certain; these are venous congestion in the neck increasing on inspiration due to constricted veins, dyspnea more or less continuous from constriction of trachea or bronchus, or reflex from pneumogastric pressure, radiating pain from pressure on phrenic or intercostal nerves.

Cyanosis may appear in the neck and spread to the face and upper extremities with or without edema. Later enlargement of the liver, ascites, and edema of the lower extremities may result from constriction of the inferior vena cava. The pulsus paradoxus described by Kussmaul is often present but is not distinctive.

The physical signs in the chest are increase of precordial dulness and sometimes a mediastinal friction sound heard over the sternum when the arms are raised, in cases of mediastinopericarditis.

The *prognosis* is always grave, and the *treatment* entirely that of the primary condition with supportive measures as they become necessary.

Abscess of the Mediastinum.—Hare has analyzed seventy-seven cases out of 115 collected, the reports of the balance being incomplete. Of the seventy-seven cases forty-four were acute, males were by far the most frequently involved, and the anterior mediastinum was the most frequent location.

Trauma is the most common cause. Extension of infection from suppurating glands in the mediastinum, from purulent pericarditis or pleurisy, and from caries of vertebra or sternum are also causes. Perforation of the trachea bronchi, or esophagus by instruments or other foreign bodies, or by ulceration or malignant growths will secondarily cause abscess of the mediastinal tissues. Abscess in the neck below the deep cervical fascia may involve the mediastinum by extension.

Metastatic abscess may occur in pyemia, erysipelas, smallpox, scarlet fever, typhoid fever, and other infectious diseases. Many cases especially of the chronic variety are of the tuberculous origin.

Pathology.—The abscess may be more or less walled off by granulation tissue and spread slowly; this is especially true of tuberculous or chronic abscess. In the more acute infection it may spread rapidly. The pus may burrow until it perforates the diaphragm, the sternum, or an intercostal space or opens into some of the hollow organs. West reports a case of perforation of the trachea and Ziemssen and Zenker one of perforation of both bronchi.

Cases have been reported in which the esophagus, pleural cavity, pericardial sac, aorta, and even the left ventricle have been opened. Sometimes especially in chronic abscess the pus becomes inspissated and remains dormant.

Symptoms.—Pain behind the sternum is one of the most important signs, it is often of a throbbing character, though at times a continuous ache. It may radiate to the back, shoulders, or neck. There is often tenderness to percussion over the sternum or in the interscapular region. On pressure, pain may be elicited in the suprasternal notch or above the clavicles. In acute cases we have chills, fever, sweats, rapid pulse, and other signs of a septic infection. In the chronic cases the constitutional symptoms may be slight; anemia, loss of weight with at times fever and night sweats.

Pressure signs vary with the location and size of the abscess and are relieved when evacuation occurs. They are less constant than in the case of productive mediastinitis, aneurysm, or tumor because of the yielding walls of the abscess cavity. Still they often cause the death of the patient. They are taken up in detail under tumors. Dyspnea, dysphagia, dilated veins, constricted arteries, and pain are the principal pressure signs encountered.

Physical signs in the chest will vary with the location. When the abscess is in the anterior or superior mediastinum the precordial dulness will be increased, while the heart sounds and apex beat will be muffled. When located in the posterior mediastinum, dulness may be brought out between the scapulæ to either side of the spine.

When the abscess approaches the surface edema, redness, and heat will often appear, and later a fluctuating swelling which may even show a transmitted pulsation.

When the abscess is small and deep, physical signs may be entirely absent. The cases in which absorption of the pus occurs have already been referred to.

When the pus burrows downward it may open on the anterior abdominal wall or, if deep, appear as a psoas abscess. Perforating the sternum or an intercostal space or extending upward to the suprasternal notch it will open on the surface also. If in these instances the drainage is free the patient may recover spontaneously or later die of prolonged suppuration.

If the trachea or a bronchus is opened the pus may be expectorated and recovery take place, or aspiration pneumonia, or even suffocation may be the result. The pus may be evacuated through the esophagus successfully. When the heart or large vessels are opened the result is of course fatal.

Diagnosis.—This is often difficult especially when the abscess is deep seated. If there are definite pressure symptoms associated with chills, fever, and sweats, the diagnosis is probable and is sometimes confirmed by the pointing of the abscess. When it can be palpated it often has a transmitted pulsation and fluctuation and must be differentiated from aneurysm. True expansile pulsation is present and constitutional disturbance is absent in the case of aneurysm, while the diastolic shock, bruit, and tracheal tugging would all speak for aneurysm. A fine needle may be required to clear the diagnosis and the *x*-ray is of great value to show expansile pulsation.

The diagnosis from cyst and solid tumors is taken up under that heading.

From abscess of the root of the lung the diagnosis is usually impossible, though typical pressure symptoms are often absent in the latter.

Purulent pericarditis usually gives characteristic friction sounds, at least in the early stage.

Treatment.—This is entirely surgical. As soon as the abscess approaches the surface and pus can be demonstrated by the needle, it should be freely opened by the most available route. If rupture should occur into pleura or pericardium, drainage should be at once established.

Hemorrhage into the mediastinum may result from violence, from rupture of an aneurysmal sac, or perforation of a vessel by an abscess, tumor, etc. It is usually rapidly fatal.

Emphysema of the Mediastinum.—Air may find its way into the mediastinal tissues as the result of trauma, severe diphtheria, whooping-cough, or pneumothorax.

In rupture of the lung without rupture of the visceral pleura the air may dissect its way along a bronchus to the mediastinum and even into the neck.

Tracheotomy is often the point of entrance. Money found it in sixteen of twenty-eight tracheotomies. The air enters through the wound in the deep fascia and works its way down into the mediastinum. Kinstein reports a case with the heart dulness replaced by a tympanitic note as was also part of the liver dulness. The heart sounds were completely obliterated. The air was later completely absorbed, and this is the usual result.

Tumors of the Mediastinum.—These must be divided into the benign and malignant. Even the

first, unless they are capable of operative removal are to all intents and purposes malignant, in that their continued growth brings death due to pressure upon, or ulceration into vital organs.

Under the benign tumors there have been reported dermoid and hydatid cysts, fibroma, lipoma, enchondroma, and lymphoma, while under the malignant are found carcinoma and sarcoma.

The starting points of these growths in the mediastinum are the thymus or its remnants, the thyroid and its accessory glands, the lymphatics, and the connective and fatty tissues.

Malignant Tumors.—In Hare's study of 520 cases of mediastinal disease he records 134 cases of cancer and 98 of sarcoma. Haynes reports 25 cases in which sarcoma appears 18 times and carcinoma 7 times.

This apparent discrepancy is explained by Haynes as due to the fact that many of Hare's cases were reported before a definite distinction was made between sarcoma and carcinoma and if only those cases are taken which were reported after 1870 when the distinction was first made, Hare's cases show sarcoma 66 and carcinoma 29.

Thus it is seen that sarcoma is the most common and carcinoma ranks second. This would be expected when we consider that the mediastinum contains many structures from which sarcoma could spring and few which would give rise to carcinoma.

A study of Hare's later cases and of Haynes' cases taken together gives 50 primary sarcomata and 26 primary carcinomata, while there were only 8 secondary sarcomata and 2 secondary carcinomata.

These same statistics show that the sarcomata are by far most frequently found in the anterior mediastinum (really the anterior and superior taken together), while the carcinomata most frequently find their origin in the posterior mediastinum.

The primary sarcomata most frequently spring from the lymph-nodes especially those of the anterior mediastinum, but also from the thymus or a low placed thyroid or accessory thyroids, and from the connective tissues. The primary carcinomata may start in the thymus, the thyroid, or accessory glands but more commonly start in the esophagus or a bronchus and invade the mediastinum.

Secondary tumors of both varieties involve the lymph-nodes and in some instances the thoracic duct may show secondary carcinomatous infiltration. These growths may be secondary to sarcoma of the bones, testicle, and other distant places, while the carcinomata are usually secondary to disease of some closer structure as the mammary gland or lung, more rarely the gall-bladder or stomach.

Men are more frequently affected than women, and the sarcomata are more common in young adult life, while the carcinomata usually come at a later age.

Pathology.—Under the term sarcoma are considered round and spindle-celled sarcoma, fibrosarcoma, alveolar sarcoma, and most important of all lymphosarcoma. With the exception of the last, these all arise probably from the fibrous tissue in and about the various organs, including the lymph glands, while the last arises from the lymph gland structure proper.

The tumors starting in the lymph glands may be divided into two main classes; general hyperplasia of lymphatic structures including the spleen and mediastinal glands, with or without blood changes, and local growths in the mediastinal lymphatics which may be malignant or benign. Under the first division come lymphatic leukemia and pseudoleukemia and under the second malignant lymphoma (lymphosarcoma) and benign lymphoma (lymphoma or lymphadenoma).

Leukemia and pseudoleukemia are general diseases and need not be further noticed here.

Lymphosarcoma comes under the sarcoma group, and the benign tumors will be considered under that heading.

In general the sarcomata in this region are rapidly growing soft tumors with a very cellular structure and loose delicate stroma. On section there exudes a creamy cellular material and often there are portions which are almost liquefied. A few show a more definite fibrous stroma and are of slower growth.

These tumors, especially the lymphosarcomata, spread rapidly in the direction of least resistance and gradually insinuate themselves between and around the structures of the mediastinum binding them firmly together and later infiltrating them. The growth may penetrate the veins and cause blocking or thrombosis; the arteries are more apt to escape. The bronchi, trachea, esophagus, nerves, lung, and even the heart itself may be infiltrated.

Pus collections do not occur unless secondary infection takes place.

Metastases usually occur in the parenchyma of organs as the liver, kidney, and spleen, but Kundrat claims that the lymphosarcomata are more apt to form their metastases in the solitary follicles of the intestines.

The carcinomata originate in the epithelial structures and are as a rule of slower growth and more firm in consistency, even the medullary form having a much greater proportion of stroma than the sarcomata.

This tumor differs in its method of growth from sarcoma in that it is more apt to infiltrate surrounding structures early, instead of first spreading between and around them. This gives rise early to pressure symptoms, ulceration, and hemorrhage.

Benign tumors of the mediastinum are rare, Hare in his 520 mediastinal cases having 282 cases of tumor of which only 50 were benign, 21 lymphomata, 7 fibromata, 11 dermoid cysts, 8 hydatid cysts, and one each of lipoma, gumma, and enchondroma.

Lymphomata spring from the lymph glands and are distinguished from the lymphosarcomata by the absence of malignant characteristics and by a relatively slow growth. They do not infiltrate surrounding organs.

Dermoid cysts are very interesting benign growths. They have been classified by Mandlebaum as: 1. Dermoids proper which spring from ectodermal inclusions from gill clefts. 2. Teratomata or dermoids with the addition of structures from the endoderm and mesoderm. 3. Either of these varieties with the addition of tumor formation. In three of forty cases collected by Christian there was malignant change in the growth.

All are of slow growth and in the reported cases vary much in size. Von Eiselsberg in 1903 reported the successful removal of a cyst the size of a man's head.

The true dermoid has a squamous epithelial lining, and contains sebaceous material and hair, and at times teeth, while in the teratoma may be found in addition bone, cartilage, fat, muscle, and elements of thymus or thyroid tissue. They are most apt to grow in the upper portion of the anterior mediastinum, often lying under the clavicles to either or both sides of the sternum.

Hydatid cysts have the same characteristics as in other portions of the body and are not even as frequent as are dermoids. Hare mentions eight and Marfan four of these cases.

Simple cysts have been reported.

Lipomata have been reported springing from the subpleural fat.

Fibromata have been found under the sternum compressing the trachea (Hare).

Tumors from thyroid tissue form an important group. Carcinoma and sarcoma of this origin have already been mentioned and benign growths are comparatively common. Wuhrman has collected ninety-one of these cases, seventy-five benign and sixteen malignant. Thyroid tissue in the form of accessory glands may occur anywhere from the root

of the tongue to the arch of the aorta, and at times the thyroid itself lies behind the sternum with its lobes to either side of the trachea.

Adenomata and cystadenomata are the most frequent growths of the benign type. These may be distinct from the thyroid or attached to it only by cords, or in some instances an enlargement of the thyroid itself may extend down behind the sternum and upper ribs compressing the trachea and lungs. Dittrich reports such a case with a tumor the size of a man's head. I have seen one such case in the Kocher Clinic at Berne. Osler and Packard both mention cases of cystadenoma displacing the lung.

Symptomatology.—The most important symptom, are those of pressure and they are common to all forms of growth including lymphatic enlargements inflammatory exudate, and aneurysm and have been referred to in part under those headings.

Dieulafoy speaks of this group of symptoms as the mediastinal syndrome, they are: deformity, compression of blood-vessels, compression of trachea and bronchi, changes in pneumogastric, recurrent, phrenic, and sympathetic nerves, and dysphagia.

Deformity.—The sternum may be altered in position, the manubrium sterni pushed forward at the sternoclavicular joint, or the two upper portions of the sternum may be bowed forward at their junction.

The sternum or upper ribs may be eroded by tumor, abscess, or aneurysm, so that part of the bone may be replaced by a tumor mass showing transmitted pulsation. Cysts may grow through between the ribs giving rise to external tumor as in a case reported by Mandlebaum. The tumor mass may project above the sternum or give rise to enlargement of the glands in the neck.

Dulness will be found over the area occupied by the tumor if near the surface. At times it is found in the interscapular region. In prolonged cases retraction of the chest wall on one side may result from a compressed bronchus.

Compression of Blood-vessels.—The arteries are more resistant than the veins and show less of the effect of pressure.

If the superior vena cava is compressed the veins of the head, arms, and upper thorax are prevented from emptying themselves and become distended, forming a distinct network of veins under the skin of these parts and with time forming a collateral circulation through the superficial and deep veins of the abdomen and thorax so that the blood can enter the heart through the inferior instead of the superior cava. The blood current in the superficial veins of the abdomen and thorax will be found to run from above downward. The vena azygos major will take part in this collateral circulation if it escapes compression.

As long as the collateral circulation is efficient there are few symptoms but when it fails, edema and cyanosis of the affected part occur, with nose bleed, congestive headache, and dizziness.

When one of the subclavian arteries or the innominate artery is compressed it diminishes the size of the radial pulse on that side. Compression of the pulmonary artery may give rise to thrombosis with pulmonary infarct or gangrene, or, if rupture occurs, rapid and fatal hemoptysis.

Compression of Trachea and Bronchi.—The left bronchus being the smaller is more often affected. If much compressed there is sucking observed in between the ribs, in the supraclavicular fossæ, and in the epigastrium. Stridor may be heard on inspiration, The inspiratory murmur may be diminished or absent over the affected area, but the resonance is not affected.

The dyspnea that results from this cause may be marked and is usually continuous and progressive.

Changes in the Pneumogastric, Recurrent, Phrenic, and Sympathetic Nerves.—Pressure on any of the nerves may result in irritation and later, if progressive, in paralysis. For instance the pneumogastric may at times be irritated and the heart slowed down or if it is paralyzed the heart becomes rapid because the inhibitory action of the nerve is destroyed. Vagus disturbance may also give rise to gastralgia, nausea, vomiting, spasmodic cough, and paroxysmal dyspnea resembling asthma.

Excitation of one or both recurrent nerves may give rise to spasm of the glottis and urgent dyspnea. If the nerve is paralyzed the corresponding vocal cord is put out of commission and the voice and cough are hoarse. The laryngoscope shows these conditions.

Diaphragmatic neuralgia and attacks of hiccough are due to phrenic involvement.

When the sympathetic is involved it gives rise to unilateral dilatation of the pupil or if completely destroyed as in Demme's case the pupil will contract.

Dysphagia is due to direct compression or traction upon the esophagus and may result in complete inability to swallow even liquids.

Pain or a sense of pressure may be a prominent feature; this is often felt behind the sternum or in the neck. Sometimes there is an intercostal neuralgia due to pressure upon the intercostal nerves, and sometimes pain radiating down the arm when the lower part of the brachial plexus is involved.

There is progressive loss in weight, especially if the esophagus is involved or if the tumor is malignant. In the latter case also the loss of strength is rapid, so that the patient very soon must give up his occupation.

Fever is not a constant feature, though it may come on in the later stages. Chills usually indicate secondary infection and abscess formation. Night sweats are not uncommon.

Expectoration may be absent or may be thick and purulent; in some cases of dermoid, hair has been found in the sputum.

In the late stages various positions are assumed because of the severe dyspnea; the head may be thrown back or bent forward resting on the arms. Usually the patient cannot lie down. The head and upper extremities are congested and edematous while the abdomen and lower extremities show the marked emaciation of the cancerous cachexia.

Diagnosis.—The diagnosis of tumor is often difficult, especially early, and sometimes the attention is first called to it by some single symptom as the dilatation of one pupil, the hoarseness due to paralysis of a vocal cord, dyspnea, paroxysmal cough, substernal pain, etc. All of these may be caused by other conditions which must be differentiated.

Local conditions in the larynx, as tuberculosis and syphilis, may usually be ruled out by the history, laryngeal examination, and so on, and paralysis of the cord may depend upon tabes, etc., which would show other symptoms.

Aneurysm of the aorta is one of the most difficult things to rule out; this can usually be done by the expansile pulsation of the latter, either felt or shown by the *x*-ray, and with it the diastolic shock and bruits heard over the aneurysm. The growth is usually relatively slow, at least by comparison with malignant tumors, and usually a history of syphilis or a positive Wassermann can be obtained.

In some cases, however, because of firm clotting, even the *x*-ray fails to show expansile pulsation, and Letulle, and Billings and Salisbury refer to cases where this mistake was made. On the other hand, expansile pulsation may be so very well simulated as to deceive, and Billings and Salisbury refer to a lymphosarcoma which was taken for an aneurysm because of this.

Tuberculosis of the glands usually occurs in childhood when tumor is extremely rare, but when adults are involved there is usually primary tuberculosis elsewhere.

Abscess of the mediastinum is usually associated with chills, fever, and sweats and commonly follows trauma. (See the section on Abscess.)

The differentiation between the benign and malignant growths of the mediastinum is extremely important from the standpoint of prognosis and treatment. The benign tumors are of slow growth, and severe pressure symptoms do not come on until late, as a rule, and they are not associated with cachexia. In some of the thyroid tumors a connection can be made out with the thyroid gland and the cysts may give rise to hair or sebaceous material in the sputum. The *x*-ray and the use of a fine hypodermic needle for aspiration will clear the diagnosis in many cases.

Prognosis.—This is absolutely bad in all malignant cases, death usually occurring in five to six months. In the benign tumors successful removal may sometimes be accomplished.

Treatment.—This is surgical in the benign tumors which are accessible. In the malignant tumors it can only be symptomatic and palliative.

HENRY LYNDE WOODWARD.

Medical Licensing Boards.—The object of the licensing of physicians and surgeons by a State, or commonwealth, is to protect its people against incompetent practitioners. In some countries none but the licensed are permitted to practise medicine—this is usually spoken of as the *restrictive method* of control. In other countries the license takes the form of permitting the use of certain titles, as doctor, physician, or surgeon, by the licentiate, which others are forbidden to use, although not forbidden to practise medicine; this method makes it incumbent upon the persons engaging the services of a practitioner to find out for themselves, if interested, whether or not he is registered as a qualified physician—this may be called the *registration method* for protecting the public.

A license is nothing more than a privilege granted to the licensee because of his special qualifications; under the "restrictive method" it is the privilege to practise medicine; under the "registration method" it is the privilege of having his name enrolled in the official register of duly qualified practitioners. Theoretically there is no need of published copies of the register, for the purpose of warning the public under the "restrictive method," because everyone, not licensed, who attempts to practise medicine is promptly prosecuted; whereas under the "registration method" the people are safeguarded in distinguishing qualified from unqualified practitioners by many readily accessible copies of the official register.

Just as there are two methods of safeguarding the public in the manner of licensing, so there are two methods of determining the fitness of applicants for the license; the simpler method is by examination alone; the other method is by stipulated educational requirements and supervision of the medical schools—or, in other words, regulation of the degree conferring privilege. This latter form of regulation is carried on of necessity by those governments which rely on the "registration method" of licensing as, for instance, the United Kingdom of Great Britain and Ireland, else the degrees or qualifications recognized for registration might not be up to standard.

Here in the United States some states have laws providing at once for both the restrictive and registration methods of licensing and for both the regulation of the education, preliminary and professional, and the examinations. As each State makes its own laws in this matter, irrespective of the federal government, we have a confusing lot of laws. The confusion is further added to by the frequent amendments of the laws by the States, or of the regulations by the authorities; what may hold in the case of an applicant graduated from a medical school this year, may not hold in the case of one graduated last year but who is an applicant now; yet, again, it may not be so simple as this, because what holds this year may, to a degree, affect all applicants, no allowance being made for those who were graduated several years ago. Hence, a compend of the laws and regulations is almost impossible because of the necessary lengthy explanations. The confusion is not a matter of only difference between the various states' methods, but is consequent to the development of the whole system of licentiation in medicine. In former times, in the older countries, the privilege of practising medicine was granted to certain guilds, corporations or societies, who controlled the situation by rules for membership. Relics of this method are still extant, and here in the United States, in some states, the licensing authority remains vested in medical societies. The more progressive States, however, have kept pace with the advances of foreign countries, have discarded the system of letting medical societies attend to the licensing of their members, and have given authority to officials, responsible to the State only, to regulate the practice of medicine. Our older States, of course, originally had laws patterned after those of the Mother Country. In the article on *Education, Medical, in the United States*, some information relative to these early laws is given. In New York and New Jersey, in the colonial days, the first licenses were issued by the courts, and these had the power to select examiners for helping to determine the fitness of the applicants. The courts, after the Revolution, were superseded in their authority, by the medical societies which provided boards of censors in each county for conducting the examinations and issuing licenses. Remnants of both of these former schemes are to be found in Delaware, where the Chief Justice of the Supreme Court and representatives of the medical societies form a body, called the Medical Council, which has the licensing authority, although the medical societies conduct the examinations.

Licensing by the State in the modern sense, that is, with a view to protecting the public, may be said to have begun with the passage of the Medical Act by the British Parliament in the year 1858. The purpose of this Act was to provide a means, so that persons requiring medical aid should be enabled to distinguish qualified from unqualified practitioners. The means created is The General Council of Medical Education and Registration of the United Kingdom, a body that has direct supervision over medical education in the United Kingdom, and determines the qualifications acceptable for the privilege of enrollment in the register kept by it. The graduates or licentiates of any teaching or examining body which does not comply with its requirements are denied enrollment in the register. This council also has the power to erase the name of any registered practitioner found guilty of misconduct. Any one who pretends to be a qualified practitioner and uses any title, as doctor, physician, or surgeon, which might imply that he could be registered, is penalized. The council likewise keeps track of all medical students from the very beginning of their course of studies, so that it may know whether or not each student has fulfilled its requirements when it comes time for him to receive the qualification which would entitle him to have his name and title put upon the register. The council itself does not conduct any examinations, but visits and inspects the examinations given by the universities, the Royal Colleges of Physicians and Surgeons and the other bodies whose degrees or titles are recognized in granting applicants enrollment in the register. The membership of the council is composed largely of representatives from these various university medical schools and medical corporations.

In Germany the system is about the same in principle as that in Great Britain, although at first glance it seems very different. In Germany, of course, the universities and all education are subject to state regulation. The empire, through Royal Proclamation on June 22, 1883, standardized the requirements throughout all the States which comprise it. There

is no law which restricts the practice of medicine, but there is a law which prohibits the use of the title, "physician" (*Arzt*), by any one who has not earned an "approbation" through passing the State's examination; the laws forbid also the conferring of medical degrees upon any one who has not earned this "approbation." Up to about fifty years ago the practice of medicine was reserved to the licensed physicians, in Prussia, but the restrictive measures were looked upon as more for the protection of the profession than the people; hence the registration method was adopted. The examinations are conducted by state boards at the universities, but the membership of these boards consists of only a committee of the medical faculty of the local university—in other words, it is not the same as when the board consists of members who are not interested in the medical school, and is quite different from the American plan.

Russia, in the main, has the German system in so far as university medical education is concerned, but very important to consider, when making any comparisons with America, is the fact that in Russia there are several classes of licensed physicians. If we were to consider only those given the official title "physician" (*Lekar*), or those graduated with the degree M. D., we would overlook the several grades of *Feldshers*, some of which have schools with requirements equivalent to some of the medical schools, not university departments, in other countries. There are sixty-six schools for Feldshers in Russia. As mentioned above, there are several grades of Feldshers, and likewise there are the different grades of schools; all, however, are under the control of the Ministry of Interior.

Of the countries which do not have the restrictive method, Germany alone, by its police returns, provides a means of finding out the number of persons who practise cures or healing methods as unqualified practitioners. Figures obtained through this source show that about one-third of the practice of Germany is in the hands of these unqualified practitioners. The term, unqualified, does not mean illegal; these practitioners are not qualified to use the title, *praktischer Arzt*, but they are permitted to practise by virtue of the cure-freedom which was established in Prussia as early as the year 1869 when Virchow lead the movement to change from the restrictive to the registration method, and announced that no profession has the right to protection by the State. If the number of unqualified practitioners and the number of qualified physicians in Germany are added together, the result shows one practitioner for each 1,000 of population; in large cities the proportion is nearer one to 500. These figures are just about the same as those that obtain here in the United States where the restrictive method is used—there being about one practitioner to every 600 of population. Whereas in Germany two-thirds of the practitioners are university trained and vouched for by the State, here in our own country a very small portion are university trained, and these are in no way singled out by the State as being better qualified than those of mediocre or inferior training. This naturally raises the question, whether the restrictive method safeguards the public more than the registration method? Theoretically it does; in practice, however, its standard is so low that it lets in a large class of practitioners who bring disrepute upon the entire profession, and the license instead of being a mark of proficiency means nothing to a layman in his choice of a practitioner. Besides this practical disadvantage in the application of the restrictive method, there is the fact that cults or sects parallel it with legislation for similar restrictive measures; not so much for protecting the people as for securing a monopoly.

The foregoing has been an attempt to analyze and to make clear some of the principles upon which medical licentiation is based. If the analysis is not altogether clear, it will be less so when it comes to looking for an application of these principles along sharp lines here in the States. Of course, each State must be considered separately because each makes its own laws. Some of the States began with the restrictive method which had its inception in colonial days when but a very small number of practitioners were M. D.'s or had ever attended medical lectures, for most were but apprentice-trained "chirurgeons." Later, after medical schools had been established and all practitioners, whether apprentice trained or what not, styled themselves "Doctors," the administration of the laws, which had heretofore been entrusted to the officers of the State, passed largely into the hands of this large body of apprentice-trained practitioners who sanctioned the general use of the title, "Doctor." The influence of the medical school followed and it was not long before laws requiring the degree, M. D., were passed. With this came a discrimination in favor of those holding the degree; a holder of a degree did not have to take an examination but simply had to register his diploma in the county clerk's office. By what is known as "medical politics," some of these medical schools got control of the boards of censors of the county medical societies entrusted with the matter of passing upon applicants for the license, and they soon made the requirements such that the applicants had to attend their medical lectures. It seems to be safe to make this interpretation of the influence of some of the medical schools, because we cannot conceive of the general body of practitioners requiring that aspirants to the profession should attend medical lectures two years when the same course of lectures was repeated each year—that is, that the same lectures should be heard twice. However, they may have joined the medical schools in this as an effort to keep down their increasing number of competitors. If this is true, disappointment awaited them; the commercial spirit entered the medical schools and more students became their aim. All of this tended to standardize the American medical profession on a level of its own. In understanding conditions in America, it is important to grasp the fact that the profession, medical education, and the degree M. D. were all pretty evenly standardized in the early part of the nineteenth century, but on a basis much lower than in Europe. It is for this reason that the laws of most of the States came to include the requirement that the applicant for a license should have been graduated with the degree M. D. In Germany and Russia this degree cannot be conferred until after two years' additional study following the earning of the State license. In England, medical students in the universities are graduated with the bachelor's degree, the doctor's degree requiring additional time and study; some of the graduates of hospitals and surgeons do not receive such a degree, but earn a registerable qualification by complying with the educational requirements and passing the examination of a private corporation like the Royal College of Surgeons. A licensed physician in Germany, or a licensed surgeon in England, although not an M. D. but every whit as well educated as an American M. D., cannot be licensed in many of our States. Such laws were drawn up at a time when there were very few applicants from abroad and when there was need of defining without any loophole who should be eligible to the license. Some laws have been amended, in this respect, by saying "or any equivalent diploma or license issued in a foreign country."

In the latter part of the nineteenth century—in the late 80's and the early 90's—the first State Boards were created. The members of these boards were appointed by the governor, in most instances, from a list of nominees submitted by the state medical society; there being a separate board for each "school of practice"—Regular, Homeopathic, and Eclectic—just as there were separate societies. Eight States still have

such separate boards. Connecticut, for instance, has three; each with a different standard. Fifteen States still provide for their boards either through nomination or appointment by the state medical societies. In Alabama, for instance, the law makes the Board of Censors of the State Medical Association, the State Board of Medical Examiners.

The first boards had their troubles; the country was growing rapidly—there were all sorts of medical schools. The better schools were giving a course of three years; there were all gradations of schools down to the veriest "diploma mill." The boards realizing their difficulty in determining what a reputable medical college should be, met and formed the National Confederation of State Medical Examining and Licensing Boards. This organization in cooperation with the American Academy of Medicine did the first effective work toward bringing about a standard medical course.

In the late 90's and the first part of the present century, some of these boards, having gotten a good start toward defining their educational standard, soon had it written into their respective State laws by way of enforcing their requirements. And this leads to a discussion of the awful muddle caused by the differences in the requirements, not only between one another of these States but between them and those that have left such matters subject to the regulation of the state board; it is this muddle—this lack of uniformity—which prevents the more general establishment of *reciprocity* between States in endorsing one another's licenses, so that a physician licensed in one State but desiring to move into another may have his license endorsed and not be obliged to take another examination. A feature, besides that of differences in educational requirements, which has added to this problem is the organization of some boards. Some boards are but agents of their respective state medical societies; some are appointed for one year only, by the governor, and are therefore subject to all the vicissitudes of "politics;" the strongest are the so-called *composite boards* made up from representatives of the several "schools of practice" even including osteopathy in some instances. A composite board is usually covered with full authority to regulate the practice of medicine, and more from the standpoint of the State's interest. Perhaps the arguments in favor of this kind of a board can be better grasped by turning back to the remarks of Commissioner Draper of the New York Education Department on the occasion of a conference in 1905 which led to the unification of the then three separate boards of New York into one board, the homeopathic and eclectic representatives opposing because they could not hope to have sufficient representation to control the board, and possibly through fear of the requirements that such a board might impose:

"The discussion has gone back to the question of unifying and harmonizing the different schools of medical practice. That is not our affair at all. We have no official care as to how many schools of practice there are. If there is some one sick in my family I will get a physician whose scientific attainments I believe in, whose experience has been considerable, and whose character as a man commends him to me. Every other sane citizen will do the same. He will be very likely to follow his preferences or his prejudices as to the school of medicine he patronizes. But the attitude of the department must be very different. It must have no preferences or prejudices for or against any of the people or their associations. Ours is not a representative government in the sense that has been spoken of here to-day. The government is not carried on by representation from this, that, or the other school in medicine, nor by representation from this, that, or the other school in religion, or from this or the other school, sect or class in anything else. It seems to me that the State is not to recognize any school or schools among the people so far as to promote one or depress another. But the State may very properly establish and uphold a scientific basis for the practice of medicine, in all schools. What is to prevent the State establishing a scientific basis to which every man, or woman for that matter, must come if he or she wishes to practise medicine in this State? Then let the schools take care of themselves, go up or down according as their disciples are scientific or not. Scientific truth is the same the world over; it is the same for all people and for all schools. Science has been said to be God's sense. It is a matter which must be recognized in every intellectual center, and therefore one which the State may properly recognize, it seems to me, regardless of schools. Why not establish a fundamental scientific basis for all medical practice which will protect the public against ignorance, and let the people who can come up to that standard practise and associate with any class or subsidiary society that they please?"

As New York has had a very long experience in trying to regulate the practice of medicine, an experience extending back to 1760 when the first law was passed, and as its population is now one-tenth of the total population of the United States, a population including large congregations of foreigners as, for instance, there being more Italians in New York City than in the city of Rome, it will serve to point out in detail a State's attempt at supervision of medical practice. These may be briefly epitomized:

June 10, 1760. An Act to regulate the practice of physic and surgery, which applied to the City of New York only, where there had been many complaints of quacks; under this Act the examinations were conducted at the direction of the King's Counsellor and the Judges of the High Court.

March 27, 1792. An Act to renew the law passed before the Revolution and to extend its application to all of the New York County. This exempted graduates of medical schools in the United States.

March 23, 1797. Application extended to the entire State, and a provision made for "reciprocity," that is, indorsement of licenses issued by other governments.

May 1, 1784. An Act creating the University of the State of New York. The corporate rights of King's College (now Columbia University) were vested in the regents of the university.

April 13, 1787. An Act to introduce certain reforms advocated by Alexander Hamilton who was a regent. This Act remains in force to this day and gives the regents full authority to regulate all the professions and schools *in conformity with law*. Their authority stands only when not contrary to a law. At first they appointed all professors, chiefly distinguished Europeans, in the medical schools, and granted all degrees. Later they relinquished these duties; the College of Physicians and Surgeons, which belonged to the County Medical Society, had been organized and brought too many troubles probably.

April, 1806. An Act repealed the preceding statutes and gave the power of examining and licensing to the County Boards of Censors of the State Medical Society. This Act did not prohibit persons similarly licensed in other States from practising in this State. Probably as an *oversight* it debarred holders of degrees from practising. This was corrected the next year.

April, 1818. An amendment to require any licentiate from another State to record a copy of his diploma in the County Clerk's office.

April, 1827. An Act to provide that diplomas granted by authorities outside of the State for studies pursued in New York shall not be recognized.

April, 1830. An Act to impose a penalty upon unlicensed practitioners.

April, 1844. Amendments which permitted unlicensed practitioners to collect fees.

April, 1857. An Act giving the county homeopathic societies the same privilege as the regular medical society. This was soon followed by the incorporation of the Homeopathic Medical College.

April, 1862. An Act incorporated the State Homeopathic Medical Society giving it privileges the same as those held by the regular medical society, namely, to examine, to license, and to confer the degree M. D.

———, 1880. An Act required all persons engaged in the practice of physic and surgery and those thereafter authorized to register their diplomas or licenses in the Clerk's office of the County where residing. An M.D. conferred by a medical college in the State became a license when so registered. A diploma from a school outside of the State had to be exhibited to and approved by

the faculty of a New York medical school before it could entitle the holder to registration.

June 13, 1889. An Act to provide for the preliminary education of medical students under rules of the regents of the university was passed.

June 5, 1890. An Act was passed which provided for three separate boards of medical examiners to be appointed by the regents from a list of names nominated by the respective state societies whose licensing powers were repealed.

May, 1893. In the codification of the Public Health Law the Medical Practice Act became part of it. This Act required the completion of a four-year high school course for admission to a medical school, and that the medical course should extend through four calendar years for its completion; this law also provided that New York medical schools and students should not be discriminated against by the regents recognizing any medical schools outside of the State whose standard was less than this. Provision was also made for the revocation of licenses for misconduct and for placing penalties upon those who attempt to practice without a license.

May 13, 1907. An Act repealed all former laws and established a State Board of Medical Examiners. This Act was the direct outcome of the conference referred to above as having been addressed by Dr. Draper, State Commissioner of Education, and of the attempt of the osteopaths to set up another board in addition to the three existing boards; it could be seen that there would be an unending multiplication of state boards. This law is still in force. The board consists of nine members appointed by the regents of the University of the State of New York, which had early in its history become reduced to an examining and licensing body. The law does not stipulate that representation on this board shall be apportioned to the several "schools of practice," and any difficulties along this line were averted by eliminating examinations as to medicinal treatment. However, the regents, from the standpoint of policy, have apportioned the appointments as follows: two homeopaths, one eclectic, one osteopath and five regulars. Osteopaths are required to have studied four years and to pass the same examination as that given all applicants for the medical license. The provisions in regard to the educational requirements were continued. Medical schools cannot be incorporated except by charter from the regents. Applicants are not admitted to the licensing examination unless they have complied with the law in regard to the preliminary and professional educational requirements and have been graduated by a medical school recognized (*registered*) by the regents. But sixty-six of the 106 medical schools in the United States are recognized by the regents. By a system of "accrediting" the work of schools not recognized, provision is made whereby the work may be recognized to a certain extent by *registered* schools in giving advanced standing to students coming to them from such schools; ordinarily the four-year course is accredited three years; three years' work is accredited two; two years', one; one, nothing by the regents. But they publish their values each year, and no registered school dare accept and give students from these schools larger values, lest they lose their registration and their subsequent graduates be barred forever from admission to the New York medical licensing examination.

The foregoing account of legislation would answer, in the main, for that of many of the other States in the Union, except in reference to the regents of the University. The board of regents is an unique body. The members of the board are elected for a term of twelve years by the legislature in joint session. There are twelve members; the terms are so arranged that but one expires each year. The regents are usually chosen so as to give representation to the twelve judicial districts of the State. The Board of Medical Examiners is appointed by the regents, each member for a term of three years, three terms expiring each year; the board is subject to the regents' rules.

Now in many other States all the authority that is vested in the regents in New York has been given in equally full measure to the Board of Medical Examiners itself. But authority alone does not always make for efficiency. The board of regents in their executive department is thoroughly equipped to pass upon credentials from secondary schools and all institutions of higher education no matter in what part of the world they may be situated. This equipment for the evaluation of credentials is exceedingly important in the administration of a law for requiring education. All sorts of combinations are put up by those who are trying to get by it without really meeting it, and, of course, they are the ones that the law is intended to check—applicants sometimes come with credentials from high schools that do not exist, or from so-called high schools. There are all sorts of tricks or "mental reservations" to be discovered in the credentials offered by some applicants. Again, the law specifies that the applicant should have studied medicine for four years, yet different sorts of combinations of work done in pharmacy, dentistry, or veterinary schools will be offered as substitutes. In New York State, students cannot matriculate in a medical school until they have obtained a medical student's certificate, from the regents, of having complied with the preliminary educational requirement. If an applicant's credentials are not satisfactory, he is required to earn sufficient credits either at an approved institute or by passing the regents' examinations.

It is all these facilities for carrying on their work that have put the regents in a position to administer the preliminary educational requirement so efficiently. Many boards without these facilities have set up much higher requirements, on their face, but they have not administered them absolutely, and, of course, requirements are not made for the "large percentage" that would have done the same if there had been no requirements—they are made to hold back that "percentage" that should not get by. Nearly all requirements as to preliminary education are based upon a diploma of graduation from an approved four-year high school founded on eight years of grammar school study. As it sometimes happens that an applicant has not gone to public school but has been privately tutored, or that the school has gone out of existence, or its records have been destroyed, it is necessary to provide for these applicants by inserting the words "or the equivalent" in defining the requirement. The regents provide examinations for such applicants so that they may make good their claim of having an education equivalent to the requirement.

This whole subject is presented from the viewpoint of preventing the licensing of the incompetent. Inasmuch as the regents have power equal to that given the council of Great Britain and Ireland they are in a position to carry out the *registration method*, and, in many ways, it does seem absurd that there should be the necessity of requiring further examination of the graduates of institutions which they have given the stamp of approval. The regents, by making their visitations more frequently and their inspections more searching, could prevent the graduation of the unfit. However, here in America in matters of law there must be nothing that smacks of privilege or class legislation; so all, no matter how excellent their qualifications may be, must take the State examination. Another reason for having this State examination is to help in carrying out the *restrictive method* for the regulation of practice. The law says that no one shall attempt to diagnose or treat any person for disease, injury or physical condition unless licensed to do so. The examination acts as a further check on the incompetent; from fifteen to twenty per cent. fail. It also provides a means for bridging over many irregularities in the education of older physicians desiring to enter the State to practise—graduates, for instance, of schools that had but ephemeral existence. Doubt exists as to whether the regents' system of registration might not prove weak if it stood alone. The reflex effect of the medical board's examinations had a great deal to do with raising and making uniform the standard of instruction given in many of the medical schools.

The method of examining is by written answers. The candidate's papers are designated by a number and are sent out to the examiner who rates them without his knowing the candidate's identity. In New York it is still contended that some of the examiners might be prejudiced because of race or personality, if they were to examine the candidate orally and clinically. Some state boards combine both methods. Others conduct the entire examination from beginning to end

with full knowledge as to the identity of the candidate. While there is never any trouble with the average candidate, we often find that those who have been rejected time and time again are disposed to make trouble if they can; under the system whereby their identity is not known to the examiner it could never be charged he was unfair to them. Then, too, it prevents the examiner from being influenced by a pleasing personality or other knowledge that might bias his judgment in favor of a candidate that, under the other system, would be rejected as unfit. In this connection it is of interest to note that fewer candidates are rejected by States giving the so-called practical examinations than in those where the examiner and candidate are kept apart. Statistics compiled with a view to showing the percentage of candidates rejected by a board are not fair in their comparisons unless they take into consideration the fact that some boards do not permit poorly qualified applicants to take the examination. The Massachusetts board has no stipulated educational requirements for admission to examination and during the past five years it has rejected 26.9 per cent. of 1,475 candidates examined. New York, on the other hand, has examined 3,227 during the past five years and has rejected 20.6 per cent., but nothing is said about the large number of applicants who are refused admission to the medical licensing examination because of their inability to qualify. The following States are supposed to have similar requirements for admission to the examination and, therefore, the comparison is fair: New York rejects 20.6 per cent., Ohio 4.7 per cent., New Jersey 14.8 per cent., Delaware 5.9 per cent., Indiana 4.5 per cent., Utah 11.1 per cent., Wisconsin 11.9 per cent., and Michigan 1.8 per cent.

Minnesota, Ohio, and Massachusetts give practical examinations in laboratory and physical diagnosis. States like Massachusetts which do not have any educational requirement for admission to the examination should provide very thorough practical examinations. Minnesota gives, in addition, an examination at the bedside. There is much to be said in favor of such examinations because of their influence on medical students. When the examinations are written only, they tend to shirk practical and clinical work, unless the school authorities are strict, and to become bookworms or mere crammers. In New York, besides the reasons given above, the time and funds to examine orally and practically all of the great number of candidates are the necessities which have not been provided. Nearly all State boards are administered on funds raised by the fees charged. The Pennsylvania Bureau is possibly the one exception.

Only a few States publish a list of the names of licensed practitioners. Nearly all require the registration of the license in the county clerk's office, where residing; not that this is of any service to the laity in the selection of a physician, but simply as a matter of record; it affords a quick means of finding out whether any one practising is licensed to do so, and it is required on the assumption that the local medical society will prosecute all who attempt to practise without being licensed. In large cities this proves an antiquated custom; the registration is not amended in case of removal or death and does not give enough information; it would be much better for the State to publish an official register giving the name, address, age, year of graduation, etc., of each licentiate—this would be of real service to the community and to the profession.

In speaking of the standard of medical education required in any given State we deal only with the minimum. If it happens to be absurdly low, this does not mean necessarily that all of the medical schools or the medical profession in that State are of low standard. And in any criticism of requirements it should not be forgotten that many students voluntarily seek training and clinical experience far in excess of that required by any government. It is a small minority of the medical profession in any country that is really unfit, and the whole object of the definition of minimum standards and licentiation is to do away with even this minority. Comparisons of standards required throw no light whatever on the excellence that may obtain in the best schools of any country. As a matter of fact, the minimum standard is fairly even the world over. We have no means of evaluating the quality of instruction given but we can come very close to measuring the quantity. In all countries the requirements are such that most applicants cannot qualify until about twenty-three or twenty-four years of age.

Following are a few notes on the requirements of all the self-governing States, the world over, with the addresses of the officials to whom inquiries or applications should be sent.

Abyssinia.—There are no restrictions on practice.

Alabama.—The Board of Censors of the Medical Association of the State of Alabama is by law constituted the State Board of Medical Examiners. The act is restrictive—all persons are prohibited from treating or offering to treat diseases of human beings by any system whatsoever unless licensed. The board may reciprocate with other state boards in indorsing one another's licenses. The board has the right to refuse recognition to medical colleges not considered reputable. The educational standard is not defined except by the requirement of graduation from a medical school. The examinations are held twice a year beginning the second Tuesday of January and July. The fee is $10. Address inquiries to Chairman, State Board of Medical Examiners, Montgomery, Alabama.

Alaska.—The board is appointed by the governor; each member for a term of two years. The law is drawn more for the purpose of protecting the titles—physician, surgeon, doctor, M. D., or M. B. The board may reciprocate with other States in endorsing licenses. Graduation from a medical college is required for admission to the licensing examination. The examinations are held twice a year beginning on the first Tuesday of January and July. The fee is $25. Address inquiries to the Secretary of the Territorial Medical Examining Board, Juneau, Alaska.

Alberta.—The Medical Council of the Province of Alberta has charge of the registration of physicians. The council admits to the register any one who presents a certificate from the registrar of the University of Alberta showing that the holder is duly qualified. Examinations may be taken in a foreign language, providing an interpreter is available. A standard high school education and a four-year course in a registered medical college are required. Graduates after June 1, 1913, are required to have had a preliminary education equivalent to that required by the University of Alberta, and to have completed a five-year medical course. The certificate of the medical council of Canada entitles the holder to registration in Alberta, providing he has complied with its requirements. There is no reciprocity. The fee is $100. Address inquiries to the registrar of the medical council, Calgary, Alberta.

Argentina.—The National Health Board is charged with the licensing of physicians. Besides a diploma there must be certificates for each course of study; the examinations are given in Spanish only. A foreign diploma must be approved by the Argentine Consulate and Argentine Minister for Foreign Affairs. The examination fee is about $400. There is an annual assessment of about $50. In the provinces a separate license has to be taken out; this varies in each province. Address inquiries to the National Health Board, Buenos Aires, Argentina.

Arizona.—The Board of Medical Examiners is "composite;" it consists of two regulars, one homeopath, one eclectic, and one osteopath appointed by the

Governor for a term of two years. The law is partly restrictive and partly for the protection of certain titles. It defines the practice of medicine as making known or pretending ability or willingness to diagnosticate or prognosticate any human disease, deformity, defect, or injury. The practice of medicine includes the practice of osteopathy. The licenses are issued in three different forms: (*a*) for physicians, (*b*) for osteopaths, (*c*) for practitioners of other systems. Applicants for (*a*), that is, a certificate to practise medicine and surgery, are required to have had a four-year high school education prior to studying medicine four years in a reputable medical college. Applicants for (*c*), "other systems," are merely required to have a diploma from a legally chartered college of the system of treatment. There is no provision for reciprocity. The fee is $25. Address inquiries to the Secretary of the Board of Medical Examiners, Phoenix, Arizona.

Arkansas.—There are three separate boards of medical examiners, one for each of the State medical societies, the regular, the homeopathic, and the eclectic. Each society submits a list of names to the governor who appoints the members for a term of four years. Each board has its own standard and its own rules and regulations. None has its office permanently located.

Austria.—Before the study of medicine can be undertaken an entrance examination must be passed comprising a knowledge of Greek and Latin, besides arithmetic, geometry, and geography, and an especially severe examination in physics and chemistry. Elementary education extends between the ages of six and fourteen, overlapping the gymnasium course by four years, the latter extending between the ages of ten and eighteen. Twelve years of study, therefore, admit to medicine. The medical course covers six years (ten semesters) and includes preliminary courses in physics, chemistry, and biology. The total time required is at least eighteen years, and the minimum age at completion is twenty-four years. Since all medical schools are attached to public hospitals, and are owned and governed by the State, teaching is practically on a uniform scale. Five and one-half years (eleven semesters) is the minimum period of study in the laboratories and hospital wards. Final examinations are then passed and a diploma granted. Foreign diplomas are recognized only after all examinations are passed. Women are admitted to the profession. The law is restrictive—no person other than a physician or surgeon duly certificated and licensed is allowed to diagnose or treat diseases. Physicians are licensed as follows: After graduating and securing a degree the applicant before being allowed to practise must become a member of the chamber of physicians (*Aerztekammer*) of his district, for which he pays a fee of ten crowns ($2) per annum. He is then allowed to practise in that district only. If the physician wishes to practise in another district, as during the summer, etc., he may take out a license from the chamber of that district, but while practising at the second location he is not allowed to treat patients nor to receive fees at his previous location. The fees paid by the physicians to the chamber to which they belong are used as a fund to care for widows and orphans of members. The chamber also is active in preventing practice by unauthorized doctors in its district, in maintaining a minimum scale of fees for all doctor's services, in preventing practice by quacks and in supervision to suppress unprofessional acts among members, as advertisements or selfish measures. The officers of the various chambers of physicians receive no salary, but hold honorary position only. A photograph of each physician is kept in the medical university archives attached to the certificate of his attendance at the medical faculty lectures and substantiated by the university seal.

As a rule, a foreigner is required to pass all the examinations which a native candidate in medicine has to pass. Privileges, however, can be granted by the K. K. Ministerium für Kultus and Unterricht at Vienna. Foreigners are required to become Austrian citizens before they are permitted to practise. The educational requirements are practically those of the University of Vienna. Address inquiries to the K. K. Ministerium für Kultus and Unterricht at Vienna.

Bahamas.—Any genuine diploma issued by a reputable university or high-class institution is recognized by the Colonial Secretary who has charge of the granting of privileges to medical practitioners. No examinations are held. No fee is asked except of those who sell or supply drugs to patients. Address inquiries to the Colonial Secretary, Nassau.

Barbados.—Any qualification equivalent to the British minimum standard (see United Kingdom of Great Britain and Ireland) is acceptable. No examinations are held. One guinea is the fee. Address inquiries to Registration Office, Bridgetown, Barbados.

Belgium.—The educational requirements are practically those of the universities of Brussels, Ghent, Liége, and Louvain. Foreigners must be authorized by Royal Decree after examination before the Central Jury. The applicant must write to M. le Ministre de l'Intérieur et de l'Agriculture, stating the place of abode in Belgium, and send his diploma and other credentials which he has had verified by the Belgium Diplomatic Representative to the government of the country from whence he comes. A foreigner may be examined in his own language if the jury know it.

Bermuda.—There is a medical board for examining the credentials and, if necessary, the candidates. A foreigner may be examined in his own language if an efficient interpreter is available. The fee is about $30. Inquiries should be sent to the Colonial Secretary, Bermuda.

Brazil.—The educational requirements are those of the Faculties of Medicine of the Republic. A foreigner is required to secure the consent of the Faculty of Medicine and Pharmacy. If an examination is necessary it can be taken only in Portuguese or French. The fee is about $3, but each State of the Republic makes an annual assessment which varies. Inquiries should be sent to the Directoria General de Saude Publica, Rio de Janeiro, Brazil.

British Guiana.—The educational requirements are practically those of the United Kingdom of Great Britain and Ireland. A foreigner is required to have a qualification which entitles him to registration in the United Kingdom of Great Britain and Ireland. No examinations are held. No fee is charged. Address inquiries to the Secretary of the Medical Board, Georgetown, Demerara.

Bulgaria.—The degree in medicine from a reputable university is required. An oral examination in Bulgarian only must be passed. The fee is about $20 and there is an annual assessment from $20 to $80. Address inquiries to Direction Sanitaire de Bulgarie, Sofia.

California.—The Board of Medical Examiners is appointed by the governor. Three forms of license are provided for: (*a*) physicians, (*b*) drugless practitioners, and (*c*) indorsement of licenses issued by other States. The educational requirements are graduation from a California four-year high school or its equivalent and graduation by a medical college approved by the board. The examinations are written, oral, and clinical. A physician licensed by another state may not be required to take the examination or he may be required to take just part of it. If his credentials are not satisfactory, he may be required to take the full examination. The examination fee is $25. The fee for indorsement (reciprocal registration) is $50.

Canada.—The Medical Council of Canada is composed of (*a*) three members appointed by the Governor-

in-Council, each from a different Province, (*b*) two members representing each Provincial Medical Council, (*c*) one member from each university or incorporated medical college or school and (*d*) three members elected by the homeopathic practitioners. Any person who secures registration on the medical register of Canada by examination is entitled to registration without further examination in any Province of Canada on complying with the necessary regulations pertaining thereto, including the payment of the Provincial registration fee. Any person who secured registration on the Medical Register of Canada by Provincial Registration of ten years' standing prior to the enactment (1913) of the Medical Act for the Dominion is entitled to registration without further examination in any province, but, if the medical council of the province is not satisfied with his credentials, it may exact an examination. The fee for registration is $100. The examinations are written, oral, and clinical. Provision is made for special examiners in homeopathy. Candidates who hold diplomas obtained outside of Canada must present certificates from the register of a provincial medical council the same as is required of graduates of the Canadian universities. Inquiries should be addressed to the Registrar of the Medical Council of Canada, 180 Cooper Street, Ottawa, Ontario.

Cape Colony.—There is a Colonial Medical Council which recognizes the registration certificate of the General Medical Council of the United Kingdom of Great Britain and Ireland. No examinations are held. A fee of $25 is charged. There is no annual assessment unless a practitioner dispenses his own medicine. Inquiries should be addressed to the Secretary, Colonial Medical Council, Cape Town.

Ceylon.—Any qualification which entitles to registration in Great Britain or a diploma which is certified to by the Council of the Ceylon Medical College is entitled to registration, provided there is reciprocity between Ceylon and the country of origin. Address inquiries to the Registrar, Ceylon Medical College, Colombo.

Chile.—Every person who desires to practise in Chile is obliged to pass an examination in medicine and surgery before a medical commission; but those who hold degrees of well-known universities, like that of Edinburgh, for instance, are excused from part of the examination. Foreign diplomas should be submitted to the Chilian Consul for his indorsement as to their authenticity. There is an assessment of about $10 a year after the first two years of practice. Address inquiries to the Universidad de Chile, Santiago.

China.—In China there are no restrictions as to practice, and, so far, none of the foreign settlements in the treaty ports have any regulations restricting practice. However, following the revolution, regulations may have been established in some of the Provinces. Information may be obtained from Hong Kong College of Medicine, Hong Kong; East China Union Medical College, Nanking; The Union Medical College, Pekin; Woman's Medical School, Shanghai; Harvard Medical School, Shanghai; Imperial Medical College, Tientsin; Union Medical College, Tsi-nan-fu; University Medical College; Canton; South China Medical College, Canton.

Colorado.—The State Board of Medical Examiners is appointed by the governor. The law is restrictive. The examination is written, oral, and clinical. If an applicant's credentials are satisfactory, the board may grant him a license without further examination. Applicants who have been graduated since January 1, 1900, must have attended a medical college which enforces as a minimum requirement for entrance a diploma or certificate of graduation from an accredited four-year high school or its equivalent, and which has a medical curriculum approved by the board. The board will indorse licenses earned in other States prior to 1900, whether by examination or otherwise, and those since 1900 by examination, regardless of reciprocity, provided the applicants present satisfactory evidence of reputable practice, and credentials as to their preliminary and professional education which must be at least equivalent to the board's schedule of minimum educational requirements. The fee is $25. Inquiries should be addressed to the Secretary of the State Board of Medical Examiners, Denver.

Colombia (South America).—The degree of doctor of medicine granted by any recognized faculty constitutes a license to practise. In places where no person resides possessing a degree, any one may practise if he possesses a license issued by a physician holding a degree who resides in the nearest community. A license may also be obtained by undergoing an examination by the Board of Directors of the Bogotà Faculty of Medicine. Address inquiries to the Secretary of this Board.

Columbia(British).—Applicants must have a diploma in medicine from a school requiring a four-year course of study and they must successfully pass an examination before the local Board. Examinations are oral and written and the fee for registration is $100. Persons registered in the United Kingdom of Great Britain and Ireland prior to June 30, 1887, are entitled to practise on paying a fee for registration; likewise the licentiates of the Medical Council of Canada, which was established in June, 1913. Address inquiries to the Secretary, College of Physicians and Surgeons, Victoria, B. C.

Connecticut.—There are three medical examining boards appointed by the State Board of Health from the regular, the homeopathic, and the eclectic medical societies. Each board of medical examiners makes its own rules and sets its own standard. The law is restrictive. The boards may indorse licenses earned in other states, but they seldom do so. Address inquiries to the Secretary of the State Board of Health, Hartford, Connecticut, for reference to the respective boards which do not have permanent places for transacting business or keeping the records.

Costa Rica.—Diplomas must be submitted to the Council of the Faculty of Medicine of Costa Rica. Examinations are given in Spanish only and are written, oral, and practical. The fee is about $50. Address inquiries to e Señor Secretario, Facultad de Medicina de Costa Rica, San José, Costa Rica.

Cuba.—A degree registered at the University of Havana constitutes a legal qualification to practise.

Cyprus.—See Turkey.

Delaware.—The law provides for two boards of medical examiners, one regular and the other homeopathic, appointed by the governor after nomination by the respective societies. The licenses are granted by the Medical Council of Delaware which consists of the Chief Justice of the State and the presidents of the two boards. The educational standard as to preliminary education is that of a four-year high school course, and as to professional, four years of medical study in an approved medical college. The law is restrictive. The board may indorse licenses earned in other states. Examinations are written only. The fee is $10 and a fee of $50 is charged for indorsement (reciprocity). Address inquiries to the Secretary of the Medical Council, Wilmington, Del.

Denmark.—To obtain the privilege to practise, it is necessary to be at least twenty-five years of age and to have an examination certificate earned by passing an examination in Danish. There is no provision for foreigners and there are no foreigners practising in Denmark. Address inquiries to the Minister of Justice, Copenhagen.

District of Columbia.—Three medical examining boards are appointed by the District Commission, one for each the regular, the homeopathic and the eclectic

medical societies of the district. The presidents of these three boards and two persons not physicians constitute the Board of Medical Supervisors which has general control of admission to examinations and the issuance and revocation of licenses. The examining boards submit the questions to the supervisors who select those for use in the examination. There are no definite requirements as to preliminary education. The standard is simply that of gradnation from a medical college authorized by law and giving a four-year course of study. The examinations are written and the fee is $10. The board may indorse licenses earned by passing the examination of another state board. Address inquiries to the Secretary of the Board of Medical Supervisors, Washington, D. C.

Ecuador.—A diploma with legal proof of having passed the prescribed examination constitutes a qualification to practise medicine in Ecuador. The examination is given only in Spanish by the Board of Examiners. The fee is about $60. The Republics of Ecuador, Columbia, Peru, Boliva, and Chile, by special treaties, indorse one another's medical licenses. Address inquiries to Faculdade de Medicina, Universidad Central de Ecnador, Quito, Ecuador.

Egypt.—Any one may practise who holds a degree from a reputable university or who has obtained a reputable license to practise in another State. No examinations are held and no fee is charged. Address inquiries to the Director General, Department of Public Health, Cairo.

England.—(See United Kingdom of Great Britain and Ireland.)

Falkland Islands.—There are no restrictions on practice.

Fiji.—No examinations are held but diplomas, certificates, and proof of identity must be submitted to the Chief Medical Officer, Suva, Fiji.

Florida.—The law provides for three boards of medical examiners appointed by the governor from the membership of the three State societies, the regular, the homeopathic, and the eclectic. There are no requirements as to preliminary education. Each board makes its own rules and there is no provision in the law for reciprocity, but any two members of a board may grant a temporary license which will permit the holder to practise until the next regular meeting of the board. The offices of the boards are not permanently located.

France.—In France the law is restrictive and the only legal qualification to practise is a degree granted by the State upon successfully passing the examinations of a recognized Faculty of Medicine. There are strict regulations as to preliminary education and the course of medical study. The requirement as to the former is a Bachelor's Degree, but this is only about the equivalent of a diploma from a four-year high school course in the United States of America. Foreigners are required to earn a degree from a Faculty of Medicine in France and to do this they must know French. Address inquiries to M. le Ministre de l'Instruction publique et des Beaux Arts, 110, Rue de Grenelles, Paris.

Gambia.—Any person registered or entitled to be registered in the United Kingdom of Great Britain and Ireland may be registered at once. Others must submit their credentials to the Senior Medical Officer, Bathurst. The fee is about $5. No examinations are held.

Georgia.—The law is restrictive. The State Board of Medical Examiners is a "composite board." The requirement as to preliminary education is fourteen units as evaluated by the Professor of Secondary Education in the State University; as to professional education, it is the usual four-year medical course approved by the board. The board may indorse licenses earned in other States which maintain an equal standard and which reciprocate with Georgia. The examinations are written and the fee is $20. Address inquiries to the Secretary of the Board of Medical Examiners, care of the Capitol, Athens, Georgia.

Germany.—Medical practice is free in Germany, but only those persons who have passed certain examinations and earned an "approbation" from the government are permitted to describe themselves as physicians, surgeons, oculists, accoucheurs, and the like. Foreign qualifications give no privilege whatsoever, but a foreigner may practise in Germany providing he does not call himself a physician, or if he does so that he qualifies it in some such way as this, for instance, "physician legally licensed in New York." The Chancellor of the Empire may grant a license to a foreigner without requiring an examination, but this has never been done except to honor some celebrated authority or to welcome some foreigner eminent in the profession.

The statutory regulation of the practice of medicine is to be found in Section 79 of the Industrial Ordinance of June 21, 1869. The approbation referred to is granted to candidates who meet the Imperial Ordinance of May 28, 1901, relative to the examination of physicians. The use of the title doctor, if obtained at a foreign university subsequently to April 15, 1897, is permitted only with the consent of the Minister of Education. By a decree of June 22, 1896, apothecaries are forbidden to fill prescriptions written by foreign doctors calling for strong medicines. American medical schools are not recognized and a physician educated in America desiring to enter practice in Germany and simply calling himself "Arzt" would have to enter a German university and satisfy the requirements of the examining board. As a rule, the board consists of the professors from the medical faculty of the local university. Because homeopathic physicians dispense their own drugs there is a special commission for examining homeopaths. The Aerztliche Pruefungs-Kommission is an office in the Prussian Ministry of the Interior. A record is kept of all who pass the examinations, but photographs are not required to be filed. The list of physicians is published yearly in the Medicinal Calendar obtainable for M.4, inclusive of postage to the United States, from August Hirschwald, Unter den Linden, 68, Berlin.

All of the medical schools in Germany are part of the State universities. The State boards of medical examiners are appointed from the medical faculties of these universities. Part of the State examination is taken at the end of the second year, and the final examination at the end of the fourth year. The license or "approbation" must be earned before a university can confer the title of doctor of medicine. The universities require an additional year of study after the "approbation" is granted before they will grant the degree of M. D. No fee is required. Foreigners should address inquiries to Der Minister des Innern, Berlin, N. W. 7, Unter den Linden, 72.

Gibraltar.—See United Kingdom of Great Britain and Ireland for standard required. Address inquiries to the Colonial Secretary, Gibraltar.

Gold Coast.—Documents will only be called for where doubt exists as to the qualification of a practitioner. Address inquiries to the Under Secretary of State, Colonial Office, London, S. W.

Great Britain.—See United Kingdom of Great Britain and Ireland.

Grecce.—The regulations lay emphasis upon practical examinations. A diploma from a university of a State is required, and no examination is exacted of the applicant if the university is known to give a practical examination similar to that given by Athens University to all candidates for the degree doctor of medicine. If the applicants are ignorant of Greek, they may take the examination in French, German, or Italian. Address inquiries to the Medical Secretary, Ministry of Interior, Athens.

Grenada.—No examinations are held. British qualifications are acceptable. Address inquiries to the Medical Register, St. George's, Grenada.

Guatemala.—An applicant must possess a diploma from a university, and must submit to a practical examination in clinical medicine, to performing an operation on a body, to an examination in obstetrics and to a written examination. The examination is given in Spanish only, and the fee is $25. Address inquiries to the Head of the Faculty of Medicine (Décano de la Faeultad de Medicina), Guatemala.

Guernsey.—See United Kingdom of Great Britain and Ireland.

Haiti.—There is a Central Medical Board for examining diplomas and credentials and, if necessary, the candidates. A new diploma and license is given by the Secretary of State upon the recommendation of this board. Address inquiries to the Secretary of State for Public Instruction, Port au Prince, Haiti.

Hawaii.—The governor appoints a Board of Medical Examiners in connection with the Board of Health. There is no reciprocity. The examination is given in English. The fee is $10. The law is restrictive. Address inquiries to the Secretary of the Board of Health, Honolulu.

Honduras.—The applicants must pass the general examination. An applicant may take the examination in his own language. Address inquiries to Déeano de la Escuela de Medicina, Tegucigalpa, Honduras.

Honduras (British).—The ordinance is patterned after the British method. Address inquiries to the Colonial Secretary, Belize, B. Honduras.

Hong Kong.—No examinations are held, but there is a medical board for passing upon the credentials of applicants. If the name of the practitioner appears in the Medical Register of Great Britain and Ireland, a fee of only $5 is charged; otherwise $25 is charged. Address inquiries to the Secretary, Medical Board, Hong Kong.

Hungary.—Foreigners may take the examination in their own language. Address inquiries to the Dean of the Medical Faculty of the University of Budapest.

Idaho.—The board is "composite" and is appointed by the governor. Applicants must submit a diploma of graduation by a reputable college of medicine. There are no requirements as to preliminary education. The board may indorse the licenses of other States with which it has reciprocal agreements. The law is restrictive. Examinations are written. The fee is $25. There is no permanent place for transacting business.

Illinois.—The State Board of Health is also the State Board of Medical Examiners. Applicants must present evidence of graduation from a high school, or must have earned a credential, considered the equivalent, by passing an examination. The board makes an exception in the requirement of four years of medical study by permitting graduates of colleges of arts and science, dentistry, pharmacy, or veterinary medicine to take one year's advanced standing for such work in lieu of one year of the required four years of medical study. The board may reciprocate with other state boards. The fee is $10. Foreigners may take the examination in their native tongue. Address inquiries to the State Board of Health, Springfield, Ill.

India.—Until recently there have been no restrictions upon practice in India, but at the present time means for its regulation are being provided. All of the details are not at hand. The Viceroy has just signed a bill regulating the practice of European medicine in the Madras Presidency. In this law there is a clause which gives the medical council (of fifteen men), constituted under the Act, the power to admit to registration holders of foreign degrees who, the council is satisfied, are fully and properly qualified. This clause is not in the Act passed recently in the Bombay Presidency and consequently none but British degrees are registerable. Bengal is about to pass a Medical Practitioners' Act. Address inquiries to the Secretary, National Medical College of India, 191 Bowbazar Street, Calcutta.

Indiana.—The law provides for a State Board of Medical Examination and Registration to be appointed by the governor. It is a "composite board." This board has advanced the requirements as to preliminary education for all candidates for license after January 11, 1914, to two years of work in a college of arts and science other than a medical school. The examination is written, and a foreigner may write in his native language. The fee is $25. The board will not recognize any colleges hereafter which do not have the same requirement as to preliminary education and give in addition four full years of medical instruction. The board may reciprocate with other boards, and it may issue temporary licenses. Medical students who have attended not less than two full courses of lectures in a medical college may practise under the supervision of a preceptor. Address inquiries to the Secretary of the Board, Indianapolis, Ind.

Iowa.—The Board of Medical Examiners is part of the State Department of Health and the members are appointed from the regulars, the homeopaths and the eclectics by the governor. The law in regard to practice is restrictive. Temporary permits to practise are issued to applicants whose credentials are satisfactory. All applicants graduated after January 1, 1911, must have completed two years of work in a college of arts prior to beginning the study of medicine. Since July 1, 1906, no medical college has been regarded in good standing that does not require four full years of medical study, or that grants advanced standing for work done in a literary or scientific college other than a medical school. The board may endorse the licenses of other States. Examinations are written. The fee is $10. The fee for the endorsement of another State's license is $50. Address inquiries to the Secretary, Department of Health, Des Moines, Iowa.

Isle of Man.—See United Kingdom of Great Britain and Ireland.

Italy.—A diploma from an Italian university confers the privilege to practise. In 1910 a law was passed by which foreign practitioners whose countries grant reciprocity of medical practice to Italy are permitted to practise. On this basis there is international reciprocity between Italy and the United Kingdom of Great Britain and Ireland. Foreign practitioners who were in practice in Italy have the privilege of continuing their practice only among the foreigners, if they were not licensed in accordance with this law. The law is restrictive. The fact that no claim is made to the title doctor of medicine does not justify practice. The government keeps track of the licentiates by requiring registration at certain local offices. Photographs are not filed with the records. Address inquiries to one of the universities.

Ireland.—See United Kingdom of Great Britain and Ireland.

Jamaica.—See United Kingdom of Great Britain and Ireland. Address inquiries to Register General, Jamaica.

Japan.—There seem to be no restrictions on practice in Japan, although it is said that any qualification recognized in Great Britain constitutes a right to practise. Address inquiries to Japanese Embassy, Washington, D. C.

Jersey.—Any British or French qualification is sufficient. Address inquiries to the Greffier, Greffe Office, Jersey.

Kansas.—The State Board of Medical Registration and Examination is a "composite board" appointed by the governor. The law is restrictive. Since January 1, 1910, no medical school is approved which

does not require, for entrance, at least one year of work in a college of liberal arts in addition to the completion of a four-year high school course. The board may indorse licenses earned by examination in other states. The examination fee is $15. In case of reciprocity the board charges the same fee as that charged by the other board when licentiates of Kansas apply for indorsement. The board does not have a permanent place for transacting business. Address inquiries to the Secretary of the Board of Medical Registration and Examination, The Capitol, Topeka, Kansas.

Kentucky.—The State Board of Health has charge of the licensing of physicians. It is a "composite board" appointed by the governor. The law is absolutely restrictive. The requirement as to preliminary education is that of graduation from a four-year high school or its equivalent; as to professional education, the usual four-year medical course. The board will recognize Class B-colleges as rated by the American Medical Association. The board may indorse licenses earned in other states provided similar recognition is given Kentucky licentiates. The fee is $25. Address inquiries to the Secretary of the State Board of Health, Bowling Green, Kentucky.

Leeward Islands.—For standard of qualifications see United Kingdom of Great Britain and Ireland. An annual fee of about $25 must be paid in the Presidency of Antigua. No fee is required in the rest of the colony. Address inquiries to the Colonial Secretary, Antigua, Leeward Islands, W. I.

Louisiana.—There are two boards of medical examiners appointed by the governor from the regular and the homeopathic medical societies. The law is restrictive. The rules of the boards require graduation from a high school, or its equivalent, and graduation by an approved medical school for admission to the medical licensing examination. The boards may indorse licenses earned in other states providing the states reciprocate with Louisiana. The board may issue temporary permits. The examination fee is $25. Address inquiries to the secretary of the respective board, New Orleans, Louisiana.

Maine.—There is a Board of Registration in Medicine appointed by the governor. Each member holds office for a term of six years. The law is not absolutely restrictive, but it limits the use of the title, physician, surgeon, or doctor of medicine. The board requires graduation from a four-year high school course, or its equivalent, and graduation from an approved medical school for admission to the medical licensing examination which is given in English only. The examination fee is $15. Address inquiries to the Secretary of the State Board of Registration in Medicine, c/o Capitol, Augusta, Maine.

Malta.—For standard see United Kingdom of Great Britain and Ireland. British qualifications are recognized. There is a Medical Board which conducts examinations in English, French, and Italian. The fee is about $5. Inquiries should be directed to His Honour, the Lieutenant Governor and Chief Secretary to Government, Malta.

Manitoba.—Physicians registered by the Medical Council of Great Britain, or the Medical Council of Canada, may register at once without examination. The examinations are written, oral, and clinical and may be taken in English, French, or German. The fee is $75 and there is an annual assessment of $2. Address inquiries to the Registrar, College of Physicians and Surgeons, Winnipeg, Manitoba.

Maryland.—There are two boards of medical examiners in Maryland—one representing the regular profession and the other the Homeopathic Medical Society. Physicians connected with medical colleges are not eligible for membership on the boards. The law is restrictive. The boards require evidence of a competent high-school education and of graduation from an approved medical school for admission to the examination. The boards may reciprocate with other state boards in indorsing one another's licenses. The fee for examination is $15. Address inquiries to the secretaries of the respective boards, The Capitol, Annapolis, Md.

Massachusetts.—There is a Board of Registration in Medicine appointed by the Governor, and practically it is a "composite board." The law is restrictive. Any one over twenty-one years of age and of good moral character may take the examination, for there are no requirements as to education for admission. There is no provision for reciprocity. The examinations are written, oral and clinical. The fee is $20. Address inquiries to the Secretary of the Board of Registration in Medicine, State House, Boston, Mass.

Mauritius.—No examinations are held. Any foreign qualifications are recognized. Address inquiries to the Colonial Secretary, Port Louis, Mauritius.

Mexico.—The Board of the National School of Medicine passes upon credentials. No examination is required unless the Board refuses to accept or approve the credentials offered. Reciprocity exists between Mexico and Spain. In the State of Vera Cruz and in the City of Mexico an examination in the Spanish language has been required. Some of the states comprising the Republic have their own requirements and make special assessments.

Michigan.—There is a Board of Registration in Medicine appointed by the Governor with the consent of the Senate. The Board is "composite"—there being five regulars, two homeopaths, two eclectics and one physiomedic as members. The law is restrictive. The board requires graduation from a high school, or its equivalent, and graduation by an approved medical school. The board may reciprocate with other state boards. The examination fee is $25. The fee for indorsement of another state board's license is $50. Address inquiries to the Secretary of the State Board of Registration in Medicine, Detroit, Mich.

Minnesota.—The State Board of Medical Examiners is appointed by the Governor. It is a "composite board." The law is restrictive. The rules of the board require two years of work in the college of arts in the University of Minnesota, or its equivalent, prior to entrance into an approved four-year medical course. The examination is given in English only, and is written, oral and clinical. The fee is $10. The board may reciprocate with other state boards and the fee charged for indorsing another state board's license is $50. Address inquiries to the Secretary of the State Board of Medical Examiners, St. Paul, Minn.

Mississippi.—The State Board of Health conducts the examination for the licensing of physicians. The law is not so restrictive, but provides a penalty for any person who shall practise as physician or surgeon without having been licensed by the State Board of Health. The examinations are conducted at the Capitol in Jackson. Address inquiries to the Secretary of the State Board of Health, Jackson, Miss.

Missouri.—The State Board of Health, which is appointed by the Governor, has direct supervision over the registration of practitioners in medicine. The law is restrictive. The board requires graduation from a high school, or its equivalent, and the diploma from a medical school approved by the board for admission to the medical licensing examination. The examination is conducted in English only. The fee is $15. The board may indorse the license of other state boards, with which it has a reciprocity agreement, for $25. Address inquiries to the Secretary of the State Board of Health, Jefferson City, Mo.

Montana.—The State Board of Medical Examiners is appointed by the Governor. The law is restrictive. There are no requirements as to preliminary education, but a diploma from an approved medical school is

required for admission to the medical licensing examination. The board may indorse another state's licenses. The examination is given in English only, and the fee is $25. Address inquiries to the Secretary of the State Board of Medical Examiners, Helena, Mont.

Montenegro.—Permission to practise is obtained from the Minister of Health for the Interior with the approval of the Minister of the Interior.

Morocco.—There are no regulations for the practice of medicine.

Natal.—For standard and qualifications see United Kingdom of Great Britain and Ireland. The fee for registration is $5 and there is an annual assessment of $25. Address inquiries to the Colonial Secretary, Pietermaritzburg, Natal.

Nebraska.—The State Board of Health consists of the Governor, the Attorney General and the Superintendent of Public Instruction, and the Governor appoints four secretaries who hold office for a term of four years. Two of these secretaries are regular physicians, one is a homeopathist and one an eclectic. These secretaries constitute a Board of Medical Examiners. The law is restrictive. The board may indorse licenses earned upon examination from other states. The fee is $25. Address inquiries to the State Board of Health, Lincoln, Neb.

Netherlands.—The theoretical examination is conducted by the medical faculties of the universities. The practical examination is given by commissioners appointed annually by the Queen. Examinations are given in Dutch only, and application should be made to the chairman of the local faculty or commission. The State license is for restricting the use of the title, physician. The examination fee is about $80. The degree of doctor of medicine is not required of licentiates as the universities require additional study for this degree.

Nevada.—The State Board of Medical Examiners is a "composite board" appointed by the governor. The law is restrictive. Applicants must have been graduated by a medical school, and must pass the examination. There are no prerequisites as to general education. The board may reciprocate with other state boards. The fee is $25. Address inquiries to the Secretary of the State Board of Medical Examiners, Carson City, Nev.

New Brunswick.—Licentiates of the Medical Council of Canada are permitted to register upon paying the fee required by the province. There is a Council of Physicians and Surgeons partly appointed by the governor and partly by the New Brunswick Medical Society. It prescribes a preliminary examination as well as a professional examination which must be passed irrespective of any credentials. It may be taken in English or French. Address inquiries to the Registrar, Council of Physicians and Surgeons, St. Johns, N. B., Canada.

Newfoundland.—There is a Medical Board which may accept credentials earned by meeting equivalent requirements. Otherwise the examinations must be passed. Licentiates of the Medical Council of Canada are permitted to register upon paying the Board's fee. Address inquiries to the Registrar, Newfoundland Medical Board, St. Johns, N. F., Canada.

New Hampshire.—The New Hampshire Medical Society, the Homeopathic Medical Society and the Eclectic Medical Society have their respective boards of medical examiners whose members are appointed by the governor from lists furnished by the societies. The Superintendent of Public Instruction is the regent of the three boards and conducts the examinations from lists of questions submitted. The regent may admit any applicant who submits evidence of having completed a full high-school course, or its equivalent, and who has been graduated from a medical school registered as maintaining a satisfactory standard. The examination fee is $10. The law is more for the protection of the titles—physician, surgeon, and doctor of medicine than for the restriction of practice. The boards have reciprocal relations with a number of state boards for indorsing licenses earned upon examination. Address inquiries to the regent of the Boards of Medical Examiners, Concord, N. H.

New Jersey.—The State Board of Medical Examiners is a "composite board" appointed by the governor. The law is restrictive. The law includes the prerequisite of the completion of a four-year high school course or its equivalent prior to beginning the study of medicine as well as the requirement of graduation from a medical school registered as maintaining a full four-year course. Examination is given in English only. The fee is $25. The board may indorse a license issued by another state whose standard of examination is equally high. Address inquiries to the Secretary of the State Board of Medical Examiners, Trenton, N. J.

New Mexico.—There is a State Board of Health and Medical Examiners appointed by the governor. The law is restrictive. There are no prerequisites as to general education. A diploma from an approved medical school is required. The board may indorse another state's license at its discretion. The fee is $25. Address inquiries to the State Board of Health and Medical Examiners, Santa Fe, N. M.

New South Wales.—For standard of qualifications required for registration see United Kingdom of Great Britain and Ireland. Address inquiries to the Secretary, New South Wales Medical Board, Sydney, N. S. W.

New York.—There is a Board of Medical Examiners appointed by the regents of the University of the State of New York which is the licensing body. The Board of Medical Examiners is practically a "composite board." The requirements as to preliminary education are the completion of a full four-year high school course, or its equivalent, and one year's work each in physics, chemistry, and biology. These latter studies may be completed in a high school. The professional requirement is the completion of four full years of medical study in an institution approved (*registered*) by the regents as maintaining a satisfactory standard. All applicants are required to pass an examination, except in very rare instances the Commissioner of Education may, with the consent of the regents, issue a license without examination to a physician who has reached a position of eminence and authority in the profession. The regents have defined eminence and authority, and it is practically impossible for any one but a professor or some noted scientist to obtain the commissioner's indorsement of his foreign license. Of the 106 medical schools in the country, the regents register but sixty-six. Graduates of schools not registered cannot be admitted to the licensing examination unless they have also attended a registered school and have been graduated by it. A registered school is forbidden giving credit for work done in a non-registered school except in accordance with the regents' accrediting. In most instances they are permitted to give three years' advanced standing for the completion of four years' work in a school not registered by the regents; two years for three years' work; one year for two years'; nothing for one year. The New York law forbids admitting candidates to the licensing examination who did not complete a four-year high school course, or its equivalent, prior to beginning the study of medicine, or who have not attended a medical school four full years—studies pursued in a college of arts or other scientific or professional school cannot be substituted for work in a medical school. The board may be a party to reciprocity agreements with other state boards for indorsing licenses earned upon examination, providing that the candidates have complied with all the requirements of the New York statute, and that the other board does not recognize any medical schools not

recognized by the regents, and maintains an examination of an equal standard. The law is absolutely restrictive. The fee is $25. Address all inquiries to the Secretary of the State Board of Medical Examiners, State Education Building, Albany, N. Y.

New Zealand.—For standard of qualification required for registration see United Kingdom of Great Britain and Ireland. If the qualification is not recognized by the Governor in Council, the candidate is required to pass the final examination of the New Zealand University. Personal application is necessary after becoming a resident in New Zealand. Formal application is had before any action is taken. Address inquiries to the Registrar General, Wellington, N. Z.

Nicaragua.—The degree of the Central American School of Medicine entitles the holder to registration. Foreigners are required to pass an examination given in Spanish only at Leon unless they are able to get the president of the republic to grant them permission to practise on presentation of their foreign qualifications. There are no provisions for reciprocity. Address inquiries to the Minister of Public Instruction or to the Protomedicato de la Republica, Leon, Nicaragua.

Nigeria.—No examinations are held in North Nigeria. Any qualifications recognized in Great Britain entitle the holder to register. Address inquiries to the Principal Medical Officer, Northern Nigeria.

The requirements for registration are about the same in South Nigeria. Address inquiries to the Registrar of Medical Practitioners and Dentists, Lagos, South Nigeria, West Africa.

North Carolina.—The members of the State Board of Medical Examiners are appointed by the State Medical Society. The law is restrictive. There are no prerequisities as to general education in the law. The board makes its own requirements. The board may reciprocate with other state boards, and it may issue temporary permits. The board has no permanent place for holding its meetings or for keeping its records. Address inquiries to the Secretary of the State Board of Medical Examiners, The Capitol, Raleigh, N. C.

North Dakota.—The State Board of Medical Examiners is a "composite" board. The members are appointed by the governor. The law is restrictive. The board requires evidence of education equivalent to two years of study in a college of liberal arts, prior to beginning the approved four-year course of medical study. The standards are defined by the University of North Dakota where the examinations are held beginning on the first Tuesday of January and July each year. The board may reciprocate with other state boards. The fee is $25. Address inquiries to the Secretary of the State Board of Medical Examiners, Grand Forks, N. D.

Norway.—The final examination in the University of Christiania is the requirement for the privilege to practise. It is possible for foreigners who have exceptional qualifications to have them indorsed without being required to take the examination, but this is seldom done. The examinations are given in Norwegian only. An applicant must furnish his birth certificate with his diploma and other credentials. No fee is charged. Address inquiries to the Director, Section of Medicine, Department of Justice, Christiania.

Nova Scotia.—Holders of qualifications recognized by the General Council of Medical Education and Registration of the United Kingdom of Great Britain and Ireland, or licentiates of the Medical Council of Canada, may register upon paying the provincial fee. All other applicants are required to pass an examination which is given in English only. The Provincial Medical Board is very strict about requiring certificates of identity. Foreign graduates are charged $60, whereas British registered practitioners are charged only $30 for registration. Address inquiries to the Secretary and Registrar of the Provincial Medical Board of Nova Scotia, Halifax, N. S.

Nyassaland Protectorate.—No examinations are held, but a fee not to exceed $25 is charged for registration. Standards said to be the same as those of the United Kingdom of Great Britain and Ireland. Address inquiries to the Deputy Commissioner Zomba, B. C. A.

Ohio.—The governor, with the advice of the Senate, appoints the State Medical Board which is a "composite" board. The law is restrictive. The applicants for admission to the examination must produce acceptable credentials of preliminary education equivalent to the completion of a standard four-year high school course, and must present a diploma of a medical school, or a foreign license, approved by the board. The examination is written, oral, and clinical. Candidates who cannot present satisfactory credentials as to preliminary education may take an examination before the preliminary examiner who is connected with the College of Liberal Arts in Ohio University. The fee for the examination is $25. Fee for reciprocity is $50. Address inquiries to the Secretary of the Medical Board, State House, Columbus, Ohio.

Oklahoma.—The law provides for a "composite" Board of Medical Examiners and it is restrictive. The board may indorse other state's licenses granted after an examination, or issued simply upon the basis of approval of a diploma earned prior to June 12, 1908. The fee is $15. Address inquiries to the Secretary of the State Board of Medical Examiners, Guthrie, Oklahoma.

Ontario.—Licentiates of the Medical Council of Canada may register upon paying the provincial fee. British registered practitioners of five years' standing or over are required to take only the final examinations. All others are required to pass the full examinations. The fee for registration is $100. Inquiries should be addressed to the Registrar of the College of Physicians and Surgeons, Toronto, Ont.

Orange River Colony.—The standard required is that of the General Council of Medical Education and Registration of the United Kingdom of Great Britain and Ireland. No examinations are held. A fee of about $35 is charged and there is an annual assessment of about $150. Address inquiries to the Secretary and Registrar of the Medical Council, Board of Executors Building, Bloemfontein.

Oregon.—The State Board of Medical Examiners is a "composite" board appointed by the governor. The law is restrictive and protects the title M. D. or M. B. There are no prerequisites as to general education. The requirement as to professional education is the completion of a four-year medical course in an approved institution. The board may indorse licenses issued by other state boards which reciprocate in indorsing licenses issued by Oregon. The examination fee is $10. Address inquiries to the Secretary of the State Board of Medical Examiners, Portland, Ore.

Panama.—The National Board of Health of the Republic registers practitioners who hold diplomas acceptable to it. The examination is oral and is given in either Spanish or English. The fee required is about $100 gold. This law does not apply to the Isthmian Zone controlled by the United States government, where physicians are registered by the Board of Health of the Isthmian Canal Zone. The fee for the examination and license is $5. The law for the Zone is absolutely restrictive.

Paraguay.—The examinations are given in Spanish only. The licenses and diplomas of Uruguay or Argentine are recognized. The fee for the examination is $250 (Paraguay currency). There is an annual assessment of $500 (Paraguay currency). Address inquiries to Consejo de Higiene, Asuncion.

Pennsylvania.—There is a Bureau of Medical Education and Licensure in the Department of Public Instruction, which consists of seven members appointed by the governor. It is a "composite" board and the law is restrictive as to practice. There is a prerequisite of graduation from a four-year high school course or its equivalent, prior to beginning the four-year course of medical study in an approved institution. The bureau may reciprocate with other state boards. All applicants must have served one year as an interne in an approved hospital or continue a course of study approved by the Bureau after graduation. The examination fee is $25. Address inquiries to the Superintendent of Public Instruction, Harrisburg, Pa.

Persia.—There are no restrictions upon practice. As to any regulations that may be passed in the near future address inquiries Urumia College Medical Department, Urumia.

Peru.—Two years of study in the university in addition to a good secondary education are required for admission to the seven-year medical course which is not finished until about the age of twenty-five or twenty-seven. The government examination is based upon the university requirements and a series of five examinations must be passed. The examinations are given in Spanish only, and foreign qualifications are not recognized except those of South American countries. The examination is so difficult that few foreigners succeed in passing it. The fee is about $500. Inquiries should be addressed to the Dean of the college of Medicine, University of Lima, Lima, Peru.

Philippine Islands.—The applicants are required to pass the examination of the Bureau of Health, and this may be taken in any language, providing the applicant provides a satisfactory interpreter and translator. Address inquiries to the Secretary-Treasurer, Board of Medical Examiners for the Philippine Islands, Manila, P. I.

Porto Rico.—Applicants who possess diplomas of reputable medical colleges and who have been licensed by a State Board may be licensed by the Board of Examiners without examination. Address inquiries to the Secretary of the Board of Medical Examiners, San Juan, Porto Rico.

Portugal.—A degree from the University of Coimbra or Lisbon or Oporto is required as a qualification to practise. Foreign qualifications are not recognized. The requirement as to graduation from the course of medical study in these universities includes approval of all preparatory studies prior to matriculation. Applicants with foreign qualifications are exempted from the requirements for class attendance at the local universities, but they are required to pass all the examinations. The examinations are given in Portuguese only. The fee is about $20. Address inquiries to Ex^{mo}S^{r}Reitor de Universidade de Coimbra; or Ex^{mo}S^{r}Secretario da Escola Medica de Lisboa or Ex^{mo}S^{r}Secretario da Escola Medica do Porto.

Prince Edward Island.—Licentiates of the Medical Council of Canada may register upon paying the provincial fee. For standard required see United Kingdom of Great Britain and Ireland. The examination fee is $25. There is an annual assessment of $1. Address inquiries to the Registrar-Secretary, Medical Council of Prince Edward Island, Charlottetown.

Quebec.—A British qualification entitles the holder to a license to practise without having to pass an examination. Foreign qualifications as to preliminary or medical studies are recognized, if judged by the board equivalent to those required by the provincial laws. The examinations are given in English and French, but the board may allow another language if it is understood by the members of the examination committee. The fee for the complete examination is $60. There is an annual assessment of $2. Licentiates of the Medical Council of Canada may register upon paying the provincial fee. Address inquiries to the Secretary, Royal College of Physicians and Surgeons of Quebec, Quebec or Montreal.

Queensland.—Any qualification obtained after a three-year course of study, which is granted by an institution recognized in its own country and which gives the right to practise, is recognized by the Queensland Medical Board. No examinations are held. Documents for proof of identity must be submitted. Address inquiries to the Secretary of the Queensland Medical Board, Brisbane.

Rhode Island.—The State Board of Health, which is a "composite" board appointed by the governor with the consent of the Senate, has charge of the registration and licensing of physicians. The law is restrictive, and protects the title M. D. There are no requirements as to preliminary education. All applicants are required to take the examination which is given in English only. There is no provision for reciprocity. Address inquiries to the Secretary of the State Board of Health, Providence, R. I.

Rhodesia, Northwest.—Permission to practise is obtained from the Administrator to whom inquiries should be addressed.

In *South Rhodesia* there is a medical committee. Application must be made to the Chief Secretary.

Roumania.—The degree of any one of the Roumanian Faculties of Medicine confers the right to practise. Foreigners who have earned licenses in other countries are admitted to the State examinations, but those who have not been licensed in other countries even though they hold the degree M. D. are required to pass all the examinations for the doctorate at one of the Roumanian Faculties of Medicine. The right of free practice may be granted by the Minister of the Interior on the basis of an advice from the Superior Sanitary Council. Address inquiries to the Minister of the Interior, who has the examinations conducted before a special jury.

Russia.—There are several registerable titles in Russia. The doctorate in medicine is on a very high plane in the university, and is not obtainable until about three or four years further study after passing the State examination for the license of "lekar," (physician). Feldshers include gradations ranging from medical practitioners down to midwives and nurses. The Medical Council at St. Petersburg has no connection with the universities, being attached to the Ministry of the Interior and not to the Ministry of Public Instruction. It is a body having departments throughout the empire, and dealing generally with questions of public health. The Russian laws are very strict in regard to prohibiting quack physicians from practicing. All students in Russian universities have to hand in their photographs, before they are admitted, and the licenses to graduates are all recorded before being issued. Ordinarily an American physician desiring to practise in Russia is required to take two examinations—the graduation examination at a classical gymnasium, and the university examination. The foreign diploma does away with the necessity of taking the five-year course in the university, providing permission is obtained from the ministry to take only the university examination. The Medical Council of Russia passes upon foreign qualifications. The examinations are given in Russian only. No fees are charged for the examinations, which are conducted in connection with the universities or schools under the direction of the Minister of the Interior or Minister of Public Instruction. Distinguished foreigners may not be required to pass an examination. In some cases only an oral examination is required of foreigners. Address inquiries to the Minister of Public Instruction, St. Petersburg.

San Domingo.—No examinations are held. Credentials must be approved by the Juro-Medical Superior Directing Council.

St. Helena.—There are no restrictions upon practice.

St. Lucia.—No examinations are held. Credentials are passed upon by the Medical Board. Address inquiries to the Registrar of the Medical Board, St. Lucia.

San Salvador.—A fee of about $100 is charged, and the candidate must hold a diploma from a reputable university or institution. An examination is required. Address inquiries to Senor Rector de la Universidad National, San Salvador.

Saint Vincent.—No examinations are held. Credentials are passed upon by the Medical Board. Address inquiries to the Medical Registrar, Government Office, Kingstown, St. Vincent.

Saskatchewan.—Licentiates of the Medical Council of Canada may register upon paying the provincial fee. All other applicants are required to pass the examination of the College of Physicians and Surgeons. The examination fee is $50. The registration fee is $52. Address inquiries to the Registrar, College of Physicians and Surgeons, Regina, Saskatchewan.

Servia.—Licenses are issued to Servian subjects only, who must be qualified as doctors of medicine by an institution approved by the Ministry of the Interior, to whom all inquiries should be addressed.

Seychelles.—Address inquiries to the Chief Medical Officer, who advises the governor in the acceptance of any qualifications. No examinations are held.

Sierra Leone.—No examinations are held. Any qualification approved by the Governor in Council is accepted for registration. Address inquiries to the Principal Medical Officer, Sierra Leone.

Somaliland.—There are no restrictions upon practice.

South Australia.—No examinations are held, and qualifications acceptable to the South Australian Medical Board are registered. Address inquiries to the Secretary South Australian Medical Board, Adelaide.

South Carolina.—The State Board of Medical Examiners is composed of eight members nominated by the State Medical Association, and commissioned by the governor. The law is restrictive, but makes an exception to the practice of osteopathy. The requirement for preliminary education is equivalent to that for a first-grade teacher's certificate. The board requires graduation from a recognized medical school with a four-year course. The board may issue licenses issued by other state boards, and excuse the holders thereof from the regular examinations required of all applicants. Temporary permits may be issued by the President or Secretary of the Board. Address inquiries to the Secretary of the State Board of Medical Examiners, Columbia, S. C.

South Dakota.—The Board of Health and Medical Examiners is appointed by the governor. It is a "composite" board. The law is restrictive and protects the title M. D. or simply "doctor." The prerequisites as to general education are made by the board. At present it requires evidence of preliminary education equivalent to the completion of an accredited four-year high school course and an additional two years' work in a college of liberal arts. No medical college, which accepts or graduates students who do not have the preliminary education required by the board as a prerequisite to matriculation in the four-year medical course is considered in good standing by the board. The board may enter into reciprocity agreements with other state boards for indorsing one another's licenses. The examination fee is $20. Address inquiries to the Secretary of the State Board of Health and Medical Examiners, Pierre, S. D.

Spain.—The government may, with the approval of the Royal Council of Public Instruction, grant a temporary license to a foreign graduate whose credentials are satisfactory. Address inquiries to the President of the Faculty of Medicine of the Central University, Madrid. Foreign graduates are required to pass all the examinations in a Spanish University, providing the curriculum which they have pursued is accepted *pro tanto.*

Straits Settlements.—An examination is not required of those who possess credentials approved by the Medical Council of the Straits Settlements and Federated Malay States. If an examination is required, it is given at the S. S. and F. M. S. Medical School. The fee is $50. Address inquiries to the Registrar, S. S. and F. M. S. Medical Council, P. C. M. O., Singapore, Straits Settlements.

Swaziland.—The Resident Commissioner grants certificates of registration on the recommendation of the Medical Council of the Transvaal on the payment of a fee of $50.

Sweden.—Foreigners are required to obtain permission from the King of Sweden to take the usual examinations at the local universities. For further information application should be made to the Director of the Royal Medical Board, Ministry of Interior, Stockholm.

Switzerland.—The requirements as to preliminary education may be obtained from the President of the Federated Entrance Examinations at Zurich. Information about the requirements for professional education may be obtained from the President of the Confederated Department of the Interior at Berne. The examination fees amount to about $125, and they are given in German or French.

Tasmania.—British qualifications are registerable. Address inquiries to the President of the Medical Council, Hobart, Tasmania.

Tennessee.—The State Board of Medical Examiners is a "composite" board, and the members are appointed by the governor. No qualifications are required for admission to the examination which is given in English only. Address inquiries to the Secretary of the State Board of Medical Examiners, Nashville, Tenn.

Texas.—There is a State Board of Medical Examiners which is practically a "composite" board. The law is restrictive. The board may reciprocate with other state boards. Applicants are required to present credentials as to their preliminary education as well as to their medical education. An applicant may take the examination in his native language upon the payment of an extra fee of $15. Address inquiries to the Secretary of the State Board of Medical Examiners, Fort Worth, Texas.

Transvaal.—British qualifications are registerable. (See United Kingdom of Great Britain and Ireland.) Address inquiries to the Secretary, Transvaal Medical Council, Johannesburg.

Trinidad.—No examinations are held. Any qualification registerable in Great Britain is acceptable. Address inquiries to the Secretary, Trinidad Medical Board, Port of Spain, Trinidad.

Turkey.—Licenses are issued by the School of Medicine in Constantinople. Foreigners are required to pass a short oral examination in Turkish or French —more for the purpose of being identified as the holders of acceptable qualifications. Further information may be obtained from the School of Medicine, or the American Consulate General, Constantinople.

Turks and Cacios Islands.—The holders of British qualifications will not be interfered with.

Uganda.—There are no regulations.

United Kingdom of Great Britain and Ireland.—The first medical act was passed in 1858. The law is not restrictive as to the actual practice of medicine or surgery, but only duly qualified and registered practitioners can recover in any court of law reasonable charges for professional aid rendered to their patients. Unregistered persons are disbarred from holding any appointment as physicians and surgeons in the naval or military service or in institutions not supported wholly by voluntary contributions, and they are not exempt from serving on juries and inquests as are registered, *i.e.* legally qualified, medical practi-

tioners. To regulate the qualifications of practitioners in medicine and surgery the General Council of Medical Education and Registration of the United Kingdom was established. This council consists of one person chosen from time to time by each of the following bodies: The Royal College of Physicians, The Royal College of Surgeons of England, The Apothecaries' Society of London, The University of Oxford, The University of Cambridge, The University of Durham, The University of London, The College of Physicians of Edinburgh, The College of Surgeons of Edinburgh, The Faculty of Physicians and Surgeons of Glasgow; one person chosen from time to time by the University of Glasgow and the two Universities of Aberdeen collectively; one person chosen from time to time by the University of Glasgow and the University of Saint Andrew's collectively; one person chosen from time to time by each of the following bodies: The King and Queen's College of Physicians in Ireland, The Royal College of Surgeons in Ireland, The Apothecaries' Hall of Ireland, The University of Dublin, The Queen's University in Ireland; and six persons to be nominated by His Majesty with the advice of His Privy Council, four of whom shall be appointed for England, one for Scotland and one for Ireland; and of a president to be elected by the General Council. This council does not conduct examinations, but stipulates the requirements that must be enforced by schools or examining bodies for obtaining a registerable qualification. The council has the right to visit the universities, colleges, and examining or licensing bodies and to inspect their examinations. In case it should appear that the course of study and examinations required by any institution are not satisfactory, the council may ask the Privy Council to order that the qualification (degree, diploma, license) granted by such institution shall not confer any right to register in the Council's Register. No university, school, or examining or licensing body is permitted to impose upon any candidate an obligation to adopt or refrain from adopting the practice of any particular theory of medicine or surgery. The council has the power to annul the registration of any registered medical practitioner who shall have been convicted of a felony or misdemeanor, or who, after due inquiry, shall be judged by the council to have been guilty of infamous conduct in any professional respect. Copies of the official register are printed and distributed each year so that any person requiring medical aid is enabled by this ready means to distinguish qualified from unqualified practitioners. The register gives the name, the address, the date and place of registration and the qualifications. The council also keeps a register of all medical students which gives the name of the student, tells by what certificate of examination in arts he was admitted to medical study, the date of his registration and the place and date of commencement of medical study as certified by an official of a university, school of medicine or recognized teaching institution. The medical students are obliged to be registered with the council, and before being registered a student must give evidence of having attained the age of at least sixteen years and that he has begun study in an institution approved by the council. The preliminary education required before beginning the study of medicine is the equivalent of about two years of a standard high-school course in the United States of America. The preliminary education recognized by the General Council includes the following:

(a) English (Grammar; Paraphrasing; Composition; questions on British History and Geography).

(b) Latin (Grammar, Translation into English from unprescribed Latin books; Translation into Latin from English).

(c) Mathematics (Arithmetic; Algebra, including easy quadratic equations; Geometry, including the subject matter of Euclid, books i, ii, iii, and simple deductions).

(d) One of the following subjects:

(*a*) Greek (Grammar; Translation into English from unprescribed Greek books; Translation into Greek from English); or

(*b*) A Modern Language (Grammar; Translation into English from unprescribed books; Translation from English).

The first of the five years required for professional education may be spent in an institution where elementary chemistry, physics, and biology are taught satisfactorily. Graduates in arts and science of any university recognized by the council, who have had these subjects, may be held to have completed this first year of the requisite five years. The five-year course in medicine is not a five-year course in the sense of an additional medical year—the requirements reach down and prescribe studies which would belong to the course of study in a secondary school in the United States of America.

The council has power to recognize qualifications in British Possessions or foreign countries with which reciprocal relations have been established. At present there is reciprocity with Italy and Japan. In addition to this, the licensing bodies have power to recognize the course of study and examinations other than the final examination in medicine, surgery, and midwifery taken in foreign countries. Information as to these would have to be sought from each of the several universities and examining bodies. All medical practitioners from countries other than Italy or Japan must obtain a degree or diploma from one of the universities or examining bodies in the United Kingdom before they could obtain the privilege of having their name put upon the register. Any university or licensing body can confer a registerable qualification to any person who has passed its final examination, but if the council saw that the qualification was being granted to a person who had not passed through a satisfactory medical curriculum it would report the case to the Privy Council which might direct that the qualifications of the university or body should no longer be recognized. Address all inquiries to the Registrar of the General Council of Medical Education and Registration of the United Kingdom, 299 Oxford Street, London, W.

Uraguay.—Foreign diplomas must be submitted to the Rector of the University of Montevideo, to whom inquiries should be addressed.

Utah.—The State Board of Medical Examiners is a "composite" board composed of ten members appointed by the governor. The law is restrictive. The requirement as to preliminary education is graduation from a first-grade high school, or its equivalent, with evidence of at least two units of work in Latin or German. After 1916 the applicant shall have completed, in addition to the above, one year of college work. The professional requirement is graduation from an approved medical school. The board may indorse the licenses of other state boards with which it has reciprocity agreements. The examination fee is $25; the reciprocity fee $75. Address inquiries to the Secretary of the State Board of Medical Examiners, Salt Lake City, Utah.

Venezuela.—An applicant possessing foreign qualifications must produce his degree or diploma and submit to an examination which is given in Spanish only. If the diploma is not written in the Spanish language, a translation duly certified by a public interpreter must be submitted. The examination fee is about $175. Address inquiries to the Ministro de Instrucción Pública, Caracas.

Vermont.—The State Board of Medical Examiners is a "composite" board composed of seven members appointed by the governor from lists furnished by the regular, homeopathic, and eclectic medical societies. The law is restrictive. The requirement as to preliminary education is the completion of a four-year high school course, or its equivalent, prior to begin-

ning the four years' course of medical study in an approved medical school. The examination is written, and the fee is $25. The board may reciprocate with other state boards in the matter of indorsing one another's licenses. The reciprocal registration fee is $50. Address inquiries to the Secretary of the State Board of Medical Examiners, The Capitol, Montpelier, Vt.

Victoria (Australia).—No person in entitled to registration unless he has passed through a regular course of medical and surgical study of five years or more. No school of medicine, or other body, in any country other than the United Kingdom of Great Britain and Ireland is recognized by the Medical Board unless such country permits legally qualified practitioners of Victoria to practise without further examination. No provision is made for any examination of candidates for registration. The Medical Board deals with qualifications already possessed by the applicant. The fee for registration is about $15. Address inquiries to the Secretary of the Medical Board of Victoria, Chief Secretary's Office, Melbourne, Victoria, Australia.

Virginia.—The State Board of Medical Examiners is composed of one regular physician from each congressional district, and one homeopath and one osteopath from the state at large. The regular physicians are appointed by the governor from a list furnished by the Medical Society of Virginia; the homeopathic and osteopathic members are nominated by their respective state societies. The law is restrictive. The board requires the completion of a standard four-year high school course, or its equivalent, prior to beginning the four-year medical course in a recognized school. The board may indorse the licenses of other state boards with which it has reciprocal agreements. The examination fee is $25. The fee for indorsement is $25. There is no permanent place for transacting business or keeping records. Address inquiries to the Secretary of the State Board of Medical Examiners, The Capitol, Richmond, Va.

Washington.—The Board of Medical Examiners is a "composite" board consisting of nine members appointed by the governor for a term of three years. The law is restrictive. There are three forms of licenses issued by the board. First, a certificate authorizing the holder to practise medicine; second, a certificate authorizing the holder to practise osteopathy; third, a certificate authorizing the holder to practise any other system of medicine. Applicants for the certificate to practise medicine must present the diploma of an approved medical school. There is no provision for reciprocity. The examination fee is $25. Address inquiries to Secretary of the State Board of Medical Examiners, The Capitol, Olympia, Wash.

West Australia.—Any British qualification or a degree from any legally constituted or recognized Australian, Tasmanian, or New Zealand university entitles the applicant to practise without passing the examination. The registration fee is about $50. Address inquiries to the Registrar, Medical Board, Perth, West Australia.

West Virginia.—The State Board of Health is composed of ten members appointed by the governor for a term of four years. The law is restrictive. There is no requirement as to general education. The board requires graduation from a reputable medical school. The examinations are written and oral and the fee is $10. Reciprocal relations have been established between West Virginia and some states on the basis of an examination only, and other states on the basis of a diploma and license if they were issued prior to May 23, 1895. Address inquiries to Secretary of the State Board of Health, The Capitol, Charlestown, W. Va.

Wisconsin.—The State Board of Medical Examiners is a "composite" board. There are eight members appointed by the Governor from lists presented by the Wisconsin State Medical Society, the Homeopathic Medical Society and the Eclectic Medical Society and five names presented by the Wisconsin State Osteopathic Association. The law is restrictive. The requirement as to preliminary education is the completion of a four-year high school course or its equivalent. The professional requirement is graduation from an approved medical school. The examinations are written, oral, and clinical. The board may indorse licenses earned upon the basis of an examination only or on the basis of a diploma from a reputable medical college issued prior to Jan. 1, 1901. The examination fee is $20. The fee for indorsement is $25. Address inquiries to the Secretary of the State Board of Medical Examiners, Milwaukee.

Wyoming.—There is a State Board of Medical Examiners composed of three members appointed by the governor. The law is restrictive. The board requires an accredited high-school course and graduation from a regularly chartered medical college. The board will indorse the license of state boards with which it has reciprocal relations. The examination fee is $25. Address inquiries to the Secretary of the State Board of Medical Examiners, The Capitol, Cheyenne, Wyoming.

Zanzibar.—There are no restrictions upon practice.

OTTO V. HUFFMAN.

Medicine, History of.—The history of medicine is the history of mankind, and as we strive to trace out of its mass of detail, and from much tedious repetition, the evidence of real advance and the actual spread of knowledge, we gain an inspiration and a hope for the future of our race. The astrologist, the quack, the practitioner of theurgic medicine are still with us; but they are slowly yielding to the advance of science. The profession itself contains many ill-balanced and half-educated men, but its personnel is as surely advancing as the world is advancing in the mechanical arts. The modern era in medicine, which really began with Paracelsus, has shown steady advance, albeit interrupted by periods of reaction and temporary retrogression. Medicine is the mother of the natural sciences, which sprang into life from the pursuit of the healing art in its various branches. Now the children have waxed strong and are compelling the mother to learn from them and to obey their behests. For centuries the philosophers controlled the art of medicine after the priests and theologians had ceased to rule it. Speculation allied to dogmatism and pedantry have, for the most part, had their day. Let us trace out these movements somewhat in detail.

The history of medicine naturally divides itself into five periods as follows:

I. Prehistoric and mythical medicine from the earliest times to the birth of Hippocrates, 460 B.C.

II. Greek and Roman medicine from 460 B.C. to the downfall of the Western Empire, 476 A.D.

III. Medieval medicine from 476 A.D. to the birth of Paracelsus, 1493.

IV. Philosophical medicine from 1493 to the birth of Pasteur, 1822.

V. Scientific medicine from 1822 to the present time.

PREHISTORIC MEDICINE.—Although we have only fragmentary records of the development of prehistoric medicine, these are sufficiently accurate to afford convincing evidence that the earliest recorded medical laws, regulations, and beliefs were not very different from those of much more recent date. In fact so far as we are able to collect and piece together these fragments of medical history, we find that primitive man had notions, opinions, and beliefs much like his descendants, and that advantage was taken of his fears, his credulity, and his love of the mysterious, in short of his superstition, in much the same way that Paracelsus and his congeners proceeded to bully and frighten

people into accepting their teachings, and into paying well for their medical attendance. Perhaps the oldest record we have of laws or edicts intended to regulate the practice of surgery, is that of the edicts of Hammarubi, King of Babylonia, who about 2250 B.C. published a code of laws which were inscribed on stone stelæ and set up in the principal cities of his domain. These laws ordained that "if a physician operates on a man for a severe wound with a bronze and saves the man's life, or if he opens an abscess of a man with a bronze lancet and saves that man's eye, he shall receive ten shekels of silver," but if he causes the man's death or destroys the man's eye, "they shall cut off his fingers." Thus we see that the practice of medicine in those days was beset with quacks and imposters, and that it was necessary for the government to interfere and regulate surgical practice at least.

Egyptian Medicine.—Our principal sources of knowledge of the early Egyptian medicine are the Bengsch, Ebers, and Hearst papyri. But even earlier than these and probably earlier than the laws of Hammarubi are certain engravings on a tomb near Memphis discovered by W. Max Müller, who declares that they are the earliest pictures of surgical operations and date from 2500 B.C. The medicine chest of an Egyptian Queen of the eleventh dynasty (2500 B.C.) containing vases, spoons, dried drugs, and roots is another important piece of evidence. Also two epitaphs of physicians have been found. One of a highly esteemed practitioner in the fifth dynasty (about 2700 B.C.) and one of the third dynasty (4500 B.C.). The latter was the earliest known physician. He subsequently had a temple erected to his honor upon the Island of Philae and was worshipped at Memphis. Beside the hieroglyphic inscriptions, which are like the picture writing of American or Australian savages, Egyptians wrote upon the leaves of the papyrus plant. The most important of the medical papyri is that of Ebers which was found at Thebes in 1872 and dates back to 1550 B.C. This is regarded as a simple compilation, although its discoverer supposed that he had found one of the lost sacred or Hermetic Books of Thoth, the moon god, who, like Apollo in Greece, was the special deity of medicine. The Papyrus begins with a number of incantations against sickness and follows with a detailed list of diseases and the names of about 700 different remedies for them. There are extensive sections on the eye and ear and mention is made of three different diseases all of which are believed to have been different phases of hookworm infection (chlorosis ægyptica). Each Egyptian physician was a narrow specialist confining himself to the treatment of a single disease or to diseases affecting only one part of the body. Castor oil, opium, gentian, colchicum, and squills are mentioned, as well as the salts of lead and copper, and these were directed to be compounded with such filthy ingredients as the blood, excreta, fat, and viscera of animals and reptiles. In this respect the Egyptian materia medica closely resembled those in use as near our own times as the seventeenth and eighteenth centuries. A favorite Egyptian remedy for baldness consisted of equal parts of writing ink and cerebrospinal fluid. A poultice for suppuration consisted of equal parts of a meal made from dates and wheat chaff, bicarbonate of soda, and the seeds of endives. An ointment for the eye consisted of a trituration of antimony in goose-fat. These prescriptions are by no means as absurd as, and are no more revolting than many we meet with in pharmacopœias 3,000 years later. An interesting Egyptian custom, of which examples still survive at various religious shrines, was the offering of "anathemata;" which were models in silver, gold, etc., of the diseased part of the body, feet, hands, arms, legs, etc. These were hung up in the temples for the benefit of the gods. The priests sold these offerings to subsequent sufferers with similar lesions, and so on *ad infinitum*. This procedure is dubbed by Baas "a primitive, lucrative, and pious practice, which has been preserved in our pilgrimage churches of the present day, though obsolete in private practice."

The most interesting part of the Ebers Papyrus is the description of tumors in the last section. Here, as Garrison asserts, "we find some approach to the accurate clinical pictures of Hippocrates, and many have supposed on this slender evidence, that the father of medicine was indebted to Egypt for much of his knowledge." It is true that the ethical teachings of the ancient Egyptian physicians resembled the noble sentiments of the Hippocratic oath, and this fact alone points to a connection between pre-Hippocratic medicine and Egyptian medicine. In Egypt, however, medicine was entirely sacerdotal while Greek medicine, even as early as the Trojan war, was free at least for the most part from the control of the priests. Herodotus and Diodorus Siculus have told us much of the state of Egyptian medicine during the fifth century B.C. The former dwells upon the hygienic customs of the Egyptians, the gods they worshipped, their ideas about medicine, and their methods of embalming the bodies of the dead. He states that "all places abound in physicians, some are for the eyes, others for the head, others for the teeth, others for the intestines, and others for internal disorders."

Medical practice was rigidly laid down in the Hermetic Books of Thoth, and if a patient's death resulted from any deviation from these rules, it was looked upon as a capital crime. This is no more illiberal than the requirement mentioned by Wurtz that "in many localities the surgeons were compelled to take an oath not to follow the teachings of Theophrastus" (Paracelsus). This was about the middle of the sixteenth century A.D. About the same time a Doctor Geynes was called before the college of Physicians and Surgeons of London for having ventured to impugn the infallibility of Galen and forced to make a "humble acknowledgment and recantation of his error" before he could enjoy any further privileges from the college. The statutes in force in the seventeenth century for the guidance of the professors at Helmstadt read as follows: "We desire the medical art, even as it was rightly and wholly fixed and handed down under the guidance and direction of God, by the inspired artists, Hippocrates, Galen, and Avicenna to be preserved and diffused by teaching. We recommend that all Empirics and the Tetralogies of Paracelsus, with other corruptions of medicine, not agreeable to the doctrines of Galen and Avicenna, be banished entirely from our Academy." It was not until 1655 that the adjuration of the use of mercury and antimony was taken out of the doctors' oath at Heidelberg.

Aristotle, writing a hundred years after Herodotus, says that the Egyptian physicians were allowed to alter the treatment of a case after the fourth day if the patient did not improve (or die). Herodotus says that the Egyptians "purged themselves every month for three days in succession, seeking to preserve health by emetics and clysters, for they suppose that all diseases, to which men are subject proceed from the food they use." He adds that next to the Libyans the Egyptians are the most healthy people in the world "as I think on account of the seasons, because they are not liable to change." Among the priests in ancient Egypt there were three orders of physicians. The highest class (sages, sooth-sayers) whose privilege and duty it was to study the first thirty-six Hermetic books and who officiated as physicians of the higher science. The priests of the lowest grade, the Pastophori, practised ordinary medicine. They studied the last six of the Hermetic books, which treated of anatomy, pathology, pharmacology, ophthalmology, and gynecology—in short the only real medical subjects of the day. There was a third class of priestly physicians who followed the army and received a salary from the State, military physicians.

Saber-shaped, copper surgical knives, with hooked or incurvated handles, were found in a tomb near Thebes. They date from about 1500 B.C. and are probably the oldest surgical instruments extant. The Egyptians used splints of palm fiber in the treatment of fractures. And the mummies show that many fractures so treated did not escape shortening. Garrison tells us that the main interest in Egyptian medicine is due to its evident relationship to Greek medicine. In Homer the reference to the skill of the Egyptians in compounding medicines reminds us that the word chemistry is derived from *chemi* (the Black Land) the ancient name of Egypt, whence the science was called the "black art."

No doubt the Greeks learned both medicine and chemistry from the Egyptians, who told Solon that his people were "mere children talkative and vain, knowing nothing of the past." Yet in a few hundred years, long before the Alexandrian period, Egyptian civilization had become absolutely stationary and in medicine Egypt was going to school to Greece. Just as the mythology of the former nation remained steadfast and unchanged, while that of the latter was a perpetual evolution and a succession of figures of beauty and strong human interest, so Greek medicine was as surely destined to progress and to hold the preëminence over all other ancient systems of medicine as Greek poetry, sculpture and architecture were destined to remain superior to the efforts of all their predecessors and their contemporaries.

Sumerian and Oriental Medicine.—Before the advent of the Babylonians it is supposed that a non-Semitic or Sumerian race existed about 4000–3000 B.C. who by inventing pictorial writing and by the study of astronomy laid the foundation for the development of modern civilization. The Babylonians were skilled in mathematics and astronomy, invented the decimal system of notation, weights and measures, divided time into annual divisions of twelve months each, with seven days in the week and sixty minutes to the hour, and divided the circle into 360 degrees. They started cuneiform inscriptions, knew much about military matters and the art of war, understood the manufacture of glass, pottery, cloth, and carpets.

Astronomy being the oldest of the sciences, was first applied to the practical affairs of life as astrology. This is the essence of Sumerian or Accadian medicine. The earliest Babylonian physician was a priest, who was skilled in astrology and in the inspection and interpretation of the viscera of animals. This led to a study of the urine. Among the Babylonians soothsaying was concentrated upon the liver, terra cotta models of which, about 3000 years old, have been found, divided into squares and studded with prophetic inscriptions. So we see that the modern fondness for ascribing all the unexplained illnesses of the race to disorders of the liver has at least the semblance of the authority of precedent. The Babylonian physicians regarded disease as the work of demons which swarmed on the earth, air and water and against which long litanies, or incantations were recited. Herodotus relates the beginnings of medical practice among the Babylonians. He says "they bring out their sick to the market-place for they have no physicians. Then those who pass by the sick person confer with him about his disease, to discover whether they have themselves been afflicted with the same disease or have seen others so afflicted, and advise him to have recourse to the same treatment, as that by which they recovered from a similar disease, or as they have known to cure others. And they are not allowed to pass by a sick person in silence, without inquiring into the nature of his distemper." As Montaigne observes "the whole people was the physician." They finally reached the point where like the Egyptians they had a special physician for every disease. How far they advanced beyond that stage does not appear. It is plain, however, that with these people as with others, surgery made the first step in the right direction, as noted in the code of King Hammarubi, already alluded to. Internal medication among both the Persians and the Babylonians was mainly occupied with the effort to cast out the demons of disease. If a woman among the Persians menstruated more than seven days she was considered possessed of a devil and was accordingly beaten to drive the evil spirit out of her. The excavations for the huge Babylonian drains, however, show that these people understood the proper disposal of sewage.

Jewish medicine was closely allied in point of time with Sumerian medicine, especially at the period of the Assyrian captivity (B.C. 722) and the Babylonian captivity (B.C. 604). The principal sources of our knowledge of ancient Hebrew medicine are the Bible and the Talmud. In the former the attitude is assumed that disease is caused by God's anger and is to be averted by reform, prayer, and sacrifice. There is no reference in Holy Writ to the priests acting as physicians, although they unquestionably acted as sanitary police. The prophets, however, performed miracles and raised persons from the dead. There were medicines and use was made of the obstetric chair. As shown in the first chapter of Exodus where Pharoah commanded the midwives to slay all the male children of the Hebrew women when they did "the office of midwife" and "saw them upon the stools." The primitive chipped flint (the so-called celt) was used by Zipporah the wife of Moses to circumcise their son (Exodus iv, 25). She took a "sharp stone" to cut off his foreskin. Circumcision is alleged to be the only surgical procedure mentioned in Holy Writ. Wounds were dressed, as among all the ancients, with wine, oil, and balsam. Leprosy, "the issue," and several plagues are mentioned in the Bible. King Saul is thought to have been an epileptic as were at least some of those "possessed of the devil" in the New Testament. In the plague of Baal-peor 24,000 Israelites perished. And the Assyrian army to the number of 185,000 were smitten by the Angel of the Lord and died in one night. This wholesale slaughter is equaled by that in the Purana legend, in which Siva destroys a whole town with one withering glance, as Wotan destroys Hunding in the "Walküre." No doubt this superstition of the "evil-eye" which still obtains among the peasantry of Europe, the negroes of America, etc., arises from the discomfort and even fear which a piercing, prolonged stare engenders in man and beast, especially primitive and uneducated man. The phrase "Sie fixieren mich, mein Herr!" has led to many a duel in Germany. It is therefore quite natural that the ignorant person made uncomfortable by a stare should conclude that a "spell had been cast upon him." There is no means of determining from the rather vague descriptions the real nature of the diseases and plagues of the Old Testament. It is claimed that they included, in addition to leprosy, psoriasis, syphilis, gonorrhea, and bubonic plague. The fiery serpent which bit the Children of Israel in the Wilderness is thought by some to have been the dracunculus.

The efforts made by the Jews to ward off disease are the most interesting feature of the Old Testament medical history. The ancient Hebrews were, to their credit be it recorded, the founders of public hygiene and the high priests were the chief medical policemen. The sanitary code laid down in Leviticus is worthy of modern observance and is so excellent that Virchow is said to have called Moses one of the greatest physicians of all time. An ancient Jew was imbued with the idea of the sacredness of human life and of his duty to preserve his health and care for his body as a matter of religion. The remarkable vitality of the race cannot be attributed to any other of their characteristics. Garrison says that the Hebrew regulation of sexual hygiene and morality "invested a good and virtuous woman with that peculiar halo of respect, which has

been preserved by all highly civilized nations down to the present time;" and furthermore the Hebrew hygienic code laid the foundation for the legal department of medical jurisprudence. The institution of the Sabbath, which seems to have been borrowed from the Assyrians, was and is of the greatest physiological and spiritual benefit to mankind. Among the Assyrians the physician was forbidden to visit his patients on the Sabbath Day. In short the earliest Jewish medical practice was strictly State medicine and not a private profession. The meat intended for food was carefully inspected and was either "kosher," good, or "trepha," bad. And this practice gave the Jews an insight into anatomy which the Greeks did not possess. No injured or diseased animal was passed. The Talmud dating from the second century after Christ is essentially a law book and the information relating to medicine and surgery which it contains is more precise and detailed than that found in the Bible.

No treatise on anatomy before the time of Vesalius (1514–1556) is of much value. In the Talmud the number of human bones is given as varying from 248 to 252. Of these the bone "Luz," lying somewhere between the occiput and the coccyx, was esteemed the indestructible nucleus from which the body is to be reconstructed at the Resurrection. The blood is considered the vital principle, identical with the soul, and the heart as essential to life. The pancreas is called the "finger of the liver" and the spleen, kidneys, and spinal cord are frequently mentioned but not described. Respiration is likened to burning. The effect of saliva upon food and the churning movements of the stomach are noted and the liver is believed to elaborate the blood. The Hebrews were acquainted with hyperemia, caseous degeneration and tumors of the lungs in animals, as well as abscess and atrophy of the kidneys and cirrhosis and necrosis of the liver.

Talmudic surgery included the use of sutures and bandages, applications of wine and oil and the well-known maneuver of freshening the edges of old wounds to hasten union. Venesection, cupping and leeching, were common and, according to Garrison, before attempting a serious operation, a sleeping draught was given. Cesarean section, excision of the spleen, amputations, trephining, and the operation for imperforate anus in babies were known, as was the use of the speculum and the uterine sound. Fractures and dislocations were discussed, and crutches, artificial limbs, and artificial teeth were employed. So far as known there was no special medical education among the Jews until the Alexandrian period, and individual physicians of this race were not prominent until the middle ages.

Hindu Medicine.—As the Hebrews excelled all the ancients in hygiene and public health, so the ancient Hindus surpassed all their contemporaries in operative surgery. In the earliest Sanskrit documents, the Rig Veda (1500 B.C.) and Atharva Veda, the practice of medicine is entirely theurgic and consisted of the usual spells and incantations against the demons of disease and their human agents, the witches and wizards. In the Brahminical period (800 B.C.–1000 A.D.) medicine was entirely in the hands of Brahmin priests and scholars, and the center of medical education was at Benares. The three principal names in Brahminical medicine were Charaka, who flourished about the beginning of our era, Suśruta who lived in the fifth century A.D., and Vagbhata whose time was in the seventh century A.D. Of these the leading name is that of Susruta whose work is the great storehouse of Aryan surgery. Indian anatomy was grotesquely inaccurate and consisted of enumerations of purely imaginary organs and structures. It described 300 bones, 800 ligaments, 500 muscles, 300 veins, and so on. The Hindus fancied that the air actuated the vital processes in the lower abdomen. The bile performed the same office between the navel and the heart, and the phlegm was the active agent for the portion of the body above the heart. From these activities are derived the seven proximate principles, chyle, blood, fat, flesh, bone, semen, and marrow. Health consists in a normal proportion, quantitatively, of these elements. Disease is a disarrangement of this ratio. Diseases are divided into natural and supernatural. Suśruta named as many as 1,120 different maladies. Diagnosis was carefully made and was derived from inspection, auscultation, palpation, and the use of the special senses. Semeiology and prognosis combined acute observation with the usual folk-lore and superstition (Garrison). We find an easily recognizable description of malarial fever in Suśruta which he attributed to mosquitos, and in Bhâgatava Purana there is a passage, which warns people to desert their houses "when rats fall from the roofs above, jump about and die." It is reasonable to presume that this was caused by infection with the virus of the bubonic plague. Baths, enemata, emetics, inhalations, gargles, blood-letting, and urethral and vaginal injections were employed. The diet and regimen were carefully detailed. Suśruta enumerates 760 medicinal plants, paying special attention to aphrodisiacs and poisons, particularly mentioning antidotes for snake bites and the bites of various animals. It seems that the present plan of treating the bites of venomous reptiles, rather than exterminating the pests themselves, has prevailed in India from the dawn of history. The soporific effects of hyoscyamus and cannabis indica were known and, according to Burton, their employment in surgical anesthesia is of great antiquity. Ancient Indian surgery reached, as has been said, the highest point of all ancient surgery. About 121 different surgical instruments are described including scalpels, lancets, saws, scissors, needles, hooks, probes, directors, sounds, forceps, trocars, catheters, syringes, bougies, and a rectal speculum. These were properly jointed and had good handles. The blade instruments were sharp enough to cut hairs and were, as now, wrapped in flannel and kept in cases. The Hindus seemed to know every important surgical proceedure except the use of the ligature. They used boiling oil, pressure, or cauterization to check hemorrhage after amputations, at which they seemed to be adepts. They used bamboo splints in treating fractures and dislocations. These were afterward used in the British army and called the "patent rattan cane splint." They performed lithotomy (without the staff), cesarean section, excision of tumors, and the removal of omental hernia through the scrotum. The operation for cataract extraction has survived to our day, and they excelled in plastic surgery and skin-grafting. Their operation of rhinoplasty was probably taught to the itinerant Arabian surgeons and so transmitted through private families, or guilds, like the Preciani and Norsini, from generation to generation up to Tagliacozzi. The Hindu surgeons had their students begin their practical work upon plants, until like Japhet in Captain Marryat's novel, they had acquired sufficient dexterity to "puncture very scientifically all the larger veins of a cabbage leaf." And then they tried their prentice hands upon the human body. This dexterity and precision were of course especially valuable in preanesthetic times, and were characteristic of the delicate manipulation, which the Orientals are so prone to develop in anything they do with their hands. The Hindus were pioneers of many of the recent maneuvers of modern experimental and plastic surgery.

Whether the Hindus set the pace for the pioneers of Greek medicine or were themselves influenced by the pre-Hippocratic practitioners of Greece, cannot be determined from our present knowledge. It is however certain that at the date of Alexander the Great's expedition into India (327 B.C.) their physicians enjoyed a well-deserved reputation for medical knowledge of a high order. It is asserted that Hippocrates really got his medical knowledge from

Sušruta, whereas others say that the name Sušruta was the Sanskrit transposition of the name Hippocrates and that the Indians learned what they knew of medicine from the great Greek. It is also claimed that Aristotle derived many of his ideas from the East. After the Mohammedan conquest Indian medicine passed under the sway of the Arabs and lost its individuality and its separate existence. All that remains of it in our day is the Vedantic practices of the various Swamis and Mahatmas who occasionally visit America and whose strange cult has often had a most unfortunate effect upon the mental balance of its adherents. It is true that the three Englishmen who did so much to introduce hypnotism into practical therapeutics got many of their ideas and much of their experience from the East Indians.

Chinese medicine as has already been intimated is stationary. Apparently without beginning or end, its literature is a great mass of books not one of which is of the slightest scientific importance. Even at the present day they state that there are 365 bones in the human body; why, no one seems to know, unless it is considered proper to have one bone for each day in the year. Of this assortment of bones, in one of their systems, only one is assigned to the cranium, while in another system there are eight cranial bones in the male and seven in the female skeleton. The larynx, they teach, opens into the heart, the spinal cord into the testicles. The lungs have eight lobes and the liver seven. The spleen and the heart are the organs of reason. The Chinese naturally did very little surgery, not only from their ignorance of anatomy, but because their religious convictions prevented the drawing of blood or mutilating of the body, whether alive or dead. Their only surgical operation is castration. They make use of dry cupping and massage; but not of venesection. They also practise acupuncture and employ the moxa. They are very skillful at massage and have employed the blind as masseurs. They have 10,000 varieties of fevers and fourteen kinds of dysentery. They are especially strong on the pulse which they take in an absurdly minute and complicated manner, spending some hours, we are told, in taking the pulse of a single patient. They have six sets of pulse data which are connected with the different organs and their diseases. They touch different parts of the radial artery with different fingers of both hands, like a person playing the piano. These investigations of the pulse are said to take a longer time and be more complicated in cases of wealthy and high-born patients. We do not read that they also place, as did the medieval European practitioners, such an exaggerated reliance on uroscopy. In fact much can be learned from a sagacious study of the pulse but very little, generally speaking, from most ocular inspections of the urine. This, however, as hinted above, was, before the medical renaissance, a diagnostic maneuver esteemed of about equal value to taking the pulse. So the Chinese diagnosticians of to-day are, as Garrison observes, about where European diagnosticians were in the thirteenth century, and where their own ancestors were in the time of Hippocrates. This stability in their medical practice and knowledge is a great source of pride and satisfaction to them, and a good and sufficient reason for preferring their own practitioners to those of younger countries. They evidently adopted the practice of preventive inoculation with smallpox virus from India and made considerable use of it. It is not recorded that they ever adopted anything else from any other nation. They employ an extensive and miscellaneous materia medica including many valuable drugs such as aconite, rhubarb, ginseng (which they value very highly, for no especial reason that we know of), opium, arsenic, sulphur, mercury (for inunction and fumigation in syphilis). They also have many disgusting remedies such as various parts of animals and reptiles and their excreta.

Japanese Medicine.—While Chinese medicine is steadfast to a degree, although it should be observed that there are indications that some of the European and American medical schools, recently started in the Celestial empire, have taken root and are attracting Chinese students, the Japanese have displayed an astonishing aptitude for the acquisition and assimilation of the medical and scientific culture of the most advanced nations of the world. This, however, has been going on for only half a century. Until comparatively recently their medicine was a replica of the Chinese. Before 96 B.C. medicine in Japan was a jargon of superstition and mythology; similar to that which obtained among all primitive peoples. Sickness was caused by divine or diabolic influences or by evil spirits, or the spirits of the dead. Prayers and incantations to the gods of healing, two in number, were assumed to avert illness. To these were added at a later period internal remedies, mineral water baths, and venesection (the well-nigh universal remedy). From 96 B.C. to 700 A.D. Chinese medicine prevailed in Japan. This had been introdueed by way of Corea. The practitioners were priests. Pupils were sent to China at government expense, just as they are now sent from Japan to Europe and America. Thus we observe at that early period the Japanese willingness to adopt whatever they found to be good in the culture of other nations. By 702 A.D. there were native medical schools, with seven-year courses in internal medicine and shorter periods for the other branches. The students were ordained ishi or doctors after passing a final examination in the presence of the Minister—an evidence of another prominent Japanese characteristic, namely, that the government takes a strong interest in education and desires to secure the best obtainable advantages for its subjects. Women were occasionally trained as midwives. For six hundred years the influence of the Chinese priest-healers was still dominant. Probably in spite of the latter, however, there was some advance in surgical procedure, such as suturing intestinal wounds with mulberry fiber, or couching a cataract with needles. The oldest Japanese book is the Ishinbo, written in 892, which described these surgical novelties. As in China, massage was delegated to the blind as a suitable occupation. The moxa, acupuncture, and many Chinese herbal or mineral medicines were in vogue. They also had begun to record their clinical cases and to use red hangings in the treatment of smallpox. With the arrival of St. Francis Xavier, the famous Jesuit missionary, in Japan in 1549, began the rise of European influence in that country. The physicians who came with him and with other missionaries treated the sick gratuitously, performed surgical operations, founded hospitals, and planted botanical gardens. After the missionaries had been driven out of Japan, one of their native pupils founded a medical school at Sakai. The surgeons on the Dutch trading vessels began to arrive in 1579 and they exerted some influence. A translation of Ambroise Paré's works into Japanese was made in the seventeenth century. But no European books were allowed in Japan until 1700 A.D. after which translations of Boerhaave, Van Swieten, Heister, and other Europeans were introduced. In 1848 the Japanese began to make use of vaccination. In 1857 the Dutch physicians founded a medical school at Yeddo, which was taken over by the government in 1860, and became in time the present University of Tokio. The modern period of Japanese medicine began with the revolution (1868) and its distinctive feature is the preponderance of German influence. The medical schools, the state examinations, the medical societies and medical journals of Japan are all built up on German patterns. The leading medical men of the former country have been educated in the latter. So it is no wonder that the modern Japanese physician would prefer to have the training and the reputation of a Shiga, a Kitasato, or a

Noguchi rather than to become a two-sworded Samurai.

Quoting Garrison, we may say: "To sum up what we owe to Oriental medicine, the Babylonians specialized in the matter of medical fees, the Jews originated medical jurisprudence and public hygiene and ordained a weekly day of rest, and the Hindus demonstrated that skill in operative surgery, which has been a permanent possession of the Aryan race ever since."

Ancient Greek Medicine.—From the earliest writings it is seen, as the laws of Hammarubi show, that the first medical services, after an advance had been made from fetish worship and Shamanism, were of a surgical nature and they had attained a certain degree of perfection when scarcely any mention was made of internal medicine. Midwifery and ophthalmology (undoubtedly of the mildest description) also preceded any advance in internal medicine. This showed no progress during the heroic or mythical period of Greek medicine up to about the time of Pythagoras (580 B.C.). He is usually looked upon as the founder of Greek philosophical medicine and this school, if it may be so called, lasted until after the founding of the Alexandrian Library (320 B.C.). This period was rendered glorious by the career of Hippocrates, born in 460 B.C., who was the real father of medicine. And from his time the history of medicine leaves the realm of fragmentary knowledge and becomes authentic and personal.

The Greeks were the wisest, wittiest, and most versatile of all ancient peoples. They were a composite nation made up of various adventurous tribes from Ionia, Thessaly, and Arcadia mingled with Aeolians, Dorians, and Achaians. Their semi-insular and diversified country, indented with deep arms of the sea and protected by abrupt mountain walls, practically isolated them from the rest of the world, and their separate States from each other. The inhabitants of these rocky peninsulas became strongly patriotic, proud, and self-centered, while, at the same time, they enjoyed the cultural advantages of free maritime intercourse with the outside world. The scenic grandeur of their surroundings, their natural aggressiveness and inborn love of beauty and excellence in "mind, body, and estate," bore abundant fruit and in many respects shaped the thoughts and originated the ideas for all succeeding generations of mankind. This mental superiority and independence of mind, however, is alleged to have prevented a true national amalgamation, and subordination of the individual to the State, which is essential for the development of a powerful and united nation. Still the world can never repay its obligation to the Greeks for the formative impetus they gave to the human mind, nor for the examples of beauty and excellence, with which they have embellished the earthly existence of every sentient man. In medicine as in the fine arts, philosophy, rhetoric, and poetry, they laid the foundations for all future development and themselves reached a degree of excellence which has in some respects never been surpassed. Modern medicine is as surely looking back to Hippocrates as modern religion is reverting to the simple teachings of the man of Nazareth. Both medicine and religion are being stripped of the superstructure of dogma and philosophy which succeeding generations of men have laboriously built up. And it is no exaggeration to assert that the study of medicine has at last again reverted to the methods of Hippocrates as the only safe and satisfactory path by which we can travel if we wish to reach the goal of a true scientific medicine.

Of the medical predecessors of Hippocrates in Greece we know little. We do know that inasmuch as Greece was made up of a number of roving, warlike, and seafaring tribes, who worshipped a variety of gods, so they had an assortment of tutelary and medical deities. Thus Demeter was the special divinity of farmers, Dionysius of vinegrowers, Poseidon of sailors, and so on. In medical matters also a number of gods and goddesses presided over different functions of the body and were able to produce or cure human diseases, to send plagues and pestilences and to avert them. The same disease might be caused by different deities at different times. Thus in the Hippocratic account of the "Sacred Disease" (epilepsy)—so called, apparently, because epileptics were thought to be "possessed" by devils or spirits—the seizures are attributed to different deities as follows: "if they imitate a goat, or grind their teeth, or if their right side be convulsed, they say that the mother of the gods (Cybele) is the cause; if they speak in a sharper, shriller tone, they liken this state to a horse and say that Poseidon is the cause . . . . . but if foam be emitted by the mouth and the patient kick with his feet, Ares (Mars) gets the blame." The number of gods and goddesses possessing the power to heal and to cause disease was very great. Of these the chief was Apollo also called Alexikakos (the averter of ills) whose far-darting arrows were especially dangerous and effective. He was also a god possessing various other attributes and powers. As director of the sun and giver of light he was reverenced as holding great influence over life and development. Hence he was the god of healing, as well as of poetry, art, and music, the leader of the muses, the dispenser of justice, and the patron of the fine arts. He was also physician-in-ordinary to the other dwellers on Olympus and cured their sickness or wounds with the root of the peony. Hence one of his names "Paean" and the epithet "Sons of Paean" as applied to physicians. He and his sister Artemis (Diana) instructed the Centaur Chiron, Son of Saturn, in the knowledge of medicine. Chiron had for his pupils Jason, Hercules, and Achilles and in particular Aesculapius, the Son of Apollo. This latter person, as will be recalled, was struck and killed by a thunderbolt, which Jupiter hurled at him to please Pluto, who was alarmed at the diminished numbers of the emigrants from earth to the lower regions. This falling off was attributed to the prolongation of life on earth by the medical skill of Aesculapius. Temples were raised to him and he was made an object of worship. These temples were called Asclepieia, of which the best known were at Cos, Epidaurus, Cnidus, and Pergamus. They were really popular sanatoria, usually built on mountainsides or wooded slopes near mineral springs. They were managed by trained priests and in design and management were not unlike modern health resorts. The patients were prepared for treatment by deprivation of certain foods and wine, or by absolute fasting. Without this preparation no one could enter the temple of healing. As the patient entered the priests in their robes, accompanied by their daughters, received him and recited to him many tales of the wonderful cures of the god, of the remedies employed and so on, whereby the imagination of the patient was excited to a pitch of "expectant attention." Next came prayers and a bath, in the warm or cold springs, followed by frictions and inunctions of the body and various other manipulations. Then a cock or a ram was offered to the god. After this followed the special rite of "incubation" or temple sleep, during which, according to Aristophanes, all sorts of pranks and foolish ceremonies were indulged in. The patient was then left to his slumbers. If he slept he was expected to dream dreams. If he was too excited to sleep, the priest, disguised as the god, would appear to him during the night and give him the proper medical advice. His dreams would be recited to the priest in the morning who interpreted them and prescribed accordingly, using cartharsis, emesis, phlebotomy, or whatever remedies seemed indicated. If recovery followed, the patient was expected to present a thank-offering to the god, which might be, as has already been pointed out, a model of the diseased part in wax, silver, or gold, and a votive tablet, giving a

history of the case and the treatment, was suspended in the temple. These tablets in the Asclepieia at Cos and Cnidus became the permanent clinical records in the Coan and Cnidian medical schools, at the former of which Hippocrates himself was a pupil. Pausanias, the Greek traveler, observed six of these votive columns when he visited the temple at Epidaurus about 150 A.D. and two of them have recently been excavated on which were engraved the names of about thirty patients and their diseases and what was done for them. The clinical histories are exceedingly meager. Generally it was merely stated that the god had anointed the sick man in his sleep or that one of the sacred dogs or snakes in the temple had licked the affected part. One sufferer had lost the use of four fingers, another was blind of one eye, another had an ulcer of the stomach, another had empyema, still another was infested with vermin, while another had carried a spear point in his jaw for six years. They were all "cured." These fragmentary and crude histories, none of them conveying any clinical information of value, have been supposed to have led the great Hippocrates to write his admirable descriptions of disease. Among Aesculapius' alleged offspring were two daughters, Hygieia and Panacea, who assisted in the temple rites and fed the sacred snakes. Two of his sons Machaon and Podalirius are mentioned in Homer's catalogue of the ships as leaders, commanding thirty vessels and "good physicians both." Aesculapius himself is spoken of in the Iliad as a real chieftain of Thessaly "who had learned medicine from the Centaur Chiron, from whose teaching Achilles was able to impart a knowledge of the healing art to his friend Patroclus." A number of similar allusions to the rendering of surgical aid to the wounded appear throughout the Iliad and the Odyssey. In the latter it says, "a healer of diseases is as welcome at a feast as a prophet or builder of ships, or even a god-like minstrel." From which it is plain that the surgeon's art was held in high esteem by the ancient Greeks and that the heroic and high-born leaders were proud to make use of it.

About forty different wounds are described by Homer but no details of febrile or other symptoms are given. The anatomical terms employed are quite similar to those used by Hippocrates. Although in the Homeric poems there is no mention of the Asclepieia, which date back at least to 1000 B.C., we may safely say that even at that early date physicians and surgeons were a distinct class from the priests, although the two professions may have been associated in times of peace. The philosophers also studied medicine in ancient Greece, and the "gymnasts" besides bathing and treating the body also treated wounds and injuries and even internal diseases. Osler says that Greek medicine "had a triple relationship with science, with gymnastics, and with theology." Before Hippocrates it was regarded merely as a "branch of philosophy." Before Pericles the philosophy which prevailed in Greece was Ionic and came from Egypt and the East. The founder of the school was Thales of Meletus who had studied under Egyptian priests. He taught that water is the primary element from which all else is derived. Then came the fundamental doctrine that there are four elements—fire, air, earth, and water. Anaxagoras of Clazomenae (500–428 B.C.) broached some rather incomprehensible theory about these four elements being made up of innumerable minute bodies, which were assembled and controlled by spiritualistic influences. He was the teacher of Pericles, and an able astronomer and believed that the planets and moon were bodies analogous to the earth, and that the moon was inhabited. He was a prototype of Galileo inasmuch as he was convicted of impiety by the Eumolipidæ, who were "priestly bards" and evidently exercised some authority over other peoples' opinions. He managed to escape punishment by flight. Even the free-thinking Greeks were by no means always tolerant of innovations. Empedocles of Agrigentum (504–443 B.C.) traveled through the Grecian cities expounding these doctrines. He was clad in a purple robe, wore a golden girdle and a laurel crown. His hair was long and his aspect grave and inspiring. On account of his skill as a practitioner he was held by the populace to possess supernatural powers. Some poetry attributed to him shows the great reverence with which the ancient Greeks regarded their physicians. He taught that the balance of the four elements in the human body meant health and their unbalance disease. Nothing could be created and nothing destroyed; there is only transformation, which is the modern doctrine of the conservation of energy. Everything originates from the attraction of the four elements and is destroyed by their repulsion. The same ideas under the names of love and hatred are applied to the moral world. Development is due to the union of dissimilar elements, decay to the return of like to like, air to air, fire to fire, earth to earth. Thus we see that an ingenious and plausible philosophical theory was propounded over 2,000 years ago to explain things that are still unexplained. This seems to have been practically the beginning of the everlasting invention and publication of theories and systems of medicine which have gone on intermittently up to the present day.

Empedocles is said to have checked an epidemic by draining some swamps and to have improved the climate of his native town by filling up a cleft in the side of a mountain, so we may conclude that there was much practical vigor in his professional work and that he was not unbalanced by his ingenious system.

Pythagoras (580–489 B.C.), the founder of the Italian school of philosophers, had also studied in Egypt, where he probably acquired his doctrine of the mystic power of numbers. Unity he considered perfection and the symbol of God. The number twelve represents the whole material universe, of which the factors three and four represent the worlds, the spheres, and the primordial elements. As one represents the active or vital principle in nature, so two denotes the passive principle, or matter, while three stands for the world formed by the union of the two former numbers, and the tetrad, four, represents the perfection of eternally flowing nature. Heaven is made up of ten celestial spheres (nine of which can be seen) the fixed stars, the seven planets, and the earth. The distances of the celestial spheres from the earth correspond with the proportion of sounds in the musical scale. Pythagoras was the first to investigate the mathematical physics of sound. By investigating the sounds elicited by striking an anvil with different hammers, he was led to construct a rude device from which he was able to determine the sounds of the musical scale. This is the earliest recorded experiment in physics, and the scale was, after his death, engraved in brass and set up on the temple of Juno at Samos. The distances of the spheres from the earth correspond, as has been said, to the proportion of sounds in the scale and inasmuch as they move in accordance with set laws, the sounds they produce must be harmonious. This is the doctrine of the "harmony of the spheres." The number lore of Pythagoras probably exerted a determining influence upon the Hippocratic doctrine of crises and critical days, which mark the periods of the access and resolution of different diseases. Above all things the Greek physicians aspired to the possession of ability to prognosticate correctly the course and termination of a disease with scientific accuracy.

According to the teaching of Plato and Aristotle the number four was combined with the doctrine of the four elements. They were assumed to be combinations of four principal qualities dry, hot, cold,

and moist; and they were combined according to the following table:

hot + dry = fire. cold + dry = earth.
hot + moist = air. cold + moist = water.

By reversing these equations the components of the four elements could be found. Long before Aristotle and possibly long before Hippocrates it was taught that there are four principal humors of the body which correspond to the four elements, these were blood, phlegm, yellow bile, and black bile. These three sets of quadruplicates by permutation and combination produced an alluring and intricate scheme of symptoms and stages of disease from which the proper remedies were indicated, as for instance, hot + moist = blood; cold + moist = phlegm; hot + dry = yellow bile; cold + dry = black bile. This intricate system was the so-called "humoral pathology" which has assuredly afforded a fruitful source for argument for many centuries. Health and disease were attributed to the proper balance or maladjustment of these elements. This scheme was elaborated still further by Galen and the Arabian physicians so that remedies and their compounds were classified by numbers according to the "degrees," or relative proportions, of their elementary qualities. Thus sugar was cold in the first degree, warm in the second degree, dry in the second degree, and moist in the first degree. Cardamons were warm in the first degree, cold by one-half a degree, dry in the first degree, etc. In Galen's system, the Pythagorean doctrine of numbers was applied to every aspect of medicine. For instance, there are three faculties—natural, spiritual, and animal; three spirits—the vital arising from the heart, the animal from the brain, and the natural from the liver. These were all distributed through the body by the veins, arteries, and nerves. There were four ages of man: adolescence (hot and moist), manhood (hot and dry), advanced age (cold and dry), old age (cold and moist). The eye has seven coats and three humors. There are three kinds of drinks: pure, as water; containing food, as wine; or a mixture of these, as syrups and medicines. There are three varieties of fevers: the ephemeral in the spirit, the ethic (hectic?) in the solids, and the putrid in the humors. The last are subdivided into four: the continued (synochal) in the blood; the quotidian in the phlegm; the tertian in the yellow bile; the quartan in the black bile. In a word, everything in Galenic and Arabic medicine was classified and numbered, usually by the sacred numerals of Pythagoras. The doctrine of transmigration of souls (metempsychosis) was learned by Pythagoras in Egypt. He was believed to be the first to establish the fact that the brain is the central organ of the higher bodily and mental activities, a proposition so convincingly elucidated twenty-five centuries afterward by Goltz and Flourens.

Pythagoras was adjudged by the Roman Senate to be the wisest of all the Greeks. "It was on the prevention of illness that the physicians of the Pythagorean School were the most exact, measuring the quantity of victuals and of drink, of exercise, and of rest by rule; determining the choice and manner of preparing what they allowed and making use more of external than other medicines" (excerpt from an oration by Antonio Cacchi, Florence, 1743). A statue was erected to Antonius Musa at Rome for having cured the Emperor Augustus of a liver complaint by putting him on the Pythagorean diet. This diet was an exceedingly abstemious one, of which cabbage is said to have been an important component, highly prized for its supposed curative properties. The Pythagoreans were a philosophic sect practising self denial and self discipline. They were exclusive in the choice of new members, trying them out by an arduous probation. Their main function was naturally to keep alive the teachings of their founder.

After Pythagoras came Democritus, called the "laughing philosopher," who stands next to Pythagoras, Aristotle, and Plato as one of the greatest of the philosophers. He is reputed to have put out his eyes so that he could think the more clearly when not disturbed by what he might see. His philosophical delusion was that body and soul and everything in nature, animate and inanimate, are made up of innumerable "atoms" of various shapes and sizes whose motions are the cause of life and mental activity. He, however, ascribed insanity to disease of the brain (a point of view not reached again until the eighteenth century). He was called the greatest of all skeptics, affecting to disbelieve everything. Epidemics he attributed to the descent of the atoms of destroyed heavenly bodies. He also wrote on fever, diet, prognosis, hydrophobia, etc.

At the end of the Trojan war the ruling type in the population of Greece was the Achaian. Their reverence for surgery and the surgeon was as far different from the contempt of the Romans for everything connected with medicine as the general Greek intellect was keener than the Roman. As time progressed two main elements appeared in Greek civilization, the Doric or Spartan, and the Ionian or Attic. The latter were a composite stock of keen, witty, talkative people adoring intelligence and mental acuteness, fonder of speculation than of material facts, and not over zealous for strict morality. They, however, adored art and beauty, were brave and warlike, and were deeply moved by the dramas of Æschylus and Sophocles. The Spartans on the other hand were severe moralists, so far as their light showed the way, robust, stolid, essentially hardy and brave, even fierce in their warlike ardor. Like the Homeric heroes and the early Romans they cultivated the body rather than the mind, weeding out the puny and deformed, as part of their scheme of military government. Like all military peoples they were narrowly jealous, suspicious, or contemptuous of the advance or prosperity of other nations. All Greeks were extremely curious about all manner of subjects. As it says in scripture—"For all the Athenians and strangers which were there spent their time in nothing else but either to tell or to hear some new thing." Their curiosity about the future led them in common with all ancient, and some modern, peoples to pay the greatest possible attention to all sorts of oracles, omens, and signs and, with their natural mental characteristics, prognosis was the main feature of Greek medicine, prior to Hippocrates. The Spartans held the surgeon in such regard that Lycurgus classed them as non-combatant officials. The Athenians, however, paid more attention to the medical profession, so that, as we approach the age of Pericles, we find it more highly specialized. General practitioners about this time begun to receive regular stipulated fees for their services, instead of the previously usual thank offerings of the temples, and further than this, city and district physicians began to be appointed at an annual salary, in some cases quite munificent, as for example Democedes at Athens, in the second half of the sixth century before Christ, was paid about $2,000. There were also military and naval surgeons among the Athenians and Spartans. Xenophon speaks of eight army surgeons in the expedition of the 10,000, at the end of the fifth century before Christ. These physicians and surgeons were not priests; in fact the physicians, outside of the health resorts, had never been priests in Greece, so far as we can determine. The practitioners in the temples were priests of Æsculapius and they, apparently for a long time, were the major portion of Greek practitioners; whereas the Asclepiadæ were physicians and not priests, who learned their art from practising physicians who were usually their fathers or their adopted fathers. All of these belonged to guilds or societies, probably for mutual protection and for the advancement of their professional and personal interests. Much of the teaching seems to have been esoteric and more or less surrounded

by mystery. As civilization advanced and the amalgamation of the various peoples who composed the Greek empire increased, these Asclepiadæ also, no doubt, became more influential. At all events, as has just been related, general practitioners of medicine became an integral part of the body politic, obtained more general recognition and a better position both in private and public life. Both the priests and the lay physicians seem to have claimed a direct descent from Æsculapius; hence the confusion in the names. It seems apparent that the early physicians endeavored by travel and study and association with men prominent in their profession to equip themselves as well as possible for the practice of their art, which Hippocrates tells us is "of all arts the most noble." The instruction was oral. Hippocrates was the first physician to commit his teachings to writing. He then became not only the father of medicine but the father of medical literature.

In addition to the regular physicians among the Greeks there were midwives, professional lithotomists, druggists, and veterinarians, and a special class called "rhizotomi" or root gatherers. The doctor's office was called the "iatreion" and was used for a consulting and operating room and for a dispensary. In the larger cities there were public iatreia supported by special taxes—apparently the beginnings of hospitals and public dispensaries.

There seems to have been no prescribed course of study and no set examination; when the student was supposed to be prepared he took the physician's oath of the particular medical clan or sect to which he belonged. What knowledge of anatomy the Greeks possessed was obtained from study of the naked bodies of the athletes and contestants in the games and contests. Exercises were undertaken by thousands of men, boys, and girls, not only in preparation for the games, but as part of their regular education and to remedy, if possible, any defect natural or acquired in body or limb. So the physician and the sculptor became familiar with the human form divine; and so discriminating were they that in some of their statues the pectineus muscle plainly appears, although usually hidden at the base of Scarpa's triangle; it was, however, highly developed by their athletic exercises. Nevertheless it has not been depicted by modern artistic anatomists.

In regard to education the Greeks never lost sight of their ideal of harmonious and systematic development of the body and the mind. A careful study of the individual and of the shortcomings, both mental and physical, of every person high and low, rich and poor, strong and weak, was carried out and so far as possible remedied. This idea of education, which was also to some extent that of the Romans, was lost sight of almost completely after the Caesars and is only, within a score or two of years, beginning to assert itself again. It is now making steady advances so that we may look forward to the Greek perfection of body within a few generations, which will, without question, be accompanied or followed by a revival of the great intellectual and artistic power displayed by these wonderful people. With such training, it is not surprising that the Hellenes of the fifth century B.C. attained a degree of civilization and a supremacy in philosophy, lyric and dramatic poetry, sculpture and architecture which has never been equaled; "and this culminating period was also the age of Hippocrates. With this period begins the history of European medicine. This great man gave to medicine its scientific spirit and its ethical ideals."

Greek and Roman Medicine.—We have passed now from the period of prehistoric and mythical medicine into the classical period, or that of Greek and Roman medicine, which lasted almost a thousand years from 460 B.C. (birth of Hippocrates) to 476 A.D. (fall of the western Empire). Hippocrates was born, according to Soranus, on the Island of Cos at the beginning of the Eightieth Olympiad of a Asclepiad family. He was a contemporary of Sophocles, Euripides, Aristophanes, Pindar, Socrates, Plato, Herodotus, Thucydides, Phidias, and Polygnotus. Never before nor since have so many men of genius appeared in the same narrow limits of time and space. This was the age of Pericles, the time of the highest development of the Athenian democracy. Hippocrates received his first medical instruction from his father. He studied afterward at Athens, and acquired extensive knowledge and experience by travel and practice in the cities of Thrace, Thessaly, and Macedonia. He lived to great age. The exact date of his death is not known. His eminence is chiefly based upon three cardinal achievements. First, he separated medicine from theurgy and philosophy; secondly, he crystallized the disconnected teachings of the Coan and Cnidian Schools into a synthetic science; and thirdly, he handed down to physicians the highest and noblest moral inspiration, which has always maintained a purifying and elevating influence in all medical matters. There is little probability that any subsequent discoveries of cuneiform inscriptions or papyric medical lore will seriously detract from his great reputation as the father and founder of real medicine. Before his time the Greek doctor was an associate, and perhaps a subordinate, of priests in times of peace and a surgeon in times of war. As he knew anatomy only from the appearance of the body, he practically knew nothing of internal disease or of pathology. In the routine enumeration of symptoms the Coan and Cnidian tablets and sentences might have been of scientific value if the doctors had known how to coordinate and interpret them.

This power was supplied by the genius of Hippocrates. With no so-called instruments of precision, with his own open mind and keen powers of observation, he accomplished all that a man of genius could do for internal medicine. His best descriptions of disease are models of their kind to-day. Clifford Allbutt says, however, that in the genuine writings of Hippocrates there is no mention that the pulse was taken and recorded in studying disease, although in some of the Hippocratic books, not attributed to Hippocrates himself, mention is made of observations of the pulse. Hippocrates taught the Coan physicians, his pupils in that famous medical school, that in considering maladies, like empyema or malarial fever, the basis of real knowledge lies in the inductive method; that the endless reiteration of the study of the symptoms makes their true value apparent and gives the true clinical picture. Instead of attributing diseases to the gods or other supernatural agencies, Hippocrates virtually established the bedside method in determining their nature and history—the same method which Sydenham, Bright, Laënnec, Addison, Auenbrugger, Heberden, Graves, Charcot, Frerichs, and other great clinicians have so brilliantly and usefully employed. Huchard says that "the revival of the Hippocratic methods in the seventeenth century and their triumphant vindication * * * * in the nineteenth is the whole history of internal medicine." This encomium of Hippocrates does not, of course, include his doctrine of "humoral pathology" and the four elementary bodily fluids. They were discarded long ago although some remnants of the former still persist in modern serodiagnosis and seropathology. It was his transparent honesty and high reverence for his calling, allied to his keen insight and the common sense use of his mind and his special senses, combined with his scientific fear of errors of judgment and observation, which made Hippocrates the "Father of Medicine" and the greatest of all physicians. According to Claude Bernard observation is a passive, experimentation an active science. While Hippocrates knew nothing of actual experiment, no physician ever profited more by experience than he did, and his work can

be judged by its results. He described the bilious, malarial, and hemoglobinuric fevers of Thessaly and Thrace very much as modern Greek writers have described them, and his description of phthisis, puerperal convulsions, epilepsy, mumps, etc., might, with a few emendations, take their places in any modern textbook. He reported forty-two clinical cases—almost the only bedside reports for the next 1,700 years—of these, twenty-five were honestly recorded as fatal, while, unlike the clever and glib Galen, he has nothing to say about sharp diagnosis or "remarkable cures" or the blunders of others. It is no wonder that such a truth-teller's histories were dubbed by a smooth-tongued, "all-curing" successor "a meditation upon death." "He seems" says Billings "to have written mainly for the purpose of telling what he himself knew, and this motive—rare among all writers—is especially rare among writers in medicine." It is the chief glory of Greek medicine and of its great leader Hippocrates to have introduced that first-hand, direct, honest study of medicine which is at once the starting point and the *sine qua non* of real advance in the healing art. Like every other forward movement in the improvement of man's condition on earth, this noble start toward the goal of scientific medicine was followed by a reaction after Hippocrates' time. The taking of clinical notes was suspended, as said above, for about 1,700 years, and, as Garrison points out, Galen's cases were written up only to enhance his own reputation, and no medical histories of value appeared until near the beginning of the sixteenth century when Benivieni's records of postmortems were published.

The works attributed to Hippocrates are usually divided into four groups, his own writings, those falsely claimed to be his, the works of his predecessors, and those of his contemporaries and followers. The genuine writings include the aphorisms, the treatises on prognosis, on epidemic diseases, wounds, dislocations, fractures, and ulcers, and the excursus "On Airs, Waters, and Places," which is the first volume ever written on medical geography, climatology, and anthropology, excepting, perhaps the contemporary work of Herodotus, which agrees so markedly with much of the matter in the work of Hippocrates. The so-called Hippocratic oath is thought to be an ancient temple-oath of the Asclepiads. It is the oldest and most impressive writing on medical ethics and is in strict accord with the spirit evinced in everything Hippocrates wrote or said. The aphorisms seem to us like the shorthand bedside notes of a keen diagnostician, who was especially desirous of distinguishing between the general and the particular, the essential and the accidental. Many of them go straight to the mark, and others partake of the inadequate style of the so-called Coan and Cnidian sentences. The "Prognostics" show that the aim of the Greek physician was like Skoda's rather to be able to predict the outcome of disease than to forestall or prevent it. To this end Hippocrates instituted for the first time a thoroughgoing clinical examination of each case including the facies, pulse, temperature, respiration, excreta, sputum, localized pains, and movements. (Clifford Allbutt, as stated above, denies that the taking of the pulse is directed in the genuine works of Hippocrates.)

We still recognize the "facies hippocratica," just as Shakespeare did in Henry V, where he gives that wonderfully graphic description of Falstaff's death. The surgical works of Hippocrates, while by no means above criticism, are remarkably accurate and thorough, considering the times and the limitations under which they were produced. Furthermore, they are the only surgical writings of value that were produced before the time of Celsus. They came under Matthew Arnold's criticism of Thucydides, showing "a tendency to observe facts with a critical spirit; to search for their law, not to wander among them at random; to judge by the rule of reason, not by the impulse of prejudice or caprice." Hippocrates was the first to notice that spinal deformity may be conjoined with pulmonary tuberculosis. He directed that wounds should not be washed except with clean water or wine. He preferred dry dressings and ordered that greasy and moist dressings should not be used, and that the fresh edges of the wound should be brought together, sometimes by the use of astringents. He recognized the advantages of rest and immobilization. He even ordered the water of irrigation to be boiled, unless it was of exceptional purity, and the hands and nails of the operator must be made clean. He gave the first description of healing by first and second intention. He seemed to know nothing of amputations, although he refers to trephining and paracentesis. He noted in his directions for trephining that an injury to the left temporal region will cause convulsions on the right side and *vice versa*. He was not guilty of the so-called Hippocratic aphorism that diseases not curable by iron are curable by fire, which caused an almost inconceivable amount of operative bungling down to the time of Paré. This is really pre-Hippocratic, having been mentioned in the Agamemnon of Aeschylus. Baas finds that it came from the ancient Hindus. Hippocrates was the first to describe the "succussion sound." In therapeutics he would probably be called a nihilist to-day and would be the despair of all the drug manufacturing houses. He believed in assisting nature, not in trying to "improve" upon her. Although he was not ignorant of the therapeutic properties of many drugs, he also knew how to avoid them. His treatment was usually confined to such plain expedients as fresh air, good diet, purgation, tisans of barley water, wine, massage, and hydrotherapy. Perhaps he believed, with our good Doctor Holmes, that "if the entire materia medica were cast into the sea, it would be much better for us and worse for the fishes." Hippocrates' literary style was clear, concise, and simple, like that of the best Greek writers of the classic period. Had his sensible observations "On the Sacred Disease" been fully heeded, they would have abolished forever the notion of the divine or diabolic origin of human ailments. He spoke for an entire epoch and after him there was a great gap in the continuity of rational medicine.

After Hippocrates' time the greatest name in science and philosophy was Aristotle (384–322 B.C.), an Asclepiad and son of a physician. He thought and wrote on every conceivable subject. He was the first zoologist and improved the development of medicine by the introduction of the study of comparative anatomy and embryology, and of formal logic as an instrument of intellectual precision. For twenty years he studied under Plato, who had imposed upon medical teachings some exceedingly fantastic theories. Aristotle improved upon his master by describing about 500 species of animals (some of which were imaginary) and studying their bodily structure and functions. He noticed the punctum saliens and the movements of the fetal heart and stated that superfetation was possible. He said: "It is the business of the naturalist to know also the causes of health and disease. Hence most naturalists see in medicine the conclusion of their studies; and physicians, those at least who display some scientific knowledge of the practice of their art, begin the study of medicine with the natural sciences." These as Dr. Baas observes are quite modern ideas. Aristotle also emphasized the fact that the better class of physicians lay great weight upon anatomy. Yet in spite of his extensive knowledge and the possession of one of the greatest intellects of all time, Aristotle was not free from the superstitions common to his age. He believed in dreams, in the happy significance of a sneeze, in chiromancy, etc. He was the first to use the term anthropologist but in the sense of a vain and self-important person. His "entelechies" so called were intermediaries or subservient powers exercised by the soul upon the body. They have been revived as

substitutes for "vital principles" by the morphologist Driesch in the latter part of the last century. Aristotle had a very considerable knowledge of anatomy. He gave its name to the aorta and discovered the difference between the arteries and veins, and speaks of the great vena cava. One of the cardinal errors in his anatomical teachings should be especially mentioned, inasmuch as it had a more or less causative relation to the bitter warfare that went on in the profession hundreds of years afterward, in regard to the proper sites for venesection. He taught that a great blood-vessel ran from the liver to the right arm and another from the spleen to the left arm. Hence, venesection upon the side of the body which was the seat of the disease was especially efficacious. The blood, he rightly described, as the nutritive fluid, designed for the formation, growth and warming of the body and for supplying its waste. Normally it is an indifferent fluid containing neither mucus, black nor yellow bile, nor water; but in disease it becomes contaminated with these fluids.

A worthy successor of Aristotle was his friend and pupil Theophrastus of Eresos (370–286 B.C.), who was a physician and the first botanist to do for botany what Hippocrates had done for medicine, in collating the loose plant-lore of the woodmen and rhizotomists into a systematic treatise. He described some 500 different plants in a book "De Historia Plantorum," which displays the possession of that sovereign quality of the Greek mind by which the essential is culled out and preserved and the superfluous rejected. Before Goethe and Linnæus he recognized the flower as "a metamorphosed leafy branch" and described the fruit "as every form and phase of seed encasement, seed included."

The great medical library at Alexandria, which had been founded by the first Ptolemy, under the direction of Aristotle, contained at first 50,000 and finally 700,000 volumes. This Ptolemy also fostered the study of medicine and of dissection. The city of Alexandria had been founded by Alexander the Great in 331, who recognized the unrivaled advantages of the site and foresaw the probable greatness of a city named after himself, where Europe, Asia and Africa were to meet and hold communion. After his empire was divided, the general, who became the ruler of this city, was a man of great foresight and a liberal patron of true science. As just said, he approved of human dissection; a proceeding looked upon with horror by the Greeks and still more so by the Egyptians, as an unwarranted sacrilege and "godless desecration." However, it was the beginning of the knowledge of anatomy, not studied, as the Greeks had studied it, from the external appearance of the body, but from an actual demonstration and description of the structure of the organs which make up the economy and sustain life. Under the liberal rule of the Ptolemies this great school flourished. Learned men were brought to Alexandria and paid salaries to study and to teach. Grammar, prosody, mythology, astronomy, philosophy, and especially medicine were studied. This school lasted for about a thousand years. For the first 300 years (323–30 B.C.) under the Ptolemies, great progress was made in science. From 30 B.C. to 640 A.D. the studies were mainly philosophical and little came of them, except the usual endless speculations and disputations. Science was dead for many years, choked and overwhelmed by "philosophy" and pedantry.

The colonization of Greek medicine in Alexandria led, as has just been stated, to important advances in anatomy and surgery. There was an influx of people seeking treatment at the hands of the leading professors in the school. Two of these teachers have left imperishable names behind them. They were Herophilus and Erasistratus. Garrison calls them the originators of dissecting. They studied especially the nervous system, showing the relations of the larger nerves to the brain and spinal cord, distinguishing between sensory and motor nerves, with which they, unfortunately, sometimes confused the tendons. They both are said to have referred to the lacteal vessels. Herophilus handed down his name to the present generation by describing the "torcular Herophili" and the fourth ventricle of the brain, including the calamus scriptorius. He also described the hyoid bone, the duodenum and the prostate gland, and, in the eye, the retina, the vitreous humor and the ciliary body. Erasistratus described the trachea, the auricles and chorda tendineæ of the heart, but stated that this great viscus contains no blood. At this period of the history of medicine the Greek physicians were frankly in the ascendant, dominating over their former leaders, the Egyptians, and standing in the front rank of medical progress. Elliott alludes to this time as the Anatomic Period of Medicine which lasted until Egypt was subjugated by the Romans (about 30 B.C.), and says that medical practice became so flourishing at Alexandria that three great specialties were formed, Surgery, Pharmacy, and Dietetics, and a great variety of operations were performed. There were already specialists who practised lithotomy. Erasistratus was the physician in ordinary to Ptolemy Philadelphus (B.C. 284–246). He is said to have achieved a fee of 100 talents (about $100,000) from having diagnosed and treated successfully a case of love-sickness in a young prince who was enamored of his step-mother. The treatment was as simple as it was efficacious. The astute physician induced the royal father to pass over his young bride to his son and the whole affair ended happily for all parties.

The so-called *Dogmatic School of Medicine* had arisen shortly after the death of Hippocrates and might be regarded as reactionary against the analytic method of true Hippocratic medicine. Since their day this alternation of *a priori* and inductive methods of investigation has constantly recurred in the history of medicine as, in fact, in the history of practically all human progress. The dogmatists placed speculation above all the teachings of experience, using the latter, it would seem, rather to bolster up their theories than to elucidate the truth. They invented by pure conjecture the underlying causes of illness; as, for example, the mucus flowing down from the brain (where it was for many centuries assumed to be secreted), and for this down-flow of mucus they had provided also by *a priori* methods the proper remedies duly labeled and warranted to cure. Even anatomy, whose importance as a means of establishing the etiology of disease was then acknowledged and carried so far that sometimes the bodies of living convicts were opened, was distorted to make it fit preconceived theoretical considerations.

Herophilus and Erasistratus differed mainly in treatment. The former, following Hippocrates in part, laid great stress on diet, bled freely, and used compound and so-called specific remedies. He was a friend of much medication. Erasistratus, however, was opposed to phlebotomy and purgation, and was a forerunner of Hahnemann in advocating minute doses, asserting that three drops of wine afforded a beneficial drink in bilious diarrhea. He is said to have differed widely from the high dilutionists in one respect, viz., that, on occasions, he would open the abdomen and apply his remedies directly to the affected part.

The Greek national ascendency had in a great measure departed. Alexandria had largely become, as we have seen, the commercial and intellectual successor of Athens. The schools of Erasistratus and Herophilus succeeded the dogmatists, and they were succeeded by the empirics, who flourished in the second century before Christ. This school was founded by sceptics, who rejected all search after the cause of disease and all knowledge of anatomy, and laid the greatest weight upon experience, *i.e.* the history of the particular case, its analogy to similar cases, and its

accidental surroundings. These conditions were called the "Empiric tripod." In new cases they added invention which, in so far as it was awakened by earlier experience, formed a fourth category. Their studies did, however, lead to the development of a quasi-experimental pharmacology and toxicology, in which outsiders, like Mithridates, King of Pontus, participated. This monarch is said to have immunized himself against poison by taking the blood of ducks fed upon poisons. He even aspired to inventing a universal antidote (Alexipharmacy). These "Mithridates" and "theriacs" engaged the attention of physicians and drug compounders up to the beginning of the eighteenth century. Mithridates should receive some credit as the inventor of polyvalent drugs and sera. South American Indians and other savage peoples of our own day are said to inoculate themselves with certain noxious substances as a prophylactic against snake poisons.

Roman Medicine.—After the destruction of Corinth (146 B.C.) Greek medicine may be said to have migrated to Rome. Before this period the Romans, so the younger Pliny says, "Got on for 600 years without doctors;" relying mainly, in cases of sickness, upon medicinal herbs and domestic simples and the incantations and superstitious practices of all partly civilized nations. The imperial Roman looked upon every Greek as the "Graeculus Esuriens" of Juvenal. The Roman had a household god presiding over practically every disease and every physiological function, such as Scabies, Febris, Angeronia, Fluonia, Uterina, Cloacina, Mephites, Dea Salus, and so on. To him the itinerant Greek physician was altogether a suspicious person; especially worthy of contempt because he expected a fee for his services; while he might well be an assassin or a poisoner.

Beside the remarkable writings of Celsus the Romans produced no contributions to medical or sanitary science except the famous sanitary engineering work of the architect Vitruvius. Greek medicine, however, was finally firmly established in Rome through the personality, tact, and enterprise of Asclepiades of Bithyna (124 B.C.). This practitioner, who was a past-master in the art of flattering and coddling his patients, was a pronounced opponent of the humoralism of Hippocrates. He believed in a relaxed or constricted state of the solid particles of the body as the causes of disease. This theory was called "solidism." It is really the doctrine of "strictum et laxum," which originated in the atomic theory of Democritus, and reappears at intervals in medical history as the Brunonian theory of sthenic and asthenic states, Friedrich Hoffman's "tonic and atonic" conditions, Broussais' theory of "irritation" as the cause of disease, and Rasori's doctrine of stimulus and contra-stimulus. Like all medical system makers Asclepiades scouted the belief in the *vis medicatrix naturæ*. But in practice he was a real Asclepiad, relying upon the Coan régime of pure air, light, appropriate diet, hydrotherapy, massage, clysters and local applications, wisely avoiding, for the most part, the uncertainties of internal medication. He was the first physician to mention tracheotomy. Themison and others of his pupils and followers founded a new school of medicine, based upon his teachings, and called it Methodism; while the Stoic philosophers advocated the foundation of a school based on the physical action and properties of the vital air, or pneuma. Thus arose three distinct ways of explaining the onset of disease Humoralism, Solidism, and Pneumatism. In other words a disturbance of the solid, fluid or gaseous constituents of the body. Thus the establishment of the Hellenic medical influence in Rome was characterized by, what Garrison calls, "a welter of theorizing." In the reign of Augustus Caesar lived Aurelius Cornelius Celsus, a highly educated gentleman, who wrote pure and beautiful Latin and discussed at length agriculture, medicine, and other subjects. Pliny classes him among the literary people (*auctores*) rather than the *medici*. He was ignored for the most part by the physicians of his day. But has reaped fame and popularity since the revival of learning. His works are the oldest of the classical medical writings, after those of Hippocrates, which have come down to us and nothing has been preserved of the works of the seventy-two medical authors which he mentions except the writings of the Father of Medicine.

Celsus was the first to recommend the use of nutritive enemata. In his surgical writings he speaks of the use of the ligature and gives a classic description of lateral lithotomy. Under the Romans surgical practice, including obstetrics and ophthalmology, reached a degree of perfection which did not obtain again until the time of Ambroise Paré. Over 200 different surgical instruments were found at Pompeii. The operations for cataract, and herniæ were known as well as plastic surgery, cesarean section, and version. The dissection of executed criminals was sometimes allowed. The constant warfare and the gladiatorial games afforded the material for the perfection of surgical technique. Hippocrates had said "war is the only proper school for the surgeon." Celsus also wrote fully upon malarial fevers, gout, insanity, and their treatment. And was the first medical historian of importance. Heliodorus, Archigenes, and Antyllus were the leading Greek surgeons of Celsus' time. The two first employed ligatures, which, in Galen's time, were to be bought at a special shop in the Via Sacra. They understood herniotomy, circular and flap amputations, while Heliodorus, who somewhat antedated Celsus, gave the first account of the torsion and ligation of blood-vessels and treated stricture by internal urethrotomy. Antyllus' name has been handed down to us by his method of treating aneurysms by applying two ligatures and cutting between them. This operation held the field until John Hunter's time.

Dioscorides, an army surgeon in the service of Nero (54–68 A.D.), was also a Greek. He was the originator of the materia medica. He described about 600 plants and their properties. As Theophrastus was the first scientific botanist, so Dioscorides was the first scientific medical botanist. He recognized, to some extent, families of plants long before Linneus. And his descriptions were followed word by word for sixteen centuries.

Aretæus, who also lived in the reign of Nero, ranks next to Hippocrates as a clinician and writer. He has given classic first-hand accounts of pneumonia, diabetes, tetanus, elephantiasis, diphtheria (ulcera Syriaca), and distinguished clearly between cerebral and spinal paralysis. Another great eclectic was Rufus of Ephesus, who lived in Trajan's reign (98–117 A.D.). He wrote a little book on anatomy, and gave the first descriptions of traumatic erysipelas, epithelioma, and the bubonic plague, and added many new compounds to the materia medica of which his "hiera," containing (like most successful proprietary medicines) a good purgative, became famous. Soranus of Ephesus a contemporary of Rufus is our leading authority upon ancient gynecology, obstetrics, and pediatrics. No real addition was made to obstetrical writing from his time to that of Paré 1,500 years later. Pliny the elder (23–79 A.D.) wrote extensively upon all that was then known of the natural sciences; after the invention of printing his work passed through more than eighty editions. It contains many a slap at physicians (who seem to have been especially obnoxious to Pliny) and the first references to Mithridates' experiments with poisons and Nero's use of the monocle or lorgnette, through which he viewed the gladiatorial contests, and which some commentators think was actually an eyeglass. Pliny's botanical errors, like the errors of other writers of this period, remained unchallenged for about 1,500 years.

This period of medical history closes with the name

of the greatest Greek physician after Hippocrates, Galen (131–201 A.D.), the founder of experimental medicine. He was the son of an architect and was born at Pergamus. Like so many men of old time who became famous in medicine, he was a great traveler. Garrison says that his life was one long "Wanderjahr." He began practice at Rome in 164 A.D. and soon became the leader of his profession. He, however, retired in a short time from practice and went back to his home. He was then thirty-seven years of age and, Baas tells us, was thoroughly disgusted with the jealousies and bickering of the medical men of the imperial city. In the course of a year, he was recalled to Rome by Marcus Aurelius and made his journey there on foot. When he arrived he was invited to accompany the emperor in the war against the Marcomanni. But good old Aesculapius appeared most opportunely to him, in a dream, and forbade his joining the expedition. He then settled down in Rome as physician-in-ordinary to Commodus. Of his subsequent life nothing definite is known; although he is supposed to have lived to seventy or eighty years of age. He was an author of astonishing fertility not alone in medicine, but in various other fields as well, such as grammar, mathematics, philosophy, and law. He is said to have taken issue most seriously with the School of Methodism in Rome, which was the most influential in his day, and to have striven to reintroduce the teachings of Hippocrates, which Asclepidus the father of Methodism had abjured, so that they were not in fashion when Galen came to Rome. Galen tells that some of his colleagues in the imperial city poisoned each other, not with innuendoes, as they sometimes do now, but with drugs. He is said to have written nearly 400 different volumes, of which over 300 were on some phase of medicine.

"The philosophico-physiological and general pathological views of Galen were founded upon the four elements, to which are ascribed the primary qualities, to air, coldness, to fire, warmth, to water, moisture, to earth, dryness. To these correspond the four cardinal humors, among these again the element water predominates in the mucus, which is secreted by the brain; fire in the yellow bile, which is secreted by the liver, earth in the black bile, which is secreted by the spleen. While with the blood which is secreted in the liver (an important and far-reaching error not discarded until the seventeenth century) the four elements are uniformly mixed. Mucus is cold and moist, yellow bile warm and dry, black bile cold and dry; the blood warm and moist. This coincidence of the primary qualities is the cause of the secondary, so that the latter arise from a mixture of the former. The primary qualities are not cognizable by the senses. The secondary, however, are so cognizable. The life-giving principle is the soul, understood as a primitive force, which as 'spiritus' or 'pneuma' is taken from and constantly received by the general world-soul, in the respiration, taken in its widest sense. In the brain, which the pneuma reaches through the nose, and in the nerves, it becomes the 'animal spirits;' in the arteries and heart, which are reached through the lungs, the pneuma becomes the 'vital spirits,' and in the liver and renal veins the same all pervading principle becomes the 'natural spirits.' This triad of spirits brings into action and sustains the activities of the corresponding bodily functions, which are, in effect, different manifestations of the normal force (soul) or 'pneuma,' present in the body. Subordinate to these three principal forces or faculties, Galen mentions certain secondary and occasionally active forces, the 'attractive,' the 'propulsive,' the 'retentive,' and the 'secreting.' Upon these depend assimilation, secretion, nutrition, muscular contraction, in short all the ordinary processes of function and metabolism, which keep the body alive and active. There are also 'especial forces' which are not derived from the three forms of 'spirits' already mentioned, and are therefrom 'supernatural.'" After this luminous exposition of Galen's views, Baas says that Galen was the father of teleology in medicine. After a review of Galen's philosophico-physiological teachings, however, one can hardly fail to offer a tribute of respect to Paracelsus, who, at the risk of his life, publicly burned the works of Galen and Avicenna and thus gave the first effective blow to the "authority" which had held all medical advance at bay for 1,500 years. Garrison tells us that Galen usually got his patients well and to this end had instituted a system of polypharmacy and handed down, practically to our own times, the term "Galenicals" as applied to vegetable simples. He was fond of botanizing in his travels and Garrison thinks that his wanderings did much to develop that cock-sure attitude of mind, which helped to make his writings the fountain head of ready-made theory; what the Germans call "polypragmatism." It must, however, be admitted that most of the "successful" practitioners and medical system-makers were and are "cock-sure" and that this attitude of mind has been essential to their success.

His pathology contained the humoral ideas of Hippocrates with the Pythagorean theory of the four elements, as has already been pointed out. He with "fatal facility and ingenuity" explained everything in the light of pure theory. The benumbing effect of this upon the advance of medical thought was appalling. While his monotheism and piety appealed to the Mohammedans, his assumption of omniscience made it easy for the mentally indolent and complacent to accept his dogmas and support his "authority." Until Vesalius' time (about the middle of the sixteenth century) European medicine was one unbroken *argumentum ad hominem*, in which every question was referred to Galen, from whom there could be no appeal. For fourteen centuries, medicine like the liberal arts was at a standstill. As Mumford says "with his death and the passing of his immediate successors, progress languished and expired for the ancient world was dying and was bearing down with it the humane arts."

It would not be fair not to mention certain good things in Galen's work. He gave us the four classic symptoms of inflammation, differentiated pneumonia from pleurisy, was the first to mention aneurysm, distinguishing the traumatic from the dilated form. He described the different forms of phthisis, recognized its infectious nature and proposed a full milk diet and climatotherapy for its cure. He recommended especially sea voyages and dry elevated habitations for the consumptive. He understood the diathetic relation between calculus and gout and, by his prescriptions, he displayed a considerable skill in the use of opium, hyoscyamus and other well-known drugs; and in applying cold compresses. He set the pace for the elaboration of a fantastic pulse lore or "ars sphygmica," which was still in vogue in the eighteenth century. As an anatomist he described exceedingly well the motor systems of nerves and muscles; but much of this work was defective and inaccurate, as was to have been expected from dissections of apes and pigs. As said above none of these errors were known or pointed out until Vesalius started the real study of practical anatomy nearly 1,500 years after Galen's time. However faulty his anatomical work may have been Galen was the first and only experimental physiologist before Harvey. He was the first to describe the cranial nerves and sympathetic system and made the first experimental sections of the spinal cord, producing hemiplegia. He produced aphonia by cutting the recurrent laryngeal, and gave the first valid explanation of the mechanism of respiration. Thus this truly great doctor gave to the advance of medicine the method of putting questions to nature and of manipulating the material at hand so that nature may give an answer, which we call experi-

ment. His teachings on the physiology of the nervous, respiratory, and circulating systems, however defective, contained the only real knowledge of these functions for seventeen centuries. To quote Garrison's able summary of the cardinal errors of Galen's teachings, "There are three Galenic superstitions" which, through their plausibility, were generally accepted and did much to prevent the onward march of medical science. "First, the doctrine of vitalism which maintained that the blood is endowed with 'natural spirits' in the liver, with 'vital spirits' in the left ventricle of the heart, and that the 'vital spirits' are converted into 'animal spirits' in the brain. The whole organism being animated by a 'pneuma.' Second, the notion that the blood in its transit through the body passes from the right to the left ventricle of the heart by means of certain imaginary invisible pores in the interventricular septum. Third, that 'coction' or suppuration is an essential part of the healing of wounds. Just as it was also assumed to be nature's method of moving disease out of the body. This postulate so far as it concerned wounds led to those Arabist notions of healing by 'second intention,' 'laudable' pus and the benefit, believed to follow the use of setons, etc. Although these assumptions were combated by Mandeville, Paracelsus, and Paré, they were not entirely overthrown before the advent of Lister." Galen also believed in amulets and charms and subscribed to the belief that the motions of the sun and moon had a controlling influence over the crises, which he in agreement with the dicta of Hippocrates, recognized as characteristic of acute disease. The number of his distinct treatises could not have been less than 500. He seemed to place a more implicit faith in amulets than in medicine and is supposed by Cullen to have been the inventor of the "anodyne necklace," so long celebrated in England. His practice seemed to be based on the fundamental principles (1) that disease is something contrary to nature and is to be met by remedies opposed to the ailment, and (2) that health is to be preserved by those agencies which have a constructive and upbuilding influence upon the body. Hence, he recommends two general indications for treatment (1) to overcome the disease with remedies opposed to it, and (2) to preserve and upbuild the constitution by appropriate means. With Galen passed away a commanding figure in the history of medicine. It is by no means easy to measure the scope of his intellect nor the extent of his influence. We meet many diverse opinions in the sayings of other men regarding him. Boerhaave said that his writings had done more harm than good; while the average physician up to Boerhaave's time, had been taught to revere him as divinely inspired. Dr. Atkin said of him "His own mass and modern improvements have now in a great measure consigned his writings to neglect, but his fame can only perish with the science itself." It is said that his own immeasurable superiority, like that of Hippocrates, over all contemporaries seems to have acted for a long time as a check to all further improvement in scientific medicine.

Before Galen's time, physicians were divided into several sects or schools, whose energies were largely consumed in arguments, disputes, and mutual recriminations. These were the Dogmatics, the Empirics, the Eclectics, the Pneumatics, and the Episynthetici. After Galen's death all these sects appear to have forgotten their differences and been merged in his followers. And it is a notable fact in the history of medicine that so long as his powerful influence lasted no other prominent systems or schools of medicine sprang up. After Paracelsus the bound-down medical mind seemed to free itself from Galenism and one new system after another played its greater or smaller part upon the stage of medical progress. Here is obviously one benefit to the human race, which Galen's masterful intellect handed down. Namely, it, to a great extent, united the profession and prevented a great deal of useless bickering and dispute.

Subsequent Greek and Roman medical writers were chiefly mere compilers from his works; and as soon as these were translated into Arabic, in the ninth century after Christ, they at once superseded all other medical literature throughout the entire East. For 1,500 years he was paramount and there was no appeal from his dicta. In reflecting upon this remarkable phase of medical history, we must remember that every other art and science, beside medicine, slept for over a thousand years. And that ignorance and superstition had borne down mankind, gentle and simple, to a point where, instead of any advance, there was constant retrogression and medicine had been swept down in the general decline.

To revert to Roman medicine, while considerable is known regarding it, there is not much to be said that would be of historical value. Before the second century of our era the Roman nobles employed medical slaves (*servi medici*) which was often a very economical proceeding. It is even related that, if a Roman allowed his slave to be educated for a physician, the latter was expected not alone to treat his patron and family gratuitously, but to add to their revenues and even to support them from his earnings in case of necessity. As the Romans had enslaved nearly the whole world, naturally some bright and scholarly men might become members of a patrician's family. Antonius Musa, who treated the Emperor Augustus so successfully, had been one of these *servi medici*. Beside these medical bondmen, the Romans had their especial gods for special diseases, as already mentioned, and sometimes like Cato, took a dilletante interest in practice on their own account. That they despised doctors and Greeks, who were practically the only doctors in Rome in those days, is well known. Even after Galen, Soranus, and Asclepiades had made the practice of medicine respectable at Rome, the Quirites looked upon it as beneath them. There were, as said before, a few Roman medical writers, none of whom were especially distinguished, except Celsus. One of them, Scribonius Largus (47 A.D.) left a prescription for a celebrated expectorant mixture for phthisis and was the first to suggest the use of the electric ray, or torpedo (the well-known elasmobranchiate fish), for headache. As this fish generates real electricity, and gives shocks to whomever it touches, Scribonius may be looked upon as the pioneer in an extensive and complex field of therapeutics. There were also in Rome an army of medical hangers-on and charlatans of various descriptions, such as the root and herb gatherers, salve peddlers, midwives, bath-attendants, professional poisoners, abortionists, etc. There were also archiatri, or body-physicians to the emperors, some of whom also practised among the people (*archiatri populares*). Still another nondescript body of practitioners was that of the eye specialists, or oculists, each of whom sold a special eye-salve stamped with his own private seal and made up of zinc and calamine. Nearly 200 of these seals have been found. A special feature of Roman life, which had of course a strong hygienic value, was the national habit of bathing, which became almost universal after the establishment of the empire. General hydrotherapy had been introduced by Asclepiades and no less than 1,800 public baths had been founded between 334 B.C. and 180 A.D. The baths of Caracalla and Diocletian had marble fittings and would accommodate 1,600 and 3,000 people respectively. The water was supplied by the great aqueducts. There were quite frequently swimming pools attached to the cold baths. We do not know whether the so-called warm baths (*tepidaria, calidaria*) were made warm by heating the water or the air of the bathroom. The water from warm springs (thermæ) was also used. There were a number of famous thermal and mineral springs in the various Roman provinces that were greatly

sought after. The fully equipped Roman bath was much the same as the modern Turkish bath-houses and had, in addition, lecture and recreation rooms and gardens for rest and gymnasia, which were fitted out at great expense. Dental work of a high order has been discovered among the relics of that peculiar people, the Etruscans. Some remarkable specimens of their bridge-work, resembling closely modern bridge-work, are preserved in the museum of Corneto and have been described by Walsh and Guerini.

The racial characteristics of the Roman people were toward military achievement, architecture, and the formulation and administration of law. Their hygienic practices were admirable, such as cremation of the dead, their sensible, well-ventilated houses and their great aqueducts, sewers, drains, and public baths. Their contributions to medical literature were meager and the number of names which they added to the world's list of physicians was small indeed, if we except the few prominent Greeks, who practised in Rome, and who have been already mentioned. Some writers do not even credit the Romans with a design to benefit the public health, when they built their great public sewers, baths, and aqueducts. Nevertheless the hygienic value of these structures can scarcely be overestimated. Yet the medicine of Rome, if the Romans can be truly said to have had any special medicine, was merely an offshoot of the Greek.

Medieval Medicine.—Although the Byzantine power lasted for a thousand years not much of value was added to medical history during that period except the work of four industrious compilers, who were prominent physicians in the course of the first three centuries of the existence of the Eastern empire (from about 400–732 A.D.). Garrison says that "the solitary thing that the Eastern Empire did for European medicine was to preserve something of the language, culture, and literary texts of Greece." Of the four compilers, mentioned above, the first was Oribasius (326–403), friend and physician-in-ordinary to Julian the Apostate, and some time questor of Constantinople, whose writings are valuable largely because he always gives his authorities, and so far as we know, always quotes them correctly. Medicine owes him a great debt for a fine anthology of the works of his predecessors, many of whom might otherwise have been lost and forgotten. He lavished his painstaking care upon Galen and his expositions of the works of this master did much to establish the authority of Galen through all the dark ages. Like the latter, Oribasius took all knowledge for his province. His great work on medicine was an encyclopedia of over seventy volumes, dealing with every aspect of the subject. Much of this has been lost but he had epitomized its substance in a little "synopsis," which he had compiled for the use of his son. His "Euporista," or popular treatise on medicine, had the remarkable quality that it avoided the current superstitions and taught sound therapeutic doctrine.

Another of the four worthies was Aetius of Amida who lived in the sixth century A.D. He was also a royal physician and (*comes obsequii*) lord high chamberlain at the court of Bizantium (527–65 A.D.). His work "Tetrabiblion" is the principal source of our knowledge of the work of Rufus of Ephesus and Leonides in surgery and of Soranus and Philumenus in gynecology and obstetrics. He gives a good account of an epidemic of diphtheria and the best account of the diseases of the throat, eye, ear, nose, and teeth to be found in the literature of antiquity. He also wrote well on goiter and hydrophobia. He describes certain operations of tonsillotomy, urethrotomy, and the treatment of hemorrhoids, not found elsewhere, and recommends many salves and plasters. He must have been a convert to Christianity inasmuch as he directs for example that in preparing a plaster, one should intone repeatedly "The God of Abraham, the God of Isaac, the God of Jacob, give virtue to this medicament." To remove a bone stuck in the throat one should cry out in a loud voice, "As Jesus Christ drew Lazarus from the grave, and Jonah out of the whale, thus Blasius, the martyr and servant of God commands, "Bone come up or go down."

Alexander of Tralles (525–605) a much traveled physician, who finally settled down in Rome, was the only one of the four compilers who displayed any particular originality. His "Practica" gives certain prescriptions and descriptions of disease which seem to have been his own. He gives an original chapter on worms and vermifuges, and is said to have been the first writer to mention rhubarb. He wrote very well upon insanity, gout, and dysentery. Like Galen, whom for the most part he closely follows, he recommends a full milk diet, change of air, and sea voyages for consumption. But he mars his good work by interlarding it with the usual Byzantine jargon regarding spells and charms.

Paul of Ægina (625–690 A.D.) the last of the Greek eclectics and compilers wrote an "Epitome" of medicine in seven books, first printed by the Aldine press at Venice in 1528. He frankly admits that the ancients had said all that could be said on the subject of medicine and that he was only a humble scribe. This is a strong side light upon the low state of medicine and its utter want of perspective or ambition in the seventh century.

Paul, however, was a fine surgeon and his Epitome contained the material which made it the standard on surgery until Albucasis' time, who indeed got most of his information from it. Paul gives original descriptions of tonsillotomy, lithotomy, trephining, amputation of the breast, and paracentesis. In herniotomy he advises castration, which was continued by the Arabians and medieval surgeons until well into the sixteenth century. As he omits all reference to podalic version, this procedure disappeared from medical literature, and probably from medical practice, until the time of Röslin and Paré.

Among the lesser authors of the Byzantine period was Publius Vegetius Renatus, whose "Ars Veterinaria" contains the first authentic account of glanders. And Theophilus Protospatharius, who wrote a treatise on the urine, which for centuries upheld the Galenic doctrine that this fluid is a filtrate of the blood, secreted in the portal vein and vena cava. This same doctrine received the support of Johannes Actuarius in the thirteenth century, who was the last of the Byzantine writers and whose elaborate work on the urine made the above-cited notion authoritative with the absurd "water-casters" of a later time. He was the first to use a graduated glass for examining urine, although the markings upon it were not for quantitative, but for qualitative analysis, indicating the possible position of the different scums, precipitates, and sediments.

During the Byzantine period the Fathers of the Christian Church rendered a valuable service to medicine by describing the earlier epidemics of smallpox which had occurred from 302 to 581 A.D. The term variola (spotted) was first applied to the disease by Marius, Bishop of Avenche in 570. It might be mentioned in justice to the clerical authorities of the dark ages that their help in preserving medical literature and, to a considerable extent, regulating medical practice was most valuable. While priestly medicine has, generally speaking, not been of a truly scientific character, the aid of the church in medieval times not improbably kept the study and practice of physic from lapsing into complete barbarism. This is, of course, true in regard to practically all education, in this decadent stage of the world's history.

Arabian Medicine.—Toward the latter part of the Byzantine period the lead in medicine was assumed by the Mohammedans and Jews. The Mohammedan and Jewish periods lasted about 300 years,

or until nearly the beginning of the twelfth century. While there may have been no greater advance in medicine in this period than in the preceding three centuries (the true Byzantine period, of which we have just treated) there is more interest in the study of its history. Probably largely due to the fact that we know more about the persons and events that were prominent at this time. Their lives and actions are more vivid than those of the immediate successors of Galen; partly because they were not so completely overshadowed by this prominent figure, and partly because they are nearer to us chronologically.

Mohammed and his soldiers had subdued and converted, by force of arms, the wild nomadic tribes of the desert lands of Asia and Africa into more or less homogeneous and united nations. Yet it was years after the death of the prophet, and after the division of his mighty empire into caliphates before any significant attempt was made to cultivate in them the arts and sciences and to advance civilization and learning. During the stress of conquest, when the fierce fires of fanaticism and bigotry inspired the fatalistic followers of Islam, the tendency was to destroy and tear down whatever of learning or culture they might meet among the infidel hordes. But after the death of the prophet the caliphs, like the Ptolemies after the death of Alexander, desired to make their names memorable by the cultivation of the arts and sciences. In medicine and philosophy, which at that time and for some centuries afterward were so strongly united, the monotheism and dialectic tendencies of Galen and Aristotle appealed strongly to the Mohammedans. The polypharmacy of the former especially appealed to these natural chemists (as Garrison styles them) and his haphazard and involved "polypragmatism" was moulded by them into iron-clad dogma. This was a work of delight, while the oriental idea that it was sinful to come in contact in any way with a corpse shut out any advance in surgery or anatomy. To spend an incalculable amount of time and effort in the elaboration of speculative therapeutics comported better with their mental attitude than digging out the dry facts of positive science. They loved alchemy, astrology, and fiat medicine. And tended rather to hair-splitting subtilties than to deductive or inductive scientific investigation. Naturally their pedantry and fatalism led to the establishment of authority upon a rock-bound basis and the mental processes of the Middle Ages were determined and fixed in advance. So much so that if we remember that there was no printing, no general travel, no education or mental training for the masses, we can understand why medicine, along with other forms of knowledge, sunk deeper and deeper into the slough of ignorance and superstition from which even now it has only partially emerged.

The writers of the eighth, ninth, and tenth centuries we speak of as "Arabic" on account of the language in which they wrote. Yet most of them were Spaniards or Persians by birth and many of them were Jews. The Mohammedan physicians owed their original knowledge of medicine to a litigious priest named Nestorius. This cleric had an idea that the Virgin Mary should be called the "Mother of Christ" and not the "Mother of God." He had been patriarch of Constantinople in 428 and had a considerable following. All these particular heretics were exiled from Constantinople and driven into the desert. They obtained control of the school at Edessa in Mesopotamia, with its two large hospitals, and made it a flourishing medical school. However, they were driven away from Edessa by the orthodox Bishop Cyrus in 489 and fled to Persia, where their theological views were no bar to their reception. Here most of them united with the famous school at Gondisapor, which was the true starting-point of Mohammedan medicine. The caliphs of Bagdad were true friends of learning and encouraged the collection and copying of Greek manuscripts. The earlier centuries of this period were occupied in translating Hippocrates, Galen, Dioscorides, and other Greek classics into Arabic. The three great names of this movement and the greatest physicians of the Eastern Caliphate were the Persians, Rhazes, Avicenna, and Haly Abbas. Rhazes (860–932) ranks with Hippocrates, Aretaeus, and Sydenham as an original protrayer of disease. He gives the first authentic account in literature of smallpox and measles. Although smallpox had been originally described as early as the sixth century, by some church fathers and others, Rhazes' description is so vivid and complete as to be almost up-to-date. His enormous encyclopedia, containing many extracts from various sources, together with clinical histories and therapeutic experiments of his own, reveals him as a Galenist in theory but a true follower of Hippocrates in the simplicity of his practice.

Haly ben Abbas, a Persian magus who died in 994, wrote a book which was the canonical treatise in medicine for a hundred years, when it was superseded by the "Canon" of Avicenna. It has never been printed in the original Arabic, but was translated into Latin in 1080 by Constantinus Africanus, who published it as his own work. Avicenna (980–1036) called the "Prince of Physicians" was the physician-in-chief to the famous Bagdad hospital. He is said to have written over 100 books on different subjects, only a few of which have been preserved. He has been called the "Father of Geology" and it is interesting to note that two physicians—far apart in time and location—are the only writers who had any real knowledge of geology for centuries. Avicenna appears to have been the leader in describing the qualities and preparation of alcohol and sulphuric acid. He also wrote, as intimated above, a "Canon," which Haller called a "methodic inanity." An apt phrase, by the way, highly descriptive of much so-called medical writing. Written in clear and attractive style, this ponderous tome was an attempt to codify all medical knowledge and make it agree with Galen and Aristotle. It was a "miracle of syllogism" and appealed particularly to the medieval mind. Naturally it became part of the authority from which there was no appeal. Perhaps we should have a clearer conception of Avicenna's real medical ability if his clinical records had not been lost. He seems to have practised the treatment of spinal deformities by forcible reduction, a method which was reintroduced by Calot in 1896. He also described the guinea-worm. Yet his influence was really detrimental to medicine, because it tended to confirm the delusion that ratiocination is a better means of arriving at medical truth than actual experiment.

Avicenna also did harm by inculcating the notion that surgery is an inferior and separate branch of medicine and by substituting the use of the cautery for that of the knife. Abdollatif (1161–1231) an Arabian traveler visited Egypt at Saladin's instance and studied some human skeletons, which convinced him that Galen's osteology must contain some gross errors. This, however, occurred after the close of the period of Mohammedan medicine, when other important, although perhaps not very conspicuous signs, tended to show that the medical mind was chafing under the ban of authority and was beginning the struggle toward freedom.

The Western or Cordovan Caliphate (755–1236) attained its height under the Spanish or Ommiade dynasty. Its leading medical authors were the surgeon, Albucasis, the philosopher, Averroës, and the Jewish physicians, Avenzoër and Moses Maimonides. The first named wrote a great surgical treatise showing pictures of a variety of surgical and dental instruments. The second was Averroës (1126–1198) a philosopher and free thinker, sometimes called the Mohammedan Spinoza, who attempted to found a system of medicine upon Aristotle's philosophy. He discredited Galen

and taught that the soul, or nature, of man is absorbed at death into universal nature. This led to his persecution, during his lifetime, and to the anathematization of his followers after his death.

Here seems to begin again that endless multiplication of medical systems, which had received a quietus from the overwhelming superiority of Galen and had remained dormant for a thousand years after his death. However, as medical writers and thinkers began to break away from Galen, they seemed to esteem it incumbent upon them to supply "something equally as good," in the matter of theories and systems, to take the place of those they were endeavoring to supplant: and so the dreary and futile succession of more or less sterile theories, was reinaugurated and the end is not yet. To quote Weir Mitchell it connotes "an exasperating waste of human intelligence," spread out over a dreary expanse of time. Ingenious, laborious, and useless except as a series of exercises in dialectics.

The greatest of the Jewish physicians of the Western Caliphate was the Cordovan, Avenzoar, who died in 1162. He also had the courage to dispute with Galen and, by describing the itch-mite, gains credit for being the first parasitologist, after Alexander of Tralles. He recommends goat's milk in phthisis, describes a number of diseases and wrote a book on the "Reetification of Health." The Rabbi, Moses ben Maimon, called Moses Mamoinides (1135–1204) was court physician to Saladin and his work on personal hygiene was written for that sultan's private use. It contains some admirable directions for the care of the health including a rhubarb and tamarind pill.

These Arabians were strong on pharmacology and some of their prescriptions are still with us. Insomuch that even to this day, what Osler calls, "the heavy hand of the Arabian," can be recognized in our top-heavy pharmacopœia. A mysterious writer, of the tenth or eleventh century, who used the pseudonym or eponym of Mesue, junior, compiled certain works on pharmacology, which were so popular that a Latin translation of them was one of the first medical works to be printed (Venice, 1471). A Persian manuscript of the eleventh century contains directions for examining the urine which were very complete for that date.

The Arabian physician, whose professional importance was in direct proportion to the height of his turban and the length of his sleeves, was an astrologer and a magician. He defined the heart as "the prince of the body," the lungs as the fan of the heart, the liver as the guard of the heart and the residence of the soul, the pit of the stomach as the seat of pleasure and the gall-bladder as the seat of courage. He subscribed to the Galenic pulse lore (a special pulse for each disease) and pretended to diagnose the sex of the unborn infant from an inspection of the urine, wrote charms in cups with "purgative ink" and resorted to various similar maneuvers in order to mystify his patients and maintain his influence over them. He did not dissect on account of religious conviction. He left operative surgery and venesection to itinerant "specialists" and obstetrics to midwives. He stipulated for his fees in advance and squabbled and argued with his colleagues interminably. One of them, named Gabriel Batischua, a favorite of Harun-al-Rashid for bleeding and purging the "Commander of the Faithful" received about $1,500 per annum, beside a regular monthly salary of about $2,500 and a New Year's purse of $6,250. He estimated his total fortune in fees at $10,000,000, and, on being recalled from banishment to heal Al-Meiamun, he received $125,000; said to be the largest single medical fee on record. After the Mohammedan lust for conquest had been satisfied, the caliphs, founded hospitals, universities, and libraries. They embraced with ardor all Greek, Egyptian, Indian, and Jewish culture that did not conflict with their own peculiar tenets. As early as 707 A.D. one of them had founded a hospital at Damascus. A hospital had already been established at Misr in Egypt in 597, and another at Cario in 874, two at Bagdad in 918, and two others in the same city in 925 and 977. Dispensaries and infirmaries existed in all the principal cities of the Eastern Caliphate. In 1160 there were sixty of these in Bagdad alone. The largest and best of the Mohammedan hospitals were those founded at Damascus in 1160 and at Cairo in 1276. For three centuries free treatment and medicines were provided in the hospital at Damascus. In 1427 it was claimed that its fires had not been extinguished since its opening. The great Al-Mansur hospital at Cairo enjoyed an income of about $100,000, employed male and female nurses, had a library, diet kitchens, out-patient clinics, an orphan asylum, and a chapel, and handed to each departing convalescent patient a sum of money so that he should not be obliged to go to work at once. A rich and varied diet was provided and music, or story tellers, soothed the restless hours of those who could not sleep. The Cordovan Caliphate had as many hospitals as the Bagdad Caliphate, although they were less extensive. The latter also had its ophthalmic dispensaries and lunatic asylums. The Arabians were far ahead of their European contemporaries in their humane treatment of the insane.

Medical instruction was given either at the great hospitals at Bagdad, Damascus, or Cairo, or as a special course at the academies which existed in all the cities. The principal courses were clinical medicine, pharmacology, and therapeutics. Anatomy and surgery were neglected; but chemistry was held in especial esteem. In fact this science owes to the Arabian, Geber (702–765) and to the Arabian School of Medicine as much as clinical medicine owes to Hippocrates and his Greek disciples. Geber discovered nitric acid and aqua regia and described distillation, filtration, sublimation, water-baths, and other essentials of practical chemistry. He is said, like Galen, to have written 500 books. He advanced the fundamental doctrine that all metals are composed of identical elements and that, by proper manipulation, the baser metals may be transformed into the noble. This hypothesis was the leading theory in chemistry as well as in alchemy down to the sixteenth century. Alchemy was interwoven with astrology as follows. The ancient Chaldaic Pantheism, a doctrine which assumed the Anima mundi or "soul of the world," or the indwelling "spirit" in material things was applied to anything which could be extracted from a substance by fire such as spirit of wine, spirit of niter, etc., while to the seven planets (sun, moon, Jupiter, Mars, Venus, Saturn, and Mercury) corresponded the seven days of the week and the seven known metals (gold, silver, iron, lead, tin, copper, and quicksilver). All these metals were assumed to be generated in the bowels of the earth; the riddle of alchemy was to demonstrate the germinating process or agent, under the appropriate planetary influences. Together with the above myth went the assumption of a polyvalent "elixir of life" which cures all diseases and confers immortal youth. This was dubbed "potable gold" (aurum potabile). The search for it led to a number of important chemical discoveries and laid the foundation for chemical pharmaceutics. In the beginning of the sixteenth century Paracelsus was preaching Geber's doctrine that everything is made of mercury, sulphur, and salt; and as the sun rules the heart, and the moon the brain, Jupiter the liver, Saturn the spleen, Mercury the lungs, Mars the bile, and Venus the kidneys, so the seven planetary metals and their compounds were specifics for the diseases of these organs under the will of the stars.

These Arabian pharmacists introduced a great multitude of new drugs. They originated syrups, aldehydes, alcohol, and juleps (all Arabian terms). The effect of their pharmacy upon European medicine lasted long after the Mohammedan power had nearly passed away from Europe: together with the simples of

Dioscorides and Pliny, their additions to the materia medica made up the bulk of European pharmacopœias for centuries.

Jewish Medicine.—Tolerated and even encouraged by the Mohammedans, largely because of their uncompromising monotheism, Jewish physicians became prominent at the courts of the caliphs. The mental characteristics of the Jews and Mohammedans were not unlike, with their intensive ways of thinking, their analytic cast of mind, and appreciation of "values." Physicians of both of these races began to acquire a materialistic way of looking at and measuring things, and so, while the Christian doctors were still trifling with relics of saints, amulets, and charms, the cabala and other superstitions (superstition means, according to Lowell, something left over, a survival), the Jews and Mohammedans were beginning to look upon such matters with contempt.

The Hebrew doctor, however, had anything but an easy life in Europe until long after the Middle Ages. During the tenth and eleventh centuries he was, as Billing's says, "a sort of contraband luxury," intermittently resorted to and protected by prince and prelate, because he was, in reality, more scientific and learned than his Christian competitor. In 1267 the Council of Vienna forbade the Jews to practise among the Christians. In 1412 Jewish physicians were banished from the Western Caliphate. But they were tolerated in the School of Salerno until this institution had developed enough talent among their students to get along without the Hebrews. Montpellier did the same thing and closed its doors to the Jews in 1301. Although some of the monarchs of those times continued to employ Jews as their body physicians, even up to the French Revolution, the latter were not allowed to study at the European universities and played little part in medical history during the middle ages. It was in France in 1791 that the equality of all men before the law was decreed, and so the ban was lifted at last from the Jewish student, yet he was not free from persecution and unjust discrimination for years after the date mentioned. Still he has made his way in medicine and in science and some of the most distinguished names in the annals of the medical profession for the past hundred years have been Hebrew, with the result that a great part of the advance from hypothetical into scientific medicine has been due to the labors and the devotion of this once despised race.

The middle ages were so given over to scholasticism and empty formalities, which have ever been the refuge and the delight of the mentally indolent and pedantic, that it has become common to stigmatize one seeking to suppress or distort the truth, by overbearing or underhanded methods, as "medieval minded." When learning was so superficial and so controlled by special interests and when general education was so backward that, as a rule, princes and even priests could not read and write, it would have been wonderful indeed if medicine had been able to make any marked advance in the general darkness. The medieval thinkers were all under the ban of authority, to them such a declaration of free-thought as the Hippocratic treatise "On the Sacred Disease" "was abhorrent; while Galen, with his devout monotheism, and his careful Bridgewater teleology, became an object of veneration" (Garrison). Aristotle was "prescribed under excommunication" by the Synod of Paris in 1209. However, Gregory IX restored him in 1231, and he became practically an infallible authority. Until after the renaissance there was neither induction nor experiment. As Allbutt puts it "logic was for the middle ages a means of discovery, nay, the very source of truth." The "pneuma" of Galen, the "archaeus" of Paracelsus, the "animism" of van Helmont and Stahl, the "thought and extension of Descartes and Spinoza, and the "noumenon" and "phenomenon" of Kant are all expressions of the endless endeavor to settle definitely the true relations of cause and effect, and to explain by logic and deduction, the secrets of nature. Very little advance has attended the musings of the philosophers and their attitude of mind begot intolerance and bigotry. The old Greek philosophers frequently held views entirely opposed to those of their neighbors and were, generally speaking, exempt from persecution on account of their opinions. Two or three thousand years after their time, men were burned at the stake because they declined to believe what they were ordered to believe. Such being the intellectual condition of the world; medicine, like everything else was stagnant. Hippocrates was forgotten and the subtleties of Galen and the Arabians reigned supreme. The Oriental idea that it was unclean or unholy to touch the human body, especially if injured or dead, led to the extreme development of the idea of Avicenna and, by inference, that of Galen also, that surgery is only a method of treatment. The treatment to be dictated by the physician, who was ignorant of anatomy but obsessed with the overwhelming sense of his own omniscience. Indeed, this state of the medical art carries us back to the saying of that disrespectful old Pliny, who said that "anyone with a sufficient stock of impudence may reasonably well pass for a physician." As Guy de Chauliac pointed out, the fundamental error of medieval medicine was the divorce of the practice of surgery from that of physic. The former resembled manual labor, it was not always cleanly and worst of all perhaps to the medieval mind was in most cases simple and easily understood. The latter, according to the bigots and pedants who composed the bulk of the physicians of the time was clean, dignified, elegant, abstruse, learned and, as vulgar people would say now, "gentlemanly." Hence the operating surgeon became well-nigh a vagabond; while the physician wore his long robe and assumed an indescribable amount of that "gravity" which is defined by Rochefoucauld as "a mystery of the body, invented to conceal the defects of the understanding." These prevailing notions led to the adoption of the famous edict of the council of Tours in 1163 "Ecclesia abhorret a sanguine." So medicine and surgery together tended to gradually move down into the abyss of uselessness and maladaptation to the ends demanded of them. The physicians were dilettantes, the surgeons ignoramuses and charlatans. The latter received much contumely and were subjected to many indignities. They were bath-keepers, sow-gelders, mountebanks, and especially barbers. In the Prussian army, up to Frederick the Great's time, they were obliged to shave the officers and had been at times liable to flogging for infractions of discipline.

The school of Salerno had started in some mysterious manner, probably because there had been for a long time a health resort at this little seaside town near Naples. In 1101 Robert, son of William the Conqueror, was cured of a wound of the arm at Salerno, and a very sensible collection of dietetic and hygienic receipts was composed for his benefit. This was in the form of a poem and ran throughout two hundred and forty separate editions and was translated into nearly every known language—another example of the advantage of rime in conveying knowledge to the minds of the unlettered. The "Antidotarium" of Nicholas the Salernitan, was the first formulary we have and was one of the first medical books to be printed (Venice, 1471). It contained a number of new English drugs and a table of weights and measures. The university was sacked by Henry VI in 1194 and after this it was overshadowed by the great schools at Naples, Palermo, and Montpellier. It was finally abolished by Napoleon in 1811. From this school some good surgical work grew. Roger who wrote a text-book for use in the school knew of cancer and possibly syphilis. He prescribed ashes of seaweed (iodine) for goiter and scrofula. Theodoric (1205–96) a successor of Roger

was reviled by Guy de Chauliac as a copyist and a plagiarist, probably (Garrison says) because he ventured to make light of the wicked Galenic doctrine of "coction" and "laudable pus" and took an advanced stand for rational asepsis. This doctrine was shared by Mondeville of Montpellier, in the next century, but was so to speak doomed to oblivion for five or six centuries until Lister established it beyond all controversy. Theodoric and his immediate predecessor, Hugh, made use of a soporific sponge steeped in a mixture of opium, hyoscyamus, hemlock, lettuce, and mulberry juice, the fumes of which were inhaled by the patient to produce surgical anesthesia.

The ablest Italian surgeon of the thirteenth century was Saliceto or Salicet (1201–1277). This man restored the knife to surgery which the Arabians had set aside in favor of the cautery. He also recognized dropsy as due to the contracted kidney, and distinguished arterial hemorrhage from venous. Lanfranchi of Milan was his pupil and ably upheld his surgical teachings. In 1295 Lanfranchi, who had been driven out of his native town (Milan) arrived in Paris. He was, however, shut out from teaching in the university because he was a married man. The professors being all clerical celibates. He, however, became associated with the faculty of the College de Saint Côme and by his success as a teacher was the virtual founder of French Surgery. In the previous century the universities of Oxford (1167), Bologna (1113), Montpellier (1181), and Paris (1110) had been founded, the University of Padua was founded in 1222.

Henri de Mondeville (1260–1320) was a contemporary and loyal adherent of Lanfranci. Mondeville proved to be an original thinker widely different from the conventional professors of his day. He stood up stoutly for clean and efficient surgery and inveighed with powerful wit and sarcasm against the salve surgery of the Galenists. He advised torsion of bleeding vessels, styptics, acupressure, and clean dry wounds without the use of medicaments. He is celebrated for his witty remarks of which the following is an example: "God did not exhaust all His creative power in making Galen." Guy de Chauliac (1300–70) came shortly after Mondeville. He was educated for the church and got an excellent medical education at Toulouse, Montpellier, and Paris. He was the best educated surgeon of his time and the highest authority on surgery of the fourteenth and fifteenth centuries. He was the only medical historian of consequence between Celsus and Haller. His most distinguished pupil Pietro d'Argelata (died 1423) used sutures and drainage tubes in wounds. With the gradual improvement in surgery, there necessarily came about a greater demand for a better knowledge of anatomy. Mondeville had prefixed an anatomical treatise to his surgery. Mundinus completed a little book on dissecting in 1316. Although it was full of Galenical anatomical errors, it was really the text-book on anatomy for over a hundred years. After this, dissecting, gradually, from being considered an heinous crime, came to be considered a fundamental study for both physicians and surgeons. Dissections in public were decreed, in the various universities, to the number of four or more annually. These were apparently somewhat superficial, the bodies being opened by the barber-surgeons, and the great professor with a tall cap, and a flowing robe, pointed out with a staff the different organs to the students and the lay audience. This performance seems to have been solemnized by more or less pomp, and to have concluded with a banquet. Still it was an advance along the thorny path of real learning and helped break down the barriers of ignorance, authority and superstition which held medicine in thraldom for so many centuries.

As to internal medicine having fallen behind surgery in the advance toward scientific precision, it did not regain the lost ground in the middle ages. Some brilliant names are found among the writers on medicine at this period, to wit, Roger Bacon, Thomas Aquinas, Duns Scotus, and Albertus Magnus. They were of course also philosophers and devotees of "authority." A characteristic treatise of the time was the "Conciliatio Differentiarum" (Venice, 1471) written by the heretic Peter of Abano (1250–1320) in which he tried to reconcile the medical views of the Greeks and the Arabs. Many of the Arabists were connected with the great school of Montpellier, which was founded about 738. Its influence in France has survived until this day. Its earlier professors were men fiercely searching for the aurum potabile and diligently studying the constellations and the movements of the planets. It is perhaps no wonder that so little progress was made in real medicine; because it must have taken a student many years to master all the intricate formulæ and memorize all the rules, aphorisms and directions, with which everything was loaded down. In Longfellow's Spanish student, the latter says that the first two or three years of his course of study as a medical student, were devoted to logic to enable him to argue the better with his patients. Of the writers and practitioners of the thirteenth and fourteenth centuries, few names are of much importance and most of the literature they left behind them is a mass of repetition of former treatises. The "Compendium Medicinæ" of Gilbertus Anglicus (died 1230) gives an original account of leprosy and contains the first reference to the contagiousness of smallpox. This was afterward contradicted even by Sydenham. John of Gaddesden (1280–1361), a prebendary of St. Paul's and a sorry quack, treated smallpox with red light like Finsen of later times. Albertus Magnus was the greatest naturalist of the thirteenth century. He assisted the famous Emperor, Frederick II, in his work on falconry. He was a Dominican monk and did not write on medicine, which was a subject forbidden to the Dominicans. A striking feature of medical writing of the fourteenth and fifteenth centuries was the "Consilia" or medical case books. The most important of these were written by two Paduan professors, one was the first observer of gallstones; the other, an anatomist who had dissected fourteen bodies, extracted teeth, and so forth. He left 305 recorded cases and gave seasonable advice as to diet and treatment. This shows that physicians were already keeping case records and tabulating their results.

During the dark ages the civilization of Western Europe was in state of chaos. The turbulent, semi-barbaric nations were in a formative state. They were amalgamating and welding together various diverse elements. The only pretence at learning was in the hands of an illiterate and superstitious priesthood. Feudalism, semi-barbarous, as it seems to us, did much to establish nations and States on a permanent basis. Before the building up of the school at Salerno, medicine was entirely in the hands of the Jewish and Arabian physicians. The church had intervened and at this time took the not unreasonable ground that faith, prayers, and fasting were better remedies than pagan amulets, while the sick were admonished to emulate the saints and martyrs in the endurance of suffering. However, the clerics and monks, almost of necessity, began to practise medicine, which caused the mother church to issue various edicts and orders to regulate their activities. The acceptance of fees, the intimate contact with patients of both sexes, in certain trying situations, and so forth, in those rough times seemed to call for strict surveillance to prevent both malpractice and immorality. The general effect of these edicts of the church was not alone to limit or prohibit the practice of medicine by the monks, but to cast odium upon the whole of the profession, especially upon the surgeons. Surgery was in a measure, one of the dirty trades and was so considered until almost the present century.

Garrison says that up to the time of the Crusades, the status of surgery in all of Europe, excepting perhaps Italy, was lower than it was among the Greeks at the time of the Trojan war. Internal medicine was naturally still farther sunk in ignorance and theurgy. After the tenth century, the Russian Church, like the Roman, put severe interdictions upon sorcery and magic. The Visigothic Code, of the seventh century, put the same severe restrictions upon the practice of physic as the Code Hammarubi. Under this code, if a physician lost a noble patient, he was turned over to the patient's relative to do what they pleased with him. He was forbidden to bleed a married woman in the absence of her relatives, for fear that he might commit adultery with her. Under the severe restrictions of these times, a surgeon actually took his life in his hands, when he performed operations, and the physician's position was not much better. In the seventh century, the King of Burgundy had two physicians executed on his wife's tomb because she had died of plague in spite of their ministrations. In 1337 a strolling eye surgeon was thrown into the Oder because he had failed to cure John of Bohemia of his blindness. These strolling surgeons seemed to travel largely upon their nerve, to use a colloquialism. They did not hesitate to do a herniotomy, involving the castration of the patient, which was in fact in those days considered the proper technique; inasmuch as the testicles and the bowels were supposed to descend into the scrotum through the same orifice. These men would often, in couching a cataract, put out the sight of the eye, and would resume their wanderings before the patient could proceed against them for malpractice. The cruel and ineffective treatment of many surgical cases, no doubt, had as much to do with that deep-rooted aversion to hospitals, which is still common among the ignorant, as the evil manner in which the early hospitals themselves were managed. The interference of the church in medicine and surgery, although dictated by good motives, had unfortunate results in destroying popular confidence in doctors and sometimes in discouraging any advance in the doctors themselves. They later divided themselves into cliques and guilds partly for self-protection and partly because the better educated, and more fortunately placed, delighted then, as now, in looking down upon and oppressing their less fortunate rivals who naturally were led to combine against their oppressors. The surgical bigots of the College de Saint Côme in Paris made war upon the surgeons of the "short robe" and got a number of decrees issued against the practice of surgery by the latter. The former were clerical-barber surgeons and the latter lay-barber surgeons. In 1372 Charles V decreed that the last-named should be allowed to practise, without interference by their long-robed rivals. The same thing happened in England where the surgeons formed a separate guild in 1368 and combined with the physicians about 1421.

In the year 1140 Roger II of Sicily forbade any one to practise medicine without having undergone an examination. His grandson, the liberal minded and learned Frederick II, in 1224, followed up this decree, with a similar one of broader scope, demanding a properly conducted public examination of candidates for a license to practise. This examination must be conducted by the masters of Salerno; the license to be delivered by the Emperor, or his representative. Failure to comply with the law was punishable by a year's imprisonment and forfeiture of property. This examination was upon the genuine books of Galen, Avicenna, and Hippocrates. And before being allowed to take it, the candidate must have studied logic for three years, medicine and surgery for five years, and have practised for one year under some experienced physician. The physician was required to treat the poor gratuitously; to visit his patients twice a day and once at night, if necessary; to avoid collusion with druggists and to inform upon them, if they adulterated or substituted drugs. The supplies of drug stores were examined at regular intervals by inspectors. The sale of poisons, magic potions, and aphrodisiac philters was punishable by death if any one lost his life thereby. Suitable hygienic regulations were made for the proper depth of graves and for the proper disposal of refuse. The fee for office visits was fixed at a half tarenus (about 35 cents). The same amount was allowed for calls in the city. Outside the city limits the fee was four tareni ($3), if the doctor paid his own expenses, or three tareni ($2.25), if the patient paid them. This ordinance considering the date of its issue, was admirable in scope and intention. It did much to elevate the status of the reputable physician and to diminish the number of quacks. The rulers of Spain, Germany, and Naples issued similar ordinances during the thirteenth and fourteenth centuries. In these centuries, and the one following, over forty universities were established in different parts of Europe and, as printing had been invented, and the study of the classics had been revived, the world began to make visible progress out of the darkness of superstition into the light of knowledge. At first philosophy was the principal study in the universities, with law and theology as the main objects of interest. Medicine was a mere branch of philosophy, as decreed by Aristotle, Averroes, and various Arabic writers. The courses and text-books were usually ordained by papal bulls and there were seldom over a hundred or two volumes in the library of a medieval university. A tiresome round of Galen and Avicenna, interspersed with Hippocrates and Rhazes, comprised the curriculum. Until after books began to be printed, and students had learned to read the ancient languages, more or less imperfect and corrupted translations of ancient medical worthies were used as text-books, which were, presumably, learned by heart and repeated by rote. This was hardly the style of training necessary to develop an active scientific mind. The professors were paid from $35 to $50 per annum. Yet we must remember that money was worth from fifteen to twenty times what it is now. The term "doctor of medicine" was first applied to the Salernitan graduates by Gilles de Corbeil in the twelfth century. For several hundred years, the graduation ceremonies were commonly modeled after the Salernitan pattern and were not very different, in some features, from those now in vogue.

The chief glory of medieval medicine was the organization of hospitals and systematic nursing of the sick. These had their origin in the teachings of Jesus Christ. For, as Garrison says, while the Greeks had their Asclepeia and Iatreia, which the Romans copied more or less, and while the Babylonians brought out their sick into the streets and market places, so that passers-by might give them good counsel: the feeling of compassion for another's woes, and of a general purpose to succor the sick and unfortunate, and restore them, if possible, to health cannot be claimed for any race or people before the illuminating teachings of Christianity. The Mohammedans, it is true, built and equipped large and fine hospitals but the Christians deserve the credit for originating the movement. In 335 A.D. the Asclepeia, and other pagan temples, were closed by the decree of Constantine; shortly after this the movement of building and equipping Christian hospitals went forward, in which Helena, the mother of Constantine, is said to have taken a leading part. In 369 the celebrated Basilica at Cæsarea in Cappadocia was founded by St. Basil. This was followed, in 375, by a charity hospital containing 300 beds at Edessa founded by St. Ephraim. Many other hospitals and homes, or asylums, were established during the Byzantine period. The first nosocomium

or claustral hospital in Western Europe was founded about 400. Several others followed in the immediately succeeding centuries. The Hotel Dieu was started in Paris about 650. Various religious fraternities and orders were founded about this time for nursing the sick and caring for the unfortunate. Our term "Sorority" probably comes from Soror who founded the hospital, Santa Maria della Scala, at Siena in 898. The order of St. John of Jerusalem was founded in 1099 when the Crusaders reached the Holy City. Virchow gives a remarkable catalogue of hospitals founded in one hundred and fifty-five German cities. Many of these were merely first-aid and nursing stations of the charitable order of Teutonic Knights. There were, according to Walsh, ten hospitals in Rome in the thirteenth century. The phenomenal growth of leprosy in the middle ages gave a great impetus to this multiplication of hospitals. This disease appeared in Northern Europe in the sixth and seventh centuries and its spread in connection with the crusades was appalling, reaching its acme in the thirteenth century. Leper hospitals had been mentioned by Gregory of Tours (*circa* 560). These were increased in number from time to time, until, according to Baas, there were over 19,000 of them in Europe in the thirteenth century; of which 2,000 were in France alone. According to Virchow the building of these leprosaria was a great hygienic movement (as Garrison says), a wave of genuine prophylaxis as well as of human charity. About the middle of the thirteenth century, the municipalities began to supersede the churches in the control of the hospitals.

During the middle ages epidemics devastated Europe to a degree such as had never been known before and which has not been equaled since. The earliest of these great pandemics were leprosy, St. Anthony's fire or ergotism (857), scurvy (1250), influenza, the "dancing mania" (epidemic chorea), sweating sickness, and plica polonica (1287). The most formidable were the black death (bubonic plague) and syphilis. The former which appeared in Europe about 1348 carried off a quarter of the inhabitants of the earth (over 60,000,000 people). The conditions became so horrible as to beggar description. The epidemic had at least this good effect that it led the Venetian Republic to appoint three guardians of the public health and establish the first quarantine of infected areas. This lasted forty days, hence its name. While in other cities plague ordinances and private personal orders, pesthouses, and other hygienic improvements were adopted.

The other great scourge of the middle ages was syphilis, said to have been reintroduced into Europe by Columbus' returned sailors. This is denied by many authorities. At all events the disease was widespread and of great virulence. Showing itself at first in epidemic form at the siege of Naples in 1495. The extraordinary virulence of syphilis and leprosy in these early times has not yet been adequately explained. They are attributed to the crusades, among other causes. But just why the populace was so susceptible to these afflictions at that time is not clear. No doubt the filthy habits of living, and the want of linen or cotton underwear, had much to do with the prevalence and virulence of all infectious diseases. As we know now the cleanly and vigorous Englishman is very much more immune to the bubonic plague in the Orient than his Asiatic neighbors. Syphilis and leprosy caused the abolishment of the numerous public baths which were naturally assumed to be a principal means of their dissemination.

Philosophical Medicine.—The discovery of printing and invention of gun-powder (by doing away with feudalism) gave a great impetus to all learning, and to medicine, as part of the general advance. The capture of Constantinople by the Turks, in 1453, turned many scholars into Italy who aided in the revival of learning and as Garrison puts it substituted the "spontaneous receptive mental attitude of Plato and Hippocrates for the dialectics and logic chopping of Aristotle and the Galenists."

Lionicenus (1428–1524), professor of medicine at Padua, Bologna, and Ferrara, showed the greatest courage by boldly going to work and correcting the botanical errors in Pliny's Natural History. These were many but, like Galen's, they were covered with the mantle of "authority" and were "sacrosanct and unimpeachable." He wrote other valuable works, but his important work in correcting Pliny, which of course met with violent opposition, paved the way for a more accurate and reliable materia medica. Thomas Linacre, a friend of Lionicenus, was also an elegant Latinist, whose translation of Galen showed physicians that for years they had been relying on garbled and inaccurate versions of their venerated author. Linacre was called the "restorer of learning" in England. Like Linacre, Rabelais (1490–1553) was a priest and physician, but is best known by his humorous works "Gargantua" and "Pantagruel." He made one of the first Latin translations of the aphorisms of Hippocrates. He ridiculed the medieval custom, which still largely obtains, of stuffing the youthful mind with book learning and upheld the Greek ideal of education, to wit a drawing out of all the faculties, social, mental, and physical.

The first medical book to be printed in England was entitled "A Passing Gode Lityll Boke Necessarye and Behovefull Agenst the Pestilence" (London, circa 1485), a small quarto of twelve leaves. This was followed by other similar works. The tendency of these publications, in the vernacular, was to turn men's minds away from scholasticism toward realities. At the head of the Renaissance, in the medicine of the sixteenth century, were three men of widely different characteristics; but in accord in their devotion to their art, and in their bold and persistent efforts to break up the formalism of the time, and to lead the thinkers and students out of the labyrinths of conventionality into the fields of free thought and experimental knowledge. These men were Paracelsus, Paré, and Vesalius.

Paracelsus (1493–1541) rejoiced in the names of Aureolus Theophrastus Bombastus von Hohenheim. "Paracelsus" is supposed to be either a free translation of Hohenheim, or else, to have been adopted to show his superiority to Celsus. He was, without question, an aggressive person and a peculiar mixture of bombast (although it is alleged that Bombastus in his name, does not, as Browning asserted, indicate one of his most prominent characteristics), courage, and what might be styled "general meanness." He was an iconoclast, who delighted in attacking privilege and outraging conventionality. There were brilliant flashes of truth in his teachings, which were in sharp contrast to the murk of superstition, alchemy, and romance which formed their body. Still his meteoric career, his bold attacks upon the authority of Galen, Avicenna, and the old philosophic teachers, without question, blazed the way for the beginnings of rational medicine. He was the Luther of Medicine and, like this great cleric, emphasized his contempt for the accepted dogmas of medicine by publicly burning the writings of the old masters.

He was guilty of another daring innovation; he gave his lectures in German to the horror of his contemporaries, who esteemed the use of the vernacular to impart the knowledge of medicine as an unwarranted liberty to take with the high function of teaching this art. His private character was not above reproach. He was grossly intemperate and was killed in a brawl or died from injuries received while intoxicated at an inn. Yet he must be reckoned with as one

of the brightest lights in medical history. His fame grows with the lapse of years and his shortcomings, his immeasurable vanity, and frequent deceptions of his patients, not to mention the medley of alchemistic and other nonsense, with which his writings are interlarded, should be judged in conjunction with an understanding of the rough and coarse age in which he lived. They were surely largely atoned for by the truths which he championed in the practice of surgery and his introduction of chemical remedies into the materia medica. The closest thinker and the pure logician could never have made a tithe of the impression that this dramatic, not to say, blatant person did. He was preceded as a chemist by the so-called Benedictine monk, Basil Valentine (1604) (evidently a pseudonym), who is said to have "fastened the use of antimony upon the practice of physic for years." Albertus Magnus (1193–1280) and Cornelius Agrippa (1486–1535) also preceded Paracelsus as alchemists and pioneers in true chemistry. Paracelsus accepted Valentine's teaching that everything is composed of "combustible sulphur, volatile mercury, residual salt." He also gave the rein to his fancy in defining man's relation to the universe and the existence of the "Archaeus" and the "astral bodies" and so on. He belabored without mercy the strolling, mountebank surgeons, the uroscopists, and the blind adherents of Galen. He was the first to write on miner's (occupational) diseases and the first to establish a relationship between cretinism and goiter. He was almost the only asepsist between Mondeville and Lister. He insisted on clean wounds, and deprecated officious meddling with nature's methods. He introduced the study of mineral springs, and advocated baths in mineral waters. He placed a number of valuable drugs in the pharmacopœia, dallied with the imaginary import of "signatures," and by comparing the arcana, or intrinsic, principles of drugs to a spark, he grasped the idea of catalytic action. Baas credits him with anticipating Darwin in the idea of the survival of the fittest. Shakespeare brackets his name with Galen's in "All's Well that Ends Well," as though they were equally great authorities.

After Paracelsus' time the study of alchemy was seriously and zealously pursued by those having the means and opportunity. Libavius of Coburn made a start in teaching real chemistry by his book "Alchymia" (Frankfurt, 1595). Nearly contemporary with Paracelsus was Andreas Vesalius (1514–64), the most "commanding figure in European medicine after Galen's time and before Harvey" (Garrison). He became at twenty-three years of age professor of anatomy at the University of Padua. His magnificent "De Fabrica Humana Corporis" (1543) was the work which marks an epoch in medicine. It was revolutionary, chiefly because it was an accurate description of the structures of the body, never before so thoroughly and honestly studied and described. Sylvius, his old teacher, turned against him with calumnious and insulting abuse. His own pupil, Columbus, sought to cast discredit and derision upon him by underhand methods. Others "damned him with faint praise" or joined in a conspiracy of silence, and as a last straw, he was subjected to secret and indirect persecution at the instance of authority, all because he had told the truth; which is acceptable to the average mind only on certain conditions. This broke his haughty spirit, he burned his manuscripts left Padua and became court physician to Charles V. During his long, tedious years of inglorious ease at Madrid "he could not get hold of so much as a dried skull, let alone the chance of making a dissection." However, his favorite pupil, Fallopius, proved a worthy successor, and was appointed to the same professorship which his master had held. Upon the death of Fallopius, Vesalius was invited to reoccupy his old chair at Padua; but his darling wish, to be able once more to "study that true Bible, as we count it, of the human body and of the nature of man" was never realized. Vesalius died of some obscure malady, on his return from a pilgrimage, which he had undertaken to Jerusalem, undertaken, as some say, as a penance for having dissected the body of a criminal, not yet dead. The "Fabrica" disposed of Galen's osteology for all time. Vesalius taught that artificial respiration will keep an animal alive after the chest has been opened, and that a quiescent heart may be revived by the use of the bellows. He denied that the brain action of the lower animals differs from man's and laughed at Galen's notion, so long prevalent, that the blood passes through certain hypothetical pores in the ventricular septum. Whether he would have pursued this subject, as did Servetus (1509–53), until he had almost discovered the true course of the blood in its circulation, we do not know. We do know that Servetus was burned at the stake by John Calvin for a mere theological quibble.

Servetus was one of the world's martyrs for the "crime of honest thought." The principal discoverer of the pulmonary circulation, he ranks with Ramón y Cajal, as a leader of Spanish medicine. The discovery is recorded in his book "Restitutio Christianism" (1553) of which only two copies are known to exist, the rest having been burned with him. Besides Vesalius and Servetus there were several other distinguished anatomists and teachers who were nearly contemporary with them. Eustachius (1524–74), the discoverer of the Eustachian tube. Fallopius, of whom we have already spoken, who discovered many important structures, including the Fallopian tubes, and Sylvius (1478–1555) instructor and subsequent defamer of Vesalius. Now appears a truly great surgeon who started life as a barber's apprentice and died the best loved man in France, Ambroise Paré (1510–90) accentuated his professional career by writing an epitome of the "Fabrica" of Vesalius in the vernacular which made it accessible to all surgeons. He is most distinguished for his introduction of the use of the ligature to tie all cut arteries. His immortal "Je le pansay Dieu le guarit" shows that, like the few really great men in the history of medicine, he believed implicitly in the *vis medicatrix naturæ*.

The sixteenth century must be regarded as one of the greatest epochs in the world's development. Men everywhere were greedy for knowledge. The printing presses were kept busy, supplying the demand for books on science, and naturally such men, as those we have just spoken of, had an alert and sympathetic audience, which did not exist before the time of Paracelsus, except in ancient Greece. Andrea Cesalpino (1524–1603), professor of medicine at Pisa and physician of Pope Clement VIII, is regarded by the Italians as the real discoverer of the circulation of the blood. He had enunciated the proposition that the heart in systole throws blood into the aorta and the pulmonary artery and in diastole receives it back from the vena cava and pulmonary vein. But he cited no experimental proof of his assertions, which he seemed to have advanced in a spirit of controversy, as an argument against Galenism. His contention therefore made no impression upon his contemporaries. Whether he was firmly persuaded of its truth himself, is not clear. He was an able botanist and was called by Linnaeus the first true systematist in this science. Everything had to be overhauled and investigated in the sixteenth century, even the foundation and *sine qua non* of all medical practice, blood-letting, came in for reform and Pierre Brissot (1478–1522), a professor in the Paris faculty, proposed to return to Hippocrates' idea of bleeding from the affected side in unilateral lesions, or as near the site of the disease, or wound as possible. This was called "revulsive" bleeding as opposed to "derivative" bleeding, which was from the

unaffected side. The latter was the plan advocated by the Arabists. Brissot's heretical proposition led to a storm of invective and recrimination, which resulted in his banishment and a pronouncement from Charles V, that such a doctrine was as flagitious as Lutheranism.

Another early disciple of the father of medicine was the Florentine, Benivieni (died 1502) who published a pathology of fifty-four pages. This preceded Vesalius and Eustachius and "was the only work on pathology," so Malgaigne said, "that owes nothing to any one." Fracastorius (1484–1553) was also a man of science as well as a physician and pathologist. He shares with Leonardo de Vinci the honor of having been the first geologist to interpret correctly the true relations of fossil remains (1530). He was also the first scientist to refer to the magnetic poles of the earth.

The Venetian Luigi Cornaro (1467–1566) wrote the little book *Trattato della vita sobria* (Padua, 1558) which Garrison says "is probably the best treatise on personal hygiene in existence." Carlo Ruini's work on the anatomy and diseases of the horse (1598) is considered the foundation of modern veterinary medicine. The first medical books to be printed in America were printed in the City of Mexico in 1570 and 1595. The Byzantine Greek scholars, who immigrated to Italy, after the destruction of Constantinople, have been called the forerunners of modern medicine. By their careful study of ancient literature, they exposed the many errors, prevalent in the interpretation of the old medical writers and, as it were, cleared the ground for the reception of the new truths, which the master minds in the beginning of the sixteenth century were studying out and proclaiming to the world. A number of new universities were founded. Each of these new universities was a sort of little democracy. The students elected the professors, the rector (as they do yet in a few modern universities) and the officers, and had a voice in the selection of the courses of study. As a rule, the professors held office for only one year. Both students and professors were prone to move about from one seat of learning to another. It was an age of unrest. As there were still only a few printed books to be had, and no medical periodicals and only very imperfect means of communication between different cities and countries, it was necessary for any one, who wished to hear the best teachers and absorb their ideas, to travel about from one university to another. Wandering surgeons, lithotomists and oculists have already been referred to. People lived much less in doors than they do at present. They had probably much more idle time and a keener relish for amusement. There were no regular newspapers and gossip and scandal, as well as real instruction, were passed from one person to another by word of mouth. In medical teaching, sporadic attempts were made at bedside instruction and even at postmortem sections to confirm the diagnosis, in doubtful cases. These however had, generally speaking, to be abandoned in compliance with popular prejudice. Public dissections, nevertheless, were gradually becoming more frequent. They were held at stated intervals, often four times a year. Probably from the innate human love of the horrible, and the morbid curiosity, which still leads people to chase ambulances, the populace crowded to see these public dissections, which were often followed by festivities and theatrical shows. A special papal indulgence was necessary before the dissection could be undertaken. The cadaver was first made "respectable" by the reading of an official decree, and was then stamped with the seal of the university. After which it was taken into the anatomical hall and beheaded, in deference to the universal prejudice against opening the cranial cavity. Finally, so-called anatomical theaters were built. In England by a law of 1540, four bodies of executed criminals were given over each year to the barbers and surgeons for "anathomyes." A provision which remained substantially in force until the passage of the anatomy act in 1832. Material for dissection was extremely scarce and it was the special ambition of teachers and practitioners to possess a skeleton. Botany began to be studied systematically and botanical gardens were cultivated in various universities. Professors and private practitioners were only indifferently paid. The former receiving from $40 to $200 per annum. Vesalius got $1,000 at Pisa, where he had taught as well as at Padua and Bologna. The physicians-in-ordinary to the English court got $200. Equal to about $2,000 of our currency. Whether they practised "on the outside" we are not informed. Probably they did. In Germany a single uroscopy cost about three cents. Single visits from eight to fifty cents, according to the patient's means. Then as now the surgeons and the genito-urinary practitioners fared better than the clinicians. The former often making small fortunes from the treatment of syphilis.

The practice of medicine during the sixteenth century was bad enough. The influence of the great discoveries, of the leading men of the time, was hardly felt in general practice, which was an unintelligible mixture of quackery, superstition, herb-doctoring, alchemy, and astrology. The followers of Paracelsus were prone to talk of "signatures and quack for universal cures." "Signatures" went way back to ancient East Indian medicine, where yellow plants were given for jaundice, red cows for disease of the vital force (the blood), trefoil (from its shape) for heart disease, walnut shells for disease of the skull, etc., etc. A little reflection will show what superior men the real leaders of medicine were, when surrounded on every hand with such dense ignorance, when superstition, religion, and belief in witchcraft were all united together with medicine in a general mélange, appealing to man's fears and occluding his judgment. The same might be said of the comparatively few true surgeons of ancient times.

Ambroise Paré made the first judicial postmortem examination in 1562, after which the practice gradually became common. Special laws were passed regulating the sale of food, the adulteration of alcoholic liquors, street-cleaning, the prevention of the plague, and so on. Nothing, however, seems to have been done to better the treatment of the insane, who were flogged, chained up, starved, and shamefully neglected, so that many of them died of cold. "Bedlam," originally the monastery of St. Mary of Bethlehem at London, was made into an insane asylum in 1547 and has well deserved the notoriety, which has been conferred upon it by the popular use of its abbreviated title.

Of the epidemic diseases, which had plagued the world in the middle ages, three important ones, leprosy, epidemic cholera, and the sweating sickness had well-nigh disappeared by the middle of the sixteenth century, while syphilis and the plague were still prevalent. Although the virulence of the former had perceptibly diminished, mercury given both internally and externally was the main reliance in its treatment. Medical men, according to their wont, were sharply divided into those favoring mercury and those opposed to it, as a cure for syphilis. All through the century a great number of "pest schriften" were issued. The most important of these were public documents recognizing the contagiousness of the plague and proposing various methods for isolation and disinfection. These "pest schriften" were probably not unlike the periodical publications of our modern boards of health. Gonorrhea also became common about 1520. One visible effect of the prevalence of venereal disease was the suppression of common public baths, both those used by one sex only and those used by both sexes conjointly. Bath

houses were so common in the middle ages that the city of Olm was said in 1489, to have had no less than 168 of them. Baas ascribes the greater frequency of public bathing, in the middle ages, to the fact that underclothes were not worn and the fur and woolen outergarments were seldom changed, so that more frequent bathing was an absolute necessity. He tells that on Sundays the barbers' apprentices beat their basins (which were also hung in front of their places of business, as signs that venesection was performed within) about the streets to give notice that the great bath was about to begin. The diminution of leprosy is also generally ascribed to the suppressions of these baths; yet inasmuch as the contagiousness of this disease, from bodily contact, is now generally denied, probably some other cause for its practical disappearance from Europe must be looked for.

Smallpox and measles began to appear in the north of Europe particularly in Germany (1493) and Sweden (1578). Scurvy, lead poisoning, probably from the use of lead in the cider and wine presses, and especially typhus fever were at times very prevalent in the different European countries in the sixteenth century. Many hospitals had been built in the fifteenth century. Before the reformation they were said to have been seventy-seven in Scotland alone. However as leprosy had so largely disappeared in the next century the lazar-houses were destroyed or put to other uses.

Many of the brightest names in literature and science adorn the annals of the seventeenth century. The appearance of genius in various guises did much to lessen the hold of the professional theologian over men's minds. Yet, as Garrison points out, with the decline of collectivism there came about a diminution in certain activities that had thriven under its régime. Particularly organized nursing and the charitable care of the sick and needy and the hospitals which had been organized for this purpose.

The greatest name in seventeenth century medicine is that of William Harvey (1578–1657) of Folkstone in Kent, who was a pupil of Casserius and Fabricius at Padua and whose work has had a more profound influence upon modern medicine than that of any other man, except Vesalius. In the tardy development of the true theory of the circulation of the blood, we see again the enormous incubus of a stoutly maintained false theory. Galen's hypothetical concept that the blood passes through imaginary pores in the interventricular septum is said to have diverted all speculation regarding the mechanism of the circulation into a wrong channel, for fourteen centuries. Servetus, who almost grasped the true explanation, stated that some (not all) of the blood takes a circuit through the lungs. The drawing of Vesalius, showing the disposition of the terminal twigs of the arteries and veins, almost demonstrated their true function and yet anatomists went blundering along, relying upon the infallible Galen. Harvey was cast in a different mould. He carefully collated, weighed, and found wanting all the previous explanations of the phenomena of the circulation and then proceeded by vivisection, ligation, and perfusion to an inductive proof that the heart acts as a muscular force-pump, driving the blood along in its endless cycle. He showed by mathematical demonstration that the quantity and velocity of the blood made it impossible for it to do otherwise than to return to the heart by the venous route. This was the first application of the idea of measurement of quantity and force, in any biological investigation, and the importance of Harvey's demonstration was not alone that the blood circulates, but that the laws of physics should be applied in the solution of biological questions, just as in any other scientific problem. "With this start, physiology became dynamic science."

In asserting that the heart is a muscular force-pump, Harvey originated the myogenic theory of its anatomy, which was a little later confronted by Borelli's idea that the heart beat has a neurogenic origin. Of these two views each has its adherents at the present time. In the effort to determine the site of the motor power of the cardiac muscle, Harvey fell into the usual medieval philosophical method of attributing the movements of the heart and the blood to the "innate heat" of the latter, which, he goes on to say, is celestial in nature and "identical with the essence of the stars." This astrological theory did much to impede the discovery of the true physiology of the respiration. However, the discovery of the circulation itself was the most momentous event in medical history since Galen's time. Harvey's book "De Motu Cordis" appeared in 1628. It was published at Frankfort on the Main, because, it is claimed, that it could not pass the censor in England.

The unfolding of Harvey's theory of generation is, by some, considered as of equal importance with the discovery of the circulation. It is said that, discouraged by the cold reception with which the latter had been received, he declined to publish the "De Generatione Animalium" until 1651. In it he maintained the doctrine of "epigenesis" to wit, that the organism does not exist preformed in the ovum, but is evolved from it by a gradual building up and aggregation of its parts. Yet he believed the fertilization of the ovum was something incorporeal "as iron touched by the magnet is endowed by its own powers." The great importance of this conception was, that it overthrew the ancient assumption that life is generated out of corruption (or putrefaction), a notion taught in the scriptures and generally accepted until after Harvey's time. Regarding these two great doctrines of Harvey's, Huxley has expressed himself as follows: "In his demonstration of the circulation he was brought to a standstill at one point only, viz., the capillary anastomoses between the arteries and the veins, which he could not see because he had no microscope. So in investigation of the embryo, the minute and patient work of years reached an *impasse* for the same reason." It might be mentioned as showing the thoroughness and deliberation of his methods, that he had announced his doctrine of the circulation in his lectures for twelve years before his book appeared.

The seventeenth century was exceedingly fruitful in anatomical research. The glands of Bartholin, the receptaculum chyli, the duct of Wirsung, the antrum of Highmore, the circle of Willis, the Haversian canals, were some of these important discoveries. The most important was Malpighi's discovery of the capillary anastomosis of the arterioles and minute veins which completed Harvey's monumental demonstration of the circulation. Another epoch-making discovery was Schneider's demonstration (1660) of the membrane which bears his name. This, as every one knows now, secretes the mucus, that for some thousands of years, was supposed to be secreted by the pituitary gland and to be passed from the cavity of the skull into the nose through the foramina of the cribriform plates of the ethmoid bones. Many other discoveries and careful demonstrations of the different parts and organs of the body make this period memorable. Upon them a surer and fuller scientific knowledge of the body and its functions was built up.

The invention of the microscope opened a new world to medical discovery, the study of which brought about as important results as did Galileo's telescope in astronomy. The earliest of the microscopists was the learned Jesuit priest Athanasius Kircher (1602–80) of Fulda, who was a savant and a physician, and was probably the first to make use of the microscope in the study of pathology. He thought that he had discovered countless worms in the blood of patients dead of the plague. He details experiments, showing how maggots and other living creatures are developed in

putrefying organic matter. He was undoubtedly the pioneer in stating the doctrine of a "Contagium Animatum" as the cause of infectious disease. He was followed by Robert Hooke (1635–1703) and Nehemiah Grew (1641–1712). The latter of whom "was probably the first to consider the existence of sex in plants." Swammerdam (1637–1680) discovered and described the red blood corpuscles, the valves of the lymphatics, and the medicolegal fact that fetal lungs will float in water, if the child has breathed.

One of the most distinguished of all microscopists was Leeuwenhoek of Delft (1632–1723) who described the spermatozoa, was the first to give a complete account of the red blood corpuscles, confirmed Malpighi's discovery of the capillaries of the blood-vessels, and was the first to see protozoa under the microscope. The greatest microscopist, however, was Marcello Malpighi (1628–94), professor of anatomy at Bologna, Pisa, and Messina and physician to Pope Innocent XII. He was the founder of histology. His demonstration, of the capillaries of the blood-vessels confirmed and completed Harvey's great discovery. Professor Fraser Harris has said "Harvey made their existence a logical necessity; Malpighi made it an histological certainty." Malpighi's name has been handed down to us in the rete Malpighii and the Malpighian bodies in the spleen and kidneys. Francisco Redi (1626–94) showed experimentally that grubs and maggots do not originate spontaneously in decaying matter. This demonstration, coupled with Leeuwenhoek's discovery of the yeast plant and bacteria, left the important matter of the origin of the lower forms of life in dispute, until it was settled by Pasteur and Schwann.

Theoretical medicine in the seventeenth century was divided into two principle schools or sects, the iatromathematical and the iatrochemical. According to the tenets of the former, all physiological phenomena were entirely dependent upon the laws of physics. While the members of the latter sect regarded all vital processes as essentially chemical reactions. The leading supporters of the iatromathematical school were Descartes, Borelli, and Sanctorius, who were opposed by van Helmont, Sylvius, and Willis, the protagonists of the iatrochemical school. Sylvius (1614–72) professor at Leyden, did for Harvey's work, what Paré had done for Vesalius. He was a wonderfully able and ingenious teacher and numbered among his pupils Willis, de Graaf, Stensen, and Swammerdam.

The founder of the iatrochemical school was the Belgian, van Helmont (1577–1644), originally a Capuchin friar. Like his master, Paracelsus, he believed that each material process of the body is presided over by a special archeus or spirit (which he called Blas) and that these physiological processes are in themselves purely chemical, being each of them due to a special ferment (or gas). These processes are presided over by a sensory-motor soul, located in the pit of the stomach. Hence the sensitiveness of that part of the body to injury. He claimed to have discovered carbon-dioxide gas, but seems to have confounded it with carbon monoxide.

Silvius stripped physiological chemistry of most of the fantastic trappings, with which van Helmont had adorned it. Yet he believed that chemical action underlies all the bodily functions. The great difference between the two schools of medicine was that the physicists claimed that every function of the body was controlled by the mechanical action of the organs and ignored the chemical influences, while the iatrochemists went to the other extreme. It seems almost ludicrous, as we look at it now, that such able and scholarly men should have persisted in looking at only one side of this complex question, and should have refused to believe that the various bodily functions may be accomplished by combined chemical and mechanical action.

As early as 1450 Cardinal Cusanus, a churchman and a good mathematician had made some timely suggestions as to the clinical value of weighing the blood and the urine and of comparing the rate of the pulse and the breathing in health and disease, as estimated by the clepsydra, or water clock. These suggestions were, however, allowed to slumber for some centuries. In 1600 Kepler had used the pulse, as a watch is used, to time his astronomical observations. A few years before that Galileo had invented a rude thermometer or thermoscope. Later he had conceived the idea of using his own pulse as a test of the rate of a pendulum's vibrations. This led him to adopt the converse proposition and test his pulse by the pendulum. Sanctorius (1561–1636) utilized these ideas and described a clinical thermometer and a pulsilogium, or pulse clock. The profession was not ready for these important innovations, which like so many other things of value in medicine, were forgotten for about a century and then rediscovered. Sanctorius's researches upon the "insensible perspiration" of the body and the physiology of metabolism are what have made him well known to modern medicine.

The Hippocratic method, of inductive reasoning from clinical observation, was slowly regaining its lost prestige. Sylvius* was one of the first to introduce bedside instruction in medical education, at his little infirmary of twelve beds at Leyden. He also insisted upon the absolute identity of chemical processes in all media, whether organic or inorganic.

Before Harvey's time, men still believed in the Galenic teaching, that the object of respiration was to cool the fiery heart. They thought that the chest walls expanded and contracted to draw in and expel air, for generating vital spirits by the pulmonary vein, and to get rid of the smoky vapors of the heart by the same channel. Harvey got so far in his refutation of this hypothesis as to show that the blood is changed from venous to arterial in the lungs. But, as Pepys faithfully notes in his diary, no one knew why or how men breathe. The chemist, Robert Boyle (1627–91), made a great step toward the solution of this problem, by showing that neither fire nor animals can exist *in vacuo*. Then Robert Hooke (1635–1703), in 1667, kept a dog alive by blowing air out of a bellows over its open thorax, when there was no movement of the respiratory muscles. This experiment had been performed by Vesalius, and showed, of course, that respiration is not of benefit from the movement of the chest walls but from certain blood changes which occur in the lungs. Mayow (1643–79) showed that dark venous blood is changed to bright arterial blood by taking up some ingredient from the air. He almost discovered oxygen. The physiology of respiration was mainly worked out by these distinguished British observers.

Now comes a great clinician, "who ennobled the practice of physic through those qualities of piety, good humor, and good sense, which Edmund Burke declared to be the genius of the English race." Sydenham disregarded all his predecessors, save Hippocrates, and knew little or nothing of Harvey, Vesalius, Malpighi, or Mayow. His four favorite books were Hippocrates, Cicero, Bacon, and Don Quixote and he cared little for the medical men of his time or their theories. "Authority" in medicine did not influence him for he heeded it not. Garrison says that this very aloofness and indifference, while they cost him the personal regard of his contemporaries, were the real secret of his success as an internist. He held that final causes are inscrutable and theorizing about them is of little use to a clinician. He believed with the father of medicine that materies morbi is "concocted" in the humors of the body and,

* Franciscus Silvius (1614–72) professor at Leyden, should not be confounded with Jacobus Sylvius (1478–1555), an anatomist and the teacher of Vesalius.

in favorable cases, discharged. Hippocrates was his pattern and, more than any other physician, he approaches the Hippocratic standard in his dignified ethical regard for his practice, his reverence toward God, and his careful bedside study of every case. His theory of epidemic constitutions, attributing contagion to the air or to the condition of the soil is obsolete. Although Pettenkofer did revive certain features of it with his "soil water." Sydenham was a strong exponent of "English common sense" in medicine. He believed in fresh air in sick rooms, equestrian exercise in consumption, cooling drinks in smallpox, and plenty of quinine or cinchona in agues, iron in chlorosis, and the liquid preparation of opium which bears his name. His prescriptions consisted largely of vegetable simples and he avoided the filthy ingredients which the London pharmacopœia directed even at that date. He let blood, in moderate quantities, in almost every disease. His "Processus Integri," containing his rules of practice, was the *vade mecum* of the English practitioner for more than a century, and is said to have been committed to memory by an Oxford enthusiast. He was a sound sensible all around man who denied the infectiousness of smallpox and the circulation of the blood; but was a great clinician for all that.

The first book on vital statistics was written by an Englishman, John Gaunt (London, 1662), who was the first to show that there are more boys born than girls and that the population can be estimated from the death rate.

In the seventeenth century, the time of the rise of England and Holland, the continued battle for freedom of thought made the times rather conducive to individual scientific achievement than to the concerted advance of science. The better understanding and enforcement of law did much to define and establish the position of the medical man in society and to secure for him better legal protection. Unfortunately the surgeon was still somewhat under the ban, except when needed in war time, and then he was still obliged to shave the officers, while the lucrative posts, such as court and municipal physician at a good salary, all went to the purely medical practitioners. There were two factors of great help to the profession as a whole, which became active in the seventeenth century, viz., the foundation of a number of scientific societies and the publication of scientific and medical periodicals. The great centers of medical education were Leyden, Paris, and Montpellier. In Germany, not much could be done in the universities until after the peace of Westphalia (1648). Yet even after that time, much scientific research was carried on by physicians all over Europe who were not connected with universities. There was a wonderful increase in this work and a large output of brilliant results in anatomy and physiology, after the close of the thirty years war. Just as in France, the golden age of medical advance, at the beginning of the nineteenth century, followed the close of the revolution. The Germans still seemed ashamed of their native tongue. They stirred up what Garrison styles "a lively tea-pot tempest" when Thomasius, in 1688, tried to follow the example of Paracelsus and lecture in the vernacular. The same prejudice was even met by Schönlein in 1840. Although Sydenham, Glisson, Sylvius, and a few others did more or less medical teaching at the bedside, this method had few followers in the seventeenth century. The usual plan of imparting medical instruction was by reading perfunctory didactic lectures in Latin. These were followed by a mélange of prescriptions, which were Galenical, spagirical, iatromechanical, iatrochemical, or Hermetic and which the students copied, and no doubt later "exhibited" for the benefit of their patients. Dissections were more common in Italy, Holland, and France than in England or Germany. In France, Vieussens is said to have made 500 dissections. The great popularity of dissecting in Holland is shown by the large numbers of pictures of professors and their classes, thus engaged, which were painted about this time, some of which are still highly prized as works of art.

As the leading physicians of the Renaissance were usually botanists or zoologists, as well as physicians, so we find the seventeenth century physician busying himself with astronomy, mathematics, physics, microscopy, or chemistry as well as with his profession. In university teaching, as Holmes once said, a professor "might occupy a whole settee of professorships." Meiborn, for instance, taught philosophy, philology, archeology, and geometry as well as medicine at Helmstadt. At other universities one professor frequently filled at least two or three different chairs. There seem to have been in those days two classes of chemists, the scientific and the commercial, just as there are now. Johann Glauber (1604–88) of Carlstadt, whose bust was used as a chemist's sign for about two hundred years, discovered sodium sulphate (Glauber's salt) and a number of equally important chemical substances. He published a valuable encyclopedia of chemical processes, and sold "secrets" to manufacturers; some of which were alleged to be unworkable and some, to have been previously sold to his customer's rivals. His greatest secret he declined to part with for money or any consideration whatever. It was the universal solvent or the "alkahest." Hence Oliver Cromwell probably had reason for saying "this Glauber is an arrant knave." Yet he was the greatest analytical chemist of his time. Although forbidden by papal bull, alchemy flourished apace in the sixteenth and seventeenth centuries. Just where honest delusion ends and knavery begins in the mystic rites which were cherished and practised under the name of alchemy no one can tell. It seemed to be a sort of disease or infection, which infected everybody more or less. It did unquestionably lend its aid in forming a number of offshoots from the Paracelsian or Spagiric School, which bore such titles as the Cabalistic, Zoroastrian, Hermetic, or Rosicrucian. Of course people were superstitious in those days; more so than they are to-day, and many of them believed in Sir Kenelm Digby's sympathetic powder, which was applied, in case of wounds, to the weapon and not to the patient. This remedy did not lack for testimonials, presumably "unsolicited," such as that of Madame de Sévigné, who pronounced it "a perfectly divine remedy," and that of the Duke of Buckingham, who averred that Sir Kenelm had healed his secretary of a gangrenous wound, by simply soaking the bloody bandage in a solution of the powder. There is this to be said regarding this treatment, that the wound escaped the meddlesome and often infecting treatment of salves and poultices, so commonly used in old days, and "Nature had a chance." The sympathetic treatment was, like many other things, originated by Paracelsus and was exploited by Rudolph Goelenius in 1608. Probably the action of the clergy in declaring that its power came from the devil and from magic added to its popularity. Fludd (1619), van Helmont (1621), and Maxwell (1679) started the animal magnetism theory, which was put into practice by Valentine Greatrakes (1628–66), a soldier in Cromwell's army in Ireland. He made a tremendous success of curing disease by laying on of hands and also cured scrofula by carrot poultices. The cure of the last-named disease was, however, the prerogative of royalty. Since cure by touch or laying on of hands was an attribute of the deity, it was supposed to descend to kings as part of their divine right. Thousands of scrofulous sufferers were touched by various monarchs. Charles II of England touched some 100,000 persons in twelve years. Doctor Johnson was touched by Queen Anne, without success. In his "Enquiries into Vulgar and

Common Errors" (1646) Sir Thomas Browne does not animadvert upon the royal touch. This same censor, however, firmly believed in witchcraft and other common superstitions.

Thus while medical science was really advancing in the seventeenth century, popular medicine was in some respects retrograding toward the follies of the Byzantine period, which, as Garrison observes, "bears out our main thesis, that the ways of folk-medicine are inevitably the same and independent of time, place, and circumstance." He gives us a synopsis of the materia medica of the period to prove his proposition. In this it is stated that the first edition of the London Pharmacopœia, published in 1618, contains a list of 1,960 remedies of which 1,028 were simples, 91 animal, 271 vegetable. Among these were worms, lozenges of dried vipers, foxes' lungs (for asthma), powders of precious stones, oil of bricks, oil of ants, oil of wolves, and butter made in May (for ointments), Vigo's plaster (compounded of viper's flesh, with live frogs and worms) and the celebrated antidote of Mattioli, made up of about 230 ingredients, including the multifarious mithridate (*confectio Damocratis*) and the theriaca Andromachi. The pharmocopœia of 1650 contains moss from the skull of a person, who had died a violent death, and Gascoynes' powder compounded of bezoar, amber, pearls, crabs' eyes, coral, and the black tops of crabs' claws. In the edition of 1677 there was a gratifying absence of the Greek and Arabian names of the medicaments, showing that their influence was disappearing, while such standard remedies as jalap, cinchona bark, burnt alum, digitalis, etc., including Irish whiskey (*aqua vitæ Hibernorum sive usquebaugh*), had made their appearance, as had also human urine so highly recommended by Madame de Sévigné (June 13, 1685). This talented lady also strongly advised viper meat to "temper, purify, and refresh the blood." It was even claimed that Sir Kenelm Digby had poisoned his wife by the too frequent administration of viper's wine, given for cosmetic purposes. Innumerable queer and more or less disgusting remedies appear in all three of the pharmacopœias, such as horns, hoofs, excreta of animals of all sorts, eggs, viscera, bones, claws, etc., fur, feathers, isinglass, human perspiration, saliva of a fasting man, human placenta, cast-off snake's skin, wood-lice, swallow's nests, the triangular Wormian bone from the junction of the sagittal and lambdoid sutures of the skull of an executed criminal. This mélange closely resembles the Chinese pharmacopœia of the present day. Quite likely the formulæ for many of these priceless remedies, in both European and Asiatic pharmacopœias, originally came from the same source. Paracelsus was wont to prescribe human ordure, and Minderer ordered oil of spiders and earthworms for plague. Glauber, in 1658, urged the employment of chemical preparations presumably for catharsis in place of animal excreta. In the seventeenth century people were perhaps more credulous regarding nostrums and their efficacy than they are now. Charles II gave from £5,000 to £15,000 for the formula for "Goddard's drops" recommended by Sydenham and alleged to have been made of raw silk. Rochelle salts was originally sold as a proprietary remedy. Singleton's "Golden Eye Ointment" is said to be the oldest proprietary medicine sold in England. It is still manufactured and sold as a proprietary remedy.

Professional poisoning was carried on to a notable extent in the sixteenth and seventeenth centuries. Exili left Rome for Paris with a record of 150 deaths against him. There was in Paris a fashionable epidemic of secret poisoning against which Louis XIV instituted the celebrated "Chambre Ardente." A Neapolitan woman confessed in 1709 to having poisoned over 600 persons. The poison used was probably arsenic, somewhat felicitously styled in France "*poudre de succession.*"

Apothecaries had a golden harvest in the seventeenth century, if they could get the prescriptions to put up. The grocers were originally the drug merchants, but the apothecaries finally succeeded, in 1617, in getting the business all into their own hands by means of a new charter, after which they had their troubles with the physicians. The former would, even as at present, prescribe over the counter, while the latter were disposed to dispense their own drugs. The druggists scored on the doctors in the great plague in London, in 1665, when the latter (including even Sydenham) fled for their lives, while the apothecaries stuck to their posts. They were especially celebrated for extortion. One of them in 1633 charging 30s. for a single pill and £37.10s. for a boxfull. Another charged £6 each for a pill and an apozeme (decoction). Pitt in 1703 stated that druggists charged at least ninety per cent. more than the merchant's prices for drugs. Physicians got good fees and were held in high esteem in the seventeenth century, but they had one bitter and relentless enemy in Molière (1622–73), who as Garrison puts it, afforded the best sidelight on the pedantic formalism and complacent ineptitude of the French internist of the period. Molière's biting wit and stinging sarcasm were supposed to have been aroused against the profession because the latter could not cure his own disease (consumption), and because he believed that they had killed his only son and one of his bosom friends with their everlasting antimony. The same sort of raillery is found in Gil Blas, published in 1715, in which two doctors, in consultation, agree that the patient's trouble is "a mutiny of the humors." The latter loses his life because his medical attendants cannot agree whether the Hippocratic word ὀργασμός means a fermentation or a concoction of these humors. Instances are related in which a rheumatic patient was bled sixty-four times and a fever patient thirty-six times. Guy Patin bled himself seven times for a cold in the head, his wife twelve times for a "fluxion in the chest," and his son twenty times for a continued fever. The rationale of this treatment was in the copious draughts of water, which accompanied the bleeding. They were supposed to act as a blood-washing in the evacuation of peccant humors. Higgins tells a characteristic story of the experience of Louis XIV of France who, in the short space of one year, took 215 different medicines, 212 enemata, and was bled no less than forty-seven times." Higgins adds "a kindly historian would surely take such adverse circumstances into consideration, when he gave his judicial opinions on the acts of such unfortunate monarchs." It is not likely that the sainted Louis employed physicians that Hippocrates would thoroughly approve of. For the latter said "it is in the use of simple means that great physicians especially differ from others."

Hydrotherapy in the seventeenth century was more in vogue than in the eighteenth and nineteenth. In taking a course of bathing the patient must remain 124 hours in the bath, with frequent cupping and venesection accompanied with the consumption of enormous quantities of food. The love of pageantry and ceremony was exemplified in the graduation exercises of German and French medical students, which were absurdly elaborate and expensive. The elector of Brandenburg issued an edict in 1683, on behalf of poor students, cutting down the feasting and presents, which the candidate had to pay for. The hazing and "pennalism," among the students, were barbarous beyond belief. The lower order of surgeons and strolling practitioners have already been spoken of. Some of the paintings of the period depict the tooth drawers, uroscopists, crystal-gazers, chiropodists, rope-dancers, and every variety of low mountebank and quack. The old legend that mental defectives had a stone in the head was taken advantage of, by some of these imposters, who would incise the scalp and, having palmed one or more stones, would toss them into a convenient basket during the patient's struggles.

Russian Medicine.—The seventeenth century marks the beginning of two phases of national medicine —the Russian and the American. In the fifteenth century Ivan III, the first czar, had invited foreign doctors to settle in Moscow, with the encouraging provision, that if they failed to cure their patients, they would have their throats cut. In the reign of Ivan IV (1533–84), surnamed the Terrible, many English doctors came to Moscow by invitation, and some of them acted as ambassadors or diplomatists. One of them founded an apteka or drug store in 1581. More physicians went to Russia in the times of Peter the Great and Catharine, and this influx continued until well into the eighteenth century, though, like the Greek medical men in Rome, they were looked at rather askance by the populace who did not neglect to sack their houses in civic uprisings. Upon their arrival in Russia, the foreign physicians took an oath of office pledging themselves not to use poisonous drugs. After an audience with the czar, they were given rich presents of money, horses, provender, and sometimes they were presented with an estate of from thirty to forty "souls." The Russian medical superstitions were entirely similar to the folk medicine of other countries. Extracts from insects and the viscera and organs of animals and a multitudinous array of real and supposed medicaments were recommended for use, including the unicorn's horn. For three specimens of this panacea 100,000 roubles ($30,000) had been offered in 1655. "A sort of miniature Siberian pharmacopœia" was drawn up in 1671 "based upon information gathered from the peasants by the Siberian *voyevods*, or military governors. Under the Romanoffs a Ministry of Medical Affairs was established, also a central store (apteka) for the distribution of drugs to the followers of the Moscow court. Later this distribution was extended to the soldiers and civilians, and the prevention of contagion was undertaken, which was the starting-point of the paternal public health service of Russia.

American Medicine.—A number of European physicians naturally drifted into the British colonies of North America very soon after their settlement. Prominent among these was Dr. Lawrence Bohun, who became Physician General of Virginia in 1611. Dr. John Pot was the first doctor to settle permanently in the colony. He was elected governor of Virginia in 1628. Dr. Johannes La Montague, a Huguenot, was councillor to the director general of the New Netherlands. Dr. Samuel Fuller came over in the *Mayflower* and practised in New England until his death, in 1633, and Dr. John Winthrop, Jr., was the first governor of Connecticut. One of these emigrant physicians, Thomas Thacher, was the author of the single medical work printed in North America in the seventeenth century (1677). Higher education had already made a start in New England by the foundation of Harvard College (1636), which was followed by the establishment of William and Mary College in Virginia in 1693. Those able to travel, among the students of medicine, went to Leyden, Oxford, or Paris to finish their education. The practice of physic and preaching the gospel were often combined. Giles Firmin, made famous by Oliver Wendell Holmes, was one of these clerical practitioners. He had delivered a course of anatomical lectures in New England prior to 1647. According to Dr. Holmes "His anatomy he got from Vesalius, Paré, Fallopius, and Spigelius; his internal medicine was a mixture of the Greeks, Fernelius, van Helmont, and Sir Kenelm Digby; his pathology was mythology." Holmes continues: "Barbeyrac and his scholar, Sydenham, had not yet cleansed the pharmacopœia of its perilous stuff, but there is no doubt that the more sensible physicians of that day knew well enough that a good honest herb tea, which amused the patient and his nurses, was all that was needed to carry him through all common disorders.

Two notable features of the development of American medicine were, first that medical students were apprenticed to practising physicians, and while they earned their keep by menial offices, they also became practical pharmacists, as the colonial doctor, generally from necessity, dispensed his own drugs. His students mixed the potions, rubbed the ointments, spread the plasters, and rolled the pills. They also held the broken leg while the doctor fitted the splints, held the basin while he bled the patient, sharpened the instruments, and collected the bills—in short learned the business from the bottom up. The second feature of colonial practice was also an important adjunct in developing that practical side of American medicine, which has always been one of its creditable characteristics. It was the fact that, owing to sparse settlements and crude means of locomotion, a practising physician had to depend upon himself in all sorts of emergencies. He must practise every sort of specialty, with the result that the better American doctors developed a great deal of common sense in handling their patients, just as Dr. Holmes hinted in the lines quoted above. The exasperating distinctions of the old world between physicians and surgeons; between surgeons of the long robe and the short robe; the professor of high degree and the humble apothecary, who was allowed to do certain things, but must not purge a patient, never hindered medical progress in America. Also owing to the comparative poverty of the early settlers and the long distances between different settlements, and so on, the strolling quacks and mountebanks, the vagabond surgeons and lithotomists have never flourished in this country. On the other hand, the fact that in America the people are not and never have been so thoroughly under medical influence as in Europe is no doubt one of the principle reasons that any half-baked theory of treatment can be more successfully exploited here than abroad, and our people are probably the most zealous and incurable self-druggers in the world. Garrison says that no doctors were mentioned in connection with the scandals of the Salem witchcraft trials in 1692. The professional men of Boston, however, bitterly opposed and even persecuted Dr. Zabdiel Boylston (1680–1766), who advocated and attempted to introduce into general practice, in the early part of the eighteenth century, the inoculation with the virus of smallpox as a prophylactic against the disease.

Such medical legislation as was passed in America in the seventeenth century was, like the Code Hammurabi, mainly directed toward the absorbing question of fees. As early as 1636, the assembly of Virginia passed an act providing that those who had served an apprenticeship as surgeon and apothecary should receive five shillings a visit and university graduates should receive ten shillings. Doctors' bills were generally settled in merchandise; and in 1638–39 the assemblies of Maryland and Virginia passed laws to moderate them. In 1649 the Massachusetts colony adopted a law forbidding any one to practise medicine, surgery, or midwifery, who had not been judged competent by "some of the wisest and gravest" or most skilful in the same art, with the additional consent of the patient. A similar law was passed in New York in 1665, and in 1699 an act to prevent the spread of infectious diseases became a law in Massachusetts.

The first hospital in the New World was built by Cortez in the city of Mexico in 1524. A Hôtel Dieu was established in Canada by the Duchesse d'Aquilon. It was ultimately located at Quebec. The Montreal Hôtel Dieu was founded in 1644 and the General Hospital at Quebec in 1693. The first hospital in what is now the United States was established on Manhattan Island in 1663.

During the seventeenth century wars, famines, and pestilences devastated the earth, and took as great a toll in human life as they had done in the preceeding hundred years. No sermons on the necessity for

health-boards and quarantine restrictions could possibly be as eloquent as the figures of the death rates from contagious diseases in the middle ages. Making all due allowance for possible error and exaggeration, the death rate from pestilences was simply appalling in the seventeenth century and its predecessors, probably nothing quite so bad will ever be seen again; certainly not unless the world shall relapse once more into barbarism, which, judging from the present war in Europe, it is quite capable of doing.

The eighteenth century in medicine was essentially an age of theorists and system-makers. Leaving out a few brilliant thinkers, like Jenner, Hunter, and Morgagni, the entire century was almost as dull and unproductive in medicine as the Arabic period. As Garrison beautifully puts it, "We see the great theorists of the time, as Emerson has described the gods, each sitting apart in his own sphere, 'beckoning up to their thrones,' yet somehow Hippocrates and Sydenham, Vesalius and Harvey, Celsus and Paré seem nearer and more accessible to moderns than Stahl of Barthez, Bordeu or Boerhaave, Brown or Reil."

Goethe has dwelt upon the ludicrous side of the eighteenth century mania for sterile, formal, desiccated, soulless classifications of everything in the earth and heaven. He was the ablest plant morphologist of his time and took a strong interest in every rational science including medicine. An essay on the history of medicine must deal with the theorists that occupied the stage a century or two ago, and solemnly arrogated to themselves all possible credit for any advance that had been made or might be made in medicine so long as the world should stand. But a careful examination of their different theories would be entirely beyond the limits of this paper.

Georg Ernst Stahl (1660–1734) of Ansbach revived van Helmont's idea of a "sensitive soul" as the source of all vital phenomena. As this acted without the aid of archæi or ferments, its author maintained that a knowledge of anatomy and chemistry is useless in medicine. His conception of life seemed to be "a natural power of perpetual duration as a consequence of exemption from putrefaction." He did write on the diseases of the portal system (1698) so well that even Virchow praised his work; he also left an account of lacrymal fistula. These two productions sum up his contributions to medical science that were of any value. Although a great chemist, he did a great deal to set back progress in chemistry by his doctrine that a substance, which he called phlogiston, is set free from any material when it is burned. He said that the burned matter was "dephlogisticated," although it had been experimentally shown that matter gains instead of losing weight during combustion. Stahl seemed to be unbalanced mentally. At any rate he became at last a confirmed melancholic. One notable achievement, however, should be credited to him. He was a great chemist, and he liberated chemistry from the stain of alchemy and from its servitude to pharmacy, and transformed it into an independent science.

His principal follower was Sauvages, whose "Nosologica Methodica" was published in 1768 and was an example of taxonomy gone mad. His classification of disease was similar to those used in natural history, subdividing them into ten classes, with as many as 295 genera and 2,400 species.

The animism of Stahl finally merged into the vitalism of Bordeu, Barthez, Bichat, and Bouchut and seemed to wind up in the "entelechies" of Driesch. Then we have the doctrine of "irritability" advocated by Glisson and Haller. William Cullen (1712–90) of Edinburgh had a nervous theory which looked upon muscle as merely a continuation of nerve and life itself as simply a function of nervous energy. The ancient doctrine of the Methodists, the "strictum et laxum," so strongly urged by Asclepiades, was revivified. Hoffman (1660–1742) assumed a mysterious, ether-like fluid which acted upon the muscles through the nerves and kept them in a state of partial tonic contraction, and also kept the humors in motion. When this agent acted too strongly acute diseases followed and when it was too much relaxed, chronic ailments were present. He also admitted that faulty excretions or changes in the humors might cause disease. He has been called the greatest of the iatromechanists and seemed to perceive in a blundering way that "pathology is an aspect of physiology."

And now comes John Brown (1735–88), "the disputatious and disreputable Brown" as Allbutt dubs him. His doctrine of sthenic and asthenic diseases was, like so many of these theories, only a modification of Methodism. The chief reason for its rather remarkable success was that nearly all diseases were esteemed "asthenic" and were to be combated with rich food and alcoholic beverages, supplemented at times by opium of which Brown was very fond. Baas says that his therapeutic ideas killed more people than the French Revolution and the wars of Napoleon combined. If we are to construe this statement as a rough estimate of the deadly effects of alcohol, even for one century, it must be admitted that it is highly conservative.

Johann Kampf, like some more modern practitioners, asserted that the causa causans of most human ills was fecal impaction, only he gave it a Latin name, calling it the "doctrine of the infarctus." This fine theory accentuated the then fashion of using clysters, to which Molière and sundry other humorists and artists of the period have called our attention.

Herman Boerhaave (1668–1738) was the greatest clinician of the eighteenth century, a great teacher and a good chemist. His "Elementæ Chemicæ" was the best book on the subject which appeared in that century. He founded what he called the "Eclectic School," "hashing up the partial truths and entire errors of his time." He kept Peter the Great, who came to consult him, waiting over night, because he was no respector of persons. He was said to have said that he preferred to treat the poor because they had the best paymaster. In other words, he understood human nature. He is credited with being the first to prove that smallpox is conveyed only by contagion and that pleurisy is confined to the pleura. As a chemist he is best known for his discovery of the affinity of substances and for an improved method of making vinegar.

These eighteenth century theories are certainly not entitled to the respect with which we regard their prototypes, and give much color to the popular notion that the progress of medicine itself is only a "succession of forgotten theories." It might seem to the irreverent that these learned professors discouraged, as "professors" still sometimes do, the study of medical history so that the sources of their "inspirations" might not be too familiar to the average practitioner.

One of the greatest figures in all medical history was von Haller (1708–77), the leading physiologist of his time. Sir Michael Foster said of his great work on physiology that to open it is to pass into modern times. He was also a literateur, a poet, and the best medical historian since Guy de Chauliac. He neglected to promulgate a system and left no school or sect to argue over unessentials with posterity. Remazzini (1633–1714) deserves credit for opening a new department in modern medicine, namely, a study of occupational diseases. He was the first after Paracelsus to describe stonemason's and miner's phthisis and similar preventable maladies. An old Prussian army chaplain, Süssmelch (1707–77), did epoch-making work in collecting vital and medical statistics and insisting on their moral and political significance. He showed that the true wealth of any nation depends upon its industrious and vigorous native population and not merely upon material resources. The intelligent application of this principle is the secret of the great power and influence

of the present German Empire. He was followed by Peter Frank (1745–1821), the founder of public hygiene. His great work on this subject, covering the whole of a man's life "from the womb to the tomb," sewerage, water supply, sexual hygiene, school hygiene, including proper food and benches for children, as well as the ideal of a scientific "medical police," really, as Garrison thinks, leaves little for Pettenkofer and modern hygienists. In the preventive medicine of the future, his name will shine with increasing brightness for he was really a modern. Blumenbach (1752–1840) of Göttingen and Pieter Camper (1722–89) were the founders of the science of anthropology and craniology. Stephen Hales (1677–1761), an English clergyman, was the originator of artificial ventilation and invented a manometer or tonometer, with which he made quantitative estimates of the blood pressure, the capacity of the heart, and the velocity of the blood current. de Réaumur (1683–1757) advanced the knowledge of the physiology of digestion by isolating the gastric juice of a bird and demonstrating its solvent action. The Abbé Spallanzani (1729–99), a priest of Scandiano, Italy, was a great experimental physiologist and originator of important experimental results. He discovered the digestive power of saliva, reaffirmed the solvent power of gastric juice, and refuted experimentally the doctrine of spontaneous generation. His work lay dormant for about a hundred years when it was taken up and proved to be correct by Roux, Driesch, Morgan, Loeb, and others. Hewson, Cruikshank, Whytt, and Black were eminent and successful teachers and experimenters in physiology, neurology, and the use of electricity in physiology and therapeutics. Probably the best bit of physiological work in the century was the complete demonstration of the modern theory of respiration in which Joseph Black (1728–99) bore a leading part. He was followed by Priestley (1733–1804), the discoverer of oxygen, who, however, was a confirmed Stahlian and referred to respiration as "the phlogistication of dephlogisticated air." It was left to the great French chemist Lavoisier (1743–94) to discover the true nature of the interchange of the gases in the lungs, and to demolish the phlogiston theory, by introducing a knowledge of quantitative relations in chemistry. With the aid of Laplace, he demonstrated that respiration is in every way the analogue of combustion, the chemical products being carbon dioxide and water. He was in error in assuming that the oxidation of carbon and hydrogen takes place in the tubules of the lungs. This was corrected by Lagrange, in 1791, who showed that the dissolved oxygen of the inspired air slowly takes up carbon and hydrogen from the tissues as the blood courses through them. The crowning work of this long and intricate demonstration was done when Gustav Magnus, in 1837, showed that venous and arterial blood both contain oxygen, as well as carbon dioxide, proving that all the tissues respire in the sense of taking up oxygen and giving off carbon dioxide. Thus we see that the development of the knowledge of the physiology of respiration from Borelli to Magnus (about 150 years) was practically the work of three mathematicians, two physicists, and five chemists.

The eighteenth century produced one of the three greatest surgeons of the world, John Hunter, the other two being Paré, belonging to the sixteenth, and Lister belonging to the nineteenth, centuries.

Clinical medicine made a notable advance, which tended to replace shrewd guesswork with demonstrable certainty in the diagnosis of chest diseases, when Auenbrugger (1722–1809) brought out his discovery of immediate percussion of the chest. Like most valuable discoveries in medicine, according to the dictum of Dr. Baas, it was at first snubbed and ridiculed. de Haen, Springel, and other contemporaries of Auenbrugger delighted in holding it up to derision, just as the wise professors in Philadelphia inveighed against Dr. Holmes when he published his memorable essay on the infectiousness of puerperal fever. Thirty or forty years after the appearance of Auenbrugger's book, Corvisart took the matter up and introduced Auenbrugger to his own countrymen and to all the world, as the sole inventor of this great aid to diagnosis. The chivalrous Frenchman disclaimed all credit for his part in the transaction, although, without his intervention, the knowledge of the discovery might have slept indefinitely.

Morgagni (1682–1771), a professor at Padua, published the results of his life work in his seventy-ninth year. It was the true foundation of modern pathological anatomy, because for the first time the postmortem findings were compared with the clinical records of the cases on an extensive scale. While others like Bonetus or Benivieni had made some postmortem sections and studied the diseased viscera with intelligence, still Morgagni, by the vast extent of his researches and their thoroughness, established pathological anatomy as a branch of modern scientific medicine, even if, as Allbutt asserts, the "seed fell upon hard and sterile ground." He first described syphilitic aneurysm, disease of the mitral valve, acute yellow atrophy of the liver, tuberculosis of the kidney, the first recorded case of heart block, and so on. He had a worthy successor in Matthew Baillie (1761–1823) who like the Hunters, Smellie, and Cullen was a native of Lanarkshire, Scotland. He described hepatization of the lungs in pneumonia, distinguished renal cysts from hydatids, described gastric ulcer, endocarditis, and the ulceration of Peyer's patches in typhoid fever (although he did not understand the lesion).

During the eighteenth century clinical medicine reached out toward the employment of diagnostic instruments of precision. Sir John Floyer (1649–1734) of Staffordshire published his "Physicians Pulse Watch," which was the first effort for a hundred years to revive the studies of Galileo, Kepler, and Sanctorius in the matter of accurately timing the pulse. Floyer tried to time the pulse rate with a watch which ran for exactly one minute. He tabulated his results and published them, but his efforts were largely vitiated by an officious revival of the old Galenic doctrine of "specific pulses," *i.e.* an especial pulse for every disease. Dr. Weir Mitchell, writing on instruments of precision in medicine, says regarding the pulse studies in the eighteenth century, "It is observation gone minutely mad; a whole Lilliput of symptoms; an exasperating waste of human intelligence." Similar strictures would apply to a great many things in medical history down even to the present day.

The clinical thermometer, already conceived and partly developed by Sanctorius, Boerhaave, de Haen, and Haller was revived by George Martine (1702–1741), a Scotchman. His ideas were put into practice by James Currie (1756–1805), another Scot. Long before Brand's time, Currie used cold baths in the treatment of typhoid fever and tabulated his results according to the readings of a clinical thermometer. He used sea-water douches, regulating their temperature and frequency by the thermometrical readings. Weir Mitchell declares that there is "absolute genius" in Currie's book which like Floyer's, Auenbrugger's, and Martine's was soon laid aside. Withering (1741–99) of Shropshire, England, introduced digitalis, the use of which in dropsy had been communicated to him by an old woman. The distinction between cardiac, renal, and hepatic dropsy had not then been made, and Withering was much disappointed that he could not reduce "cerebral dropsy" (hydrocephalus) and ovarian (cystic) dropsy with digitalis.

Cullen (1710–90) was the first lecturer in Great Britain to use the vernacular, instead of Latin, in his medical lectures. He is known for his system of nervous pathology and for his great vogue as a teacher. His "First Lines of Medical Practice" was for years a text-book in Great Britain and America.

Many well-known names of English physicians in Queen Anne's time, such as Radcliffe, Mead, Garth, Arbuthnot, Sloane, and Blackmore have a social or literary rather than a scientific interest. Heberden (1710–1801) conferred a favor on the world, if not directly on the apothecaries, by banishing mithridatium and theriaca forever from the pharmacopœia. They were antique and almost indestructible monuments of the barbarous and childish polypharmacy of the middle ages. Heberden's little book is one of the shining lights of real scholarship in a medical man. John Lettsom wrote the first paper on the drug habit in 1789. It was an original account of alcoholism. Parry (1755–1822) deserves the credit for the first description of Graves' disease, which should have been named after him. Huxham (1692–1768) wrote some famous essays, invented Huxham's tincture, and cured scurvy with a vegetable diet. Sir George Baker (1722–1809), having proved that the lead used in making Devonshire cider produced lead colic in those who drank the beverage, was denounced from the pulpit as "a faithless son of Devon." Sir John Pringle (1707–82) was a true philanthropist. He was the founder of modern military surgery and the originator of the Red Cross idea. He secured better ventilation in barracks, ships, jails, and mines and was the pioneer in establishing the idea of antisepsis. The epoch-making jail reforms of John Howard (1726–90) had much to do with the suppression of that vermin-carried disease typhus fever.

In the clinical medicine of France we find little of value in the eighteenth century. Théophile de Bordeu (1722–76) founded another of those tiresome systems of medicine called the "Vitalistic School of Montpellier." This was not unlike van Helmont's. The bodily organs, he taught, were presided over by the "tripod of life:" the stomach, the heart, and the brain. He held that each organ and gland of the body is a workshop for the production of a specific secretion, which passes into the blood, and upon these the integration of the economy depends. So he outlined in theory the modern doctrine of internal secretions and "harmonic equilibrium." He was followed by Barthez (1734–1806) of Montpellier, a versatile and ingenious man of many callings, who invented the term "vital principle" to denote the cause of the phenomena in the living body. The vitalism of Bordeu and Barthez underwent a third transformation in the nineteenth century as the "seminal vitalism" of Bouchut.

Van Swieten (1700–72) was the great Austrian clinician and statesman and an especial friend of Maria Theresa. He spent thirty years in writing a commentary on the aphorisms of Boerhaave. Anton de Haen (1704–76) of the Hague was a prominent member of the Vienna group. He occasionally used the clinical thermometer and quarreled with almost everyone he met. His treatment of his contemporary Auenbrugger has already been mentioned. In Germany there were a number of clinicians and writers of no especial excellence. Stahl, and his system, we have already noticed. Zimmermann (1728–95) wrote among other works a "Treatise on Solitude" which (Garrison says) "so tickled the sentimental palates of our grandfathers." Tissot (1728–97) of Lausanne was a well-known and popular writer on medicine and hygiene. His best known work was "*Avis au peuple sur la santé*" (1760), a popular medical tract which ran through ten editions in less than six years and was translated into every European language. Tronchin (1709–81) of Geneva, Voltaire's favorite physician, wrote on lead colic, introduced inoculation into Holland, Switzerland, and France and had 20,000 successful cases to his credit. He was the pioneer in the open-air cult, in psychotherapy, and suspension in spinal curvature.

Pellagra was originally described by Gaspar Casal (1691–1759), a Spanish physician. It was called at first rose sickness. An Italian, Francisco Frapolli, in 1771, described the disease thoroughly, giving it its present name. Franz Anton Mesmer (1734–1815) of Itznang, Switzerland, revived Athanasius Kircher's hypnotic ideas, calling his theory "animal magnetism." He started practice in Vienna, but was driven out by a royal commission. He opened an office in Paris in 1778 and soon had a lucrative practice. In his séances, he appeared clad in a lilac suit in a dimly lighted chamber, playing upon a harmonica, touching his patients with a wand, staring into their eyes, and attending them in a private chamber in case of a "crisis." He also had a number of magnetic tubs, or *baguets*, which contained a mixture composed of hydrogen sulphide and other ingredients and provided with iron conductors from which depended a ring for touching the patients, who stood around these ill-smelling tubs joining hands. He was finally investigated by another committee and driven from Paris. Although mesmerism, or hypnotism, did not have any scientific status until after Braid's book was published in 1843, it excited very great interest. In London the quack James Graham, an Edinburgh physician, established the notorious "Temple of Health" (Templum Æsculapio Sacrum), a gorgeous affair in which for some time he successfully perpetrated "a gigantic system of impostures."

With all its lack of instrumental precision the internal medicine of the eighteenth century, as a whole, surpassed its surgery, so Garrison thinks, because the systematic tendencies of the time brought out specialized text-books and some new and valuable drugs, and led to the accurate study and description of many diseases previously undefined or misunderstood.

Toward the end of the century came one of the greatest triumphs in the history of medicine—the successful introduction of vaccination against smallpox by Edward Jenner (1749–1823). He had long been cognizant of the reputed immunity to the disease which those who had had cowpox possessed. In 1778 he began a systematic study of the two diseases and the collection of all available data and, after eighteen year's study, in 1796 vaccinated his first patient, using virus from the arm of a milkmaid who had contracted cowpox in the usual way. Six weeks afterward he inoculated the vaccinated patient with smallpox virus, which would not "take." In 1798 he had repeated the same processes with twenty-three patients and published his cases, all of which had been successful. In the next eight years he published five pamphlets recording further cases and giving directions for improved technique in vaccination, even mentioning ivory points as the best vectors of the virus. Thus he had followed out the advice of John Hunter, his friend and preceptor, who, after hearing Jenner's account of the probable efficacy of cowpox virus as a prophylactic against smallpox, said "Don't think, try; be patient, be accurate."

So pressing was the need for some defense against the common scourge, smallpox, that by 1800 as many as 6,000 persons had been vaccinated. In 1802 and 1807 Parliament granted Jenner an aggregate of £20,000 to be used in prosecuting his experiments. Inoculation with smallpox virus is probably older than recorded medicine. Baas says that it was mentioned in the Atharva Veda. It was certainly mentioned in the Flos of the School of Salerno and was known to most Oriental peoples. Jenner, with that catholicity of mind which marks a man of genius, was able to appreciate not alone the enormous importance of any real prophylaxis against smallpox, but the fact that what seemed a very humble instrument might prove to be the solution of an enormous problem. And he had the painstaking and careful methods of the real scientist and that devotion to truth which belongs to the scientific character. The results of his work are almost beyond our comprehension. Extravagant as the dictum ascribed to Virchow at the celebration of

the centenary of Jenner's discovery may sound, it is probably true. Virchow is reported to have said that had not vaccination been discovered and applied, smallpox would have depopulated the earth.

There was no American medical literature, to speak of, until long after the Revolutionary War. Billings says that when the Revolution began we had one medical book by an American author, three reprints, and about twenty pamphlets. The book furthermore is alleged to contain but one original observation. Yet it contained a practical appendix on camps and military hospitals and was of great use to the army and navy surgeons, for whose use it was primarily designed.

The Revolutionary War, like the great wars in the old world, had a powerful influence on the development of medicine in America. Morgan, Shippen, and Rush did yeoman service in the army with their meager equipment and small funds, and, after the conclusion of the struggle, proceeded to lay the foundation of medical education in this country. From a medical viewpoint, as opposed to a surgical or obstetrical one, Rush was the most important and interesting of the three worthies mentioned. He was opposed to Cullen's solidism and accepted a modified Brunonianism. He was easily the most able American clinician of his time and had a great European reputation. To a considerable extent he followed Sydenham, using phlebotomy and keeping careful bedside notes of his cases. He did heroic work in the epidemic of yellow fever in Philadelphia, seeing from 100 to 150 patients a day. He insisted that the disease was not imported but arose *de novo* in the city. In treating the disease he used his celebrated powder of calomel and jalap, let blood freely, used cold water, externally and internally, with low diet and a low temperature in the sick room. His results are claimed to have been very good, although no statistics seem to be available. He also was probably the first American writer on anthropology and wrote on camp hygiene and the Indians and their vices.

Benjamin Franklin also turned his genius toward the advance of medicine. He invented bifocal lenses (1785) and a flexible catheter and treated nervous diseases with electricity (Franklinism). He was the principal founder and first president of the Pennsylvania Hospital. Thomas Cadwalader (1708–79) of Philadelphia, a pupil of Cheselden, was a leader in introducing inoculation and the first to teach anatomy by dissections in the city (1730–31). He also wrote on lead palsy and lead colic (under the name of an "Essay on the West-India Dry Gripes") which was produced by drinking Jamaica rum distilled through leaden pipes.

The eighteenth century was the age *par excellence* of successful quacks, and it only yields to the nineteenth century in the use and abuse of nostrums and patent medicines. Probably the scarlet coats, gold-headed canes, powdered wigs, and lace ruffles of the higher physicians formed so considerable a part of their stock in trade that it was easy to imitate them and pass oneself off as a doctor and a savant by assuming the requisite paraphernalia and gravity of demeanor. At any rate some notable cases of successful quacks, who operated in this period, have been recorded. The earliest of these was Sir William Read, who started out as a tailor, but in 1694 put out his sign in the Strand as an oculist, having taken the precaution to hire some one to write a book on ophthalmology under his name and a Grub Street poet to emit a panegyric of him in verse. Queen Anne, whose bad eyesight made her an easy victim to anyone who would promise her relief, consulted Read, who wormed himself so far into royal favor that he was actually knighted, finally becoming oculist to George I. He frequented the coffee houses and entertained lavishly Swift and the wits of the day, who lampooned him while partaking of his bounty. Another charlatan, named Taylor, went about lecturing dressed in black and with a long flowing wig, having however a good address and some skill in eye surgery. He managed to secure Gibbon and Händel for his patients. He used queer distorted sentences which he called "true Ciceronian." Another kindred spirit, named Ward, won the complete confidence of George II. He was called "Spot Ward," from a birthmark on his face. Chesterfield, Walpole, and Gibbon delighted to patronize this friend of royalty, who was specially exempted from the penalties imposed on the irregular practice of medicine by the Act of Parliament of 1748. In his will he requested burial in Westminster Abbey. Joanna Stevens sold her invaluable remedy for stone in 1739 for £5,000, for which Parliament made a special grant, after having been urged to do so by Cheselden, Sharp, and Caesar Hawkins. In each one of her certified "cures" the stone was found in the bladder after the death of the patient. The incomes of physicians in good standing in those days were often very liberal. Mead used to charge a guinea for an office visit and two guineas or more for visiting well-to-do patients. Both he and Radcliffe would write prescriptions for a half guinea, while sitting in their coffee houses, without seeing the patient. An income of $30,000 was enjoyed by several of these leading physicians. Inasmuch as money was over three times as valuable then as now, the assertion made above, that the eighteenth century was the golden age for doctors, had a good foundation. Thomas Dimsdale for inoculating Catherine of Russia and her son received $50,000, with $10,000 in addition for traveling expenses, a pension of $2,500 for life, and the rank of baron of the empire. The fifth London pharmacopœia (1746), while it professed to condemn the old astrological and folk remedies, and while it drops human fat, spider-webs, moss from human skulls, unicorn's horn, virgin's milk, bone from the stag's heart, and the like, still retained mithridate, theriac, crab's eyes, wood-lice, pearls, bezoars, vipers, corals, etc. In 1745 Heberden had shown that the actual formula for theriac was twenty leaves of rue, one grain of salt, two nuts, and two dried figs, a decent and reasonable compound instead of the hodge-podge of two hundred or more ingredients, which later pharmacists had compounded it of. In the sixth pharmacopœia, 1788, practically all the animal materia medica and the theriac and mithridate had disappeared. Many physicians of this century, including Hoffman, Stahl, Sloane, and Mead, made money by selling secret remedies of their own composition. A large medicine spoon was not infrequently a part of a bride's dowry. The fact that medical men compounded and dispensed their own remedies and charged for them separately accounts for the prolix and complicated prescriptions which were in vogue. Doctors' fees depended more upon their prescriptions than upon their visits.

In 1788 in the Hôtel Dieu at Paris there were 1220 beds, most of which contained from four to six patients. There were about 486 beds for single patients. Acute contagious cases were often in close proximity to mild cases. Vermin and filth abounded. The ventilation was of such a character that the wards could not be entered in the morning, unless the person entering held a sponge dipped in vinegar to his face. Naturally all sorts of contagions occurred in the hospital and patients operated on seldom lived. The same thing was true of the Allgemeines Krankenhaus of Vienna, the Moscow Hospital, and many other large hospitals. Baas says that in Frankfurt a.-M. and other cities "even physicians declined hospital service as equivalent to a sentence of death." Tenon's report and John Howard's studies of European hospitals, lazarettos, and prisons (1777–89) led to some creditable efforts to clean up. But nothing very radical was accomplished until the immortal Florence Nightingale took hold of hospital work and really founded the order of trained nurses. Nor was there any such thing

as real surgical cleanliness until Lister's time. Bad as were the hospitals, the insane asylums were worse. No intelligent or humane treatment of lunatics was attempted until the Tukes established their Quaker retreat at York in 1792.

There were five medical schools started in the United States before 1800, of which only two survived and became permanent. The medical department of the University of Pennsylvania opened its doors to students in 1765. Seventeen years later the medical school of Harvard University was established. Of the other three schools, that of Dartmouth College and of the College of Philadelphia have ceased to exist, while that of King's college, after a short existence, was discontinued during the Revolution to be started again in a precarious manner. In 1787 the name of Columbia College was adopted. But the medical school did not flourish, so that in 1813 it was merged with its rival the College of Physicians and Surgeons, which was not officially known as the Medical Department of Columbia College until 1860. In 1791 the medical department of the College of Philadelphia and that of the University of Pennsylvania were united.

State medical societies began to be formed in the United States in 1766, when the State Medical Society of New Jersey was founded, followed in 1781 by that of Massachusetts, and in 1789 by South Carolina. The State societies of Massachusetts and New Jersey and the College of Physicians of Philadelphia issued transactions. The first medical journal of the period was the *Medical Repository* (New York, 1797–1824). The hospitals of these days were Pennsylvania Hospital, Philadelphia, organized in 1751 and opened in a permanent building in 1756; The New York Hospital, started in 1773, destroyed by fire in 1775, and rebuilt in 1791. Other hospitals, medical libraries, and private medical societies followed along in a slow but gradually increasing ratio.

There was still a strong prejudice against dissecting in America and material was usually obtained only by body-snatching. Surgery was well taught, but physiology and pathology languished. There were a few strolling dentists and oculists here and there. Perkins tractors made a stir and gained a foothold in the colonies and the mother country. But the quacks were not abundant in the former because there was as yet not harvest enough to tempt their enterprise and their cupidity.

There was a general quarantine act passed by Congress in 1799. Acts intended to regulate the practice of medicine and surgery had been passed during the century in New York, New Jersey, Virginia, Massachusetts, Pennsylvania, and other states.

In the first half of the nineteenth century, the status of medicine was, with a few noteworthy exceptions, only a continuation of the stationary theorizing of the century before. Up to 1850 and for some years afterward most of the advance in medicine was due to the French. After 1858, the year of the publication of Virchow's cellular pathology, German medicine began to show in the ascendant. The portrayal of the hitherto undescribed forms of disease and the discovery of anesthesia (1847) and antiseptic surgery (1867) were the especial achievements of the Anglo-Saxon investigators. In continental Europe, Schelling's philosophy with its aim to establish the subjective and objective identity of everything in Nature; and Hegel's evolutionary idea, that all things are in the process of change into something else, exerted (Garrison says) by diverting attention away from investigation into fanciful speculation, a powerful deterent effect upon scientific medicine. Skoda's therapeutic nihilism and excessively minute and diversified physical diagnostic methods had a discouraging influence upon Austrian medicine; while in France and Italy a vast amount of effort and many lives were sacrificed in the pursuit of the doctrines of Broussais and Rassori. It has taken thousands of years, if indeed the goal has yet been reached, to demonstrate that internal medicine cannot be advanced by *a priori* reasoning or by the more or less attractive theories of the popular idols, who hold the center of the stage for the time being. Broussais did a great deal to banish metaphysical medicine in order to substitute something far worse practically. He modified the Brunonian theory that life depends upon irritation but particularly upon heat, which starts the chemical processes in the body. When things go wrong, Broussais said, it is because too much heat is concentrated upon some particular organ. To be consistent, and the consistency of the theory-maker has perhaps done as much harm in medicine as the conceit of the anthropologist, Broussais had to ignore specific infection like smallpox or great pox. He did this much good that he taught people to think of one organ or one series of viscera, as the site of the disease, and not the whole body, as in "fevers." He classed gastro-enteritis as the "basis of all pathology," as Cullen thought that every form of disease was really a neurosis. Broussais, like other system-makers, claimed that Nature had no healing power and that disease must be abated by active measures. So he deprived his patient of food and leeched him from head to foot. So taking was this new system that in the year 1833, 41,500,000 leeches were imported into France and only nine or ten million exported. Whereas ten years before the importation of two or three million had been enough to supply all demands.

About this time the convenient doctrine of "spinal irritation" was introduced and helped to cover much diagnostic incompetence and many therapeutic sins. In Italy, about 1807, Giovanni Rasori galvanized into a more or less fleeting existence the old doctrine of constricted and relaxed conditions. The diagnosis was to be made by phlebotomies. These doing good in the constricted and harm, if pressed too far, in the relaxed conditions. The former state was combated by sedatives, opium, and more bleeding; the latter by huge doses of gamboge, aconite, ipecac, and so on. So the poor patient, if he escaped the Scylla of phlebotomy was caught in the Charybdis of overpurgation and polypharmacy. Who shall say that the world was not ripe for the watery innocuousness of high potency Hahnemannism? Aided by the good sense of the clinician Chomel, the great Louis (1787–1872) overthrew the sanguinary follies of his qoundam teacher Broussais, by the stern logic of his statistical inductions. Louis was the founder of medical, as distinguished from vital, statistics. His indefatigable industry, intense application, and clever grouping of cases and symptoms, allied to his statistical skill, did much to establish clinical medicine on a scientific, or should we say, a common-sense basis. He was the first clinician after Floyer to time the pulse by the watch. Fortunately for American medicine, Holmes, the Shattucks, the Jacksons, Gerhard, and other students from the States learned clinical methods from Louis and his contemporaries, among whom was the immortal Laënnec, who discovered and introduced mediate auscultation by the use of the stethoscope in 1819. The second edition of Laënnec's book (1823) was, as Garrison says, "in effect the most important treatise on diseases of the thoracic organs that was ever written." Verily clinical medicine was just at that juncture advancing with rapid strides. Laënnec described hepatic cirrhosis and nearly all the diseases of the heart and lungs as we now know them. He died of consumption at thirty-seven years of age in 1826. Corvisart (1755–1821) has already been mentioned as the noble-hearted expositer of Auenbrugger's great discovery. He was Napoleon's favorite physician and the teacher of Dupuytren, Laënnec, and Cuvier. Pinel (1745–1826) must never be forgotten because he risked his own life in the service of the most helpless and the most shamefully maltreated class of unfortu-

nates in all history, the insane. His "Traité médico-philosophique sur l'aliénation mentale" (1801) is one of the most important of medical classics and was followed by a number of scholarly and illuminating treatises on mental diseases, published by various experts, and led eventually to a much more humane and sensible method of handling these cases.

The great Irish School of clinicians, included among others, Cheyne (1777–1836), Adams (1791–1875), Corrigan, Wallace, Stokes, and Graves. The last two were the real leaders. Graves (1796–1853) introduced clinical teaching into the Meath Hospital in Dublin and was a founder of the "Park St. School of Medicine." He wished the words "He fed fevers" engraved upon his tombstone. His name is ever in our mouths by reason of his admirable description of exophthalmic goiter, which goes by his name. William Stokes (1804–78) a colleague of Graves in the Meath Hospital is almost as well known as the latter. He is one of the few physicians who ever received the Prussian order "*pour le merite.*"

Of the English clinicians of the period probably the greatest was Richard Bright (1789–1858). He was one of the "great men of Guys," and was the leading consultant of London in his day. His description (1827) of essential nephritis and his epoch-making distinction between cardiac and renal dropsy brought him immediate fame, which time has scarcely dimmed. Thomas Addison (1793–1860), a colleague of Bright at Guys, is even said to have been a more brilliant pathologist, lecturer, and diagnostician than the latter. In collaboration with John Morgan (1829) he wrote the first book in English on the action of poisons in the living body. His great monograph on the "Local and Constitutional Effects of Disease of the Suprarenal Capsules" was regarded merely as a scientific curiosity in his own day, but is now recognized as of epoch-making importance, because, in conjunction with Claude Bernard's physiology, it inaugurated the study of the diseases of the ductless glands and the disturbances of the chemical equilibrium of the body known as "pluriglandular syndromes." Thus opening up an extensive field of investigation whose far-reaching importance has not yet been realized. Trousseau first called the suprarenal syndrome "Addison's disease."

It was Parkinson (1755–1824) who reported the first case of appendicitis in England in 1812. In this case also perforation was recognized for the first time. Parkinson was one of John Hunter's pupils and so accurately described paralysis agitans that it is called "Parkinson's disease" to-day. Charles Wells (1757–1817) described the albuminous urine of dropsy in 1811 and published perhaps the earliest clinical report on the cardiac complications of rheumatism in 1810. In 1873 Charles Murchison traced an epidemic of typhoid fever in London to a polluted milk supply. In 1843 James Braid proved that mesmeric influence is entirely subjective or personal and that no fluid or other influence passes from the operator to the patient. James Esdaile in 1845 practised hypnotism on Hindus as an anesthetic and had a record of 261 painless operations with a mortality of 5.5 per cent. In Scotland, however, he could not hypnotize his European patients as he had succeeded in hypnotizing the impressionable Indians.

In Germany the love of medical theorizing and dreaming lasted much longer than in "common sense" England. The Natural Philosophy School, founded by Schelling, claimed for its leading spirit one Oken, an idealist, a naturalist, and an unbalanced system-maker and organizer. He seemed to desire to transpose the laws of nature and physiology to suit his theories and to try to combine naturalists and physicians in one grand working union. Next came the Natural History School which aimed to classify diseases as plants and animals are classified, as Sauvages had attempted to do in the previous century. These theories, however, gave way to the physiological teaching of Henle, Wunderlich, and Roser, the forerunners of the present scientific movement of German medicine. There were also many queer sects, advocating homeopathy, hydrotherapy, Odic force, phrenology, animal magnetism, Rademacherism, Baunscheidtism, and so on. These faddists affected to despise scientific medicine and ridiculed the work of Bright, Addison, Graves, Laënnec, Louis, and their colleagues. One of them said in 1851 that a physician must not be judged by the success of his treatment, but by the extent of his knowledge, asserting that "as long as there are successful physicians there will not be scientific physicians." This sort of reasoning made up the therapeutic nihilism of the New Vienna School. The Revolution of 1848 scattered the doctrines of the foolish Nature Philosophy School, but the New Vienna School died hard. Rokitansky's idealistic notions were overthrown by Virchow, and Semmelweis had a terrible fight, which, it is alleged, cost him his reason, before German medicine could shake itself clear from the speculative day-dreams which were mixed in even with good scientific work. Even Virchow could never believe Semmelweis, we are told, any more than he could accept Darwin's great theory.

Schönlein (1793–1864) was a curious mixture of theoretical nonsense and good scientific work. He was the first since Paracelsus to lecture in German, instead of Latin (1840). He introduced modern clinical methods into Germany, insisting upon bedside teaching and examinations of the blood and urine, chemical analysis, auscultation, percussion, and microscopical investigations. These are the weapons with which superstition and dogma were finally overthrown. His pupil Canstatt (1807–1850) wrote a sterling text-book on practice, free from dogma and superstition, which Jacobi states was the "Bible of German medicine" until it was superseded by Niemeyer, as the latter was, in turn, by Strümpell.

Fortunately, there had been founded four medical periodicals of sterling worth in Germany, which kept the modern scientific spirit alive and impressed upon the younger men in medicine the necessity for exact investigation and truthful interpretation of every observed phenomenon. These journals were Müller's, Virchow's and Roser and Wunderlich's "Archives" and Henle and Pfeufer's "Zeitschrift." Such commanding intellects must have had an immense influence not on German medical thought alone but on that of the whole civilized world. Wunderlich's (1815–77) treatise on the relations of animal heat in disease (1868) is the foundation of our present clinical thermometry. It was based upon the scientific work of Clausius, Helmholtz, and Sir William Thomson (afterward Lord Kelvin). Without the "absolute scale of temperature" worked out by the latter no thermometric observations could be relied upon. Previous to Clausius many regarded heat as a material substance, a delusion which hindered the advance of medicine as much as did its parent, the phlogiston theory of Stahl.

Rokitansky (1804–78) was a great pathologist and a colleague of Skoda in the New Vienna School. He did an enormous amount of pathological work. Dissecting between 1,500 and 1,800 cadavers yearly, making a total of 30,000 in his life time. He was the first to detect bacteria in the lesions of malignant endocarditis and to recognize the difference between lobar and lobular pneumonia, and between Bright's disease and amyloid kidney. He was the first to describe spondylolisthetic deformities. His excellent treatise on pathological anatomy was injured by his doctrine of "stases" and "crases." For which he was mercilessly ridiculed by Virchow, who called his rival's attempt to revive the ancient nonsense about solidism and humoralism a monstrous anachronism. Under Skoda the habit of making elaborate diagnoses and following the cases to the dead house to confirm them,

to the exclusion of careful and thorough treatment became almost scandalously prevalent. Such a course, is still sometimes a failing of the young internes in our hospitals. Garrison says that the greatest achievement of the New Vienna School was the discovery of the true cause of puerperal fever by Semmelweis in 1847. From the treatment meted out to the unfortunate Semmelweis and the fact, that Skoda was almost his only influential friend in the faculty at Vienna, it would scarcely seem that the school as a whole should enjoy much credit for his great discovery. This had been antedated by Oliver Wendell Holmes of Boston, who read his paper before the Society for Medical Improvement "On the Contagiousness of Puerperal Fever" in 1843. Both Semmelweis and Holmes met with the treatment meted out to all true reformers; being at first opposed by practically all the orthodox obstetricians of their day. The latter were described by some wit as "unteachable mandarins." Semmelweis died, insane, from an infected wound. Whether his mental overthrow can be justly charged to his detractors is a mooted question. Certainly their abuse must have aggravated the condition. He was originally a poor man, unknown before his great discovery, and unduly sensitive to slights and misrepresentations. Whereas Holmes was well placed financially and socially, was a literateur rather than a doctor, and had that abounding sense of humor which throws off the shafts of calumny and innuendo and grows stronger in the struggle. Furthermore, Dr. Holmes was not subjected to any such persistent or malignant persecution as Semmelweis was. They were both medical heroes and, while Garrison is disposed to award the greater credit to Semmelweis, others think that this should go to Holmes.

Laryngoscopy and rhinoscopy were also developed in the New Vienna School. In 1829 a rude "glottiscope" had been exhibited in London by Babington of Guy's Hospital and in 1837 Liston had described his mode of exploring the larynx. The matter however was allowed to lie dormant until Garcia, the singing master in London, sent an account of his laryngoscope to the Royal Society in 1855. Three years afterward his method was made a permanent part of laryngology by the Viennese neurologists Türck and Czermak. So slow were the Germans in joining heartily the real forward movement of medicine, that Virchow was almost the only German of his time who appreciated Bichat and Majendie, Bright and Addison, and it was largely due to the practical tendency of the physicians of the New Vienna School, some of whom we have mentioned, that, as Garrison expresses it, German medicine finally crossed the Rubicon.

A German physician of the latter part of the eighteenth and the early decades of the nineteenth century made a greater stir in the world than many far abler men. He established a system and a school which are still nominally flourishing, although the original tenets of the faith have been largely forgotten. He was Samuel Christian Friedrich Hahnemann, the founder of homeopathy. He assembled a number of old beliefs, revived some others, and perhaps added something of his own. The foundation stone of the structure, which in sooth has stood up pretty well under much battering, was that "like cures like." This was a principle in practice for many years, having been found in medical writings said to date back to 650 B.C. Hippocrates said "Some diseases can be treated best by contraries, some by similars" and in 300 B.C. Theophrastus expressed the same sentiment. Paracelsus was strong on practising "both ways" and believed the doctrine of "signatures." Inasmuch as the remedies given by the homeopaths would, themselves, so the practitioners claimed, produce the disease they were intended to cure if they were administered in any appreciable amount, the second great postulate of infinitesimal doses was announced. The extreme titration was claimed to develop a peculiar dynamic power in the drugs and this was also heightened by agitation, like shaking with the strong right arm. And the third great postulate was that most chronic diseases are simply varying manifestations of suppressed itch or "psora." That such a crude hypothesis should revolutionize the practice of medicine seems *a priori* well nigh incredible. But Hahnemann was shrewd, he took the laity into his confidence and explained to them his theory, transmitted to him as he claimed, directly from God. These dogmas they could at least partly understand. The theory was and still is, alluring to the unscientific mind. The unsparing abuse that its author heaped upon the so-called allopaths was no doubt a pleasant reaction from the overbearing tyranny with which the older doctors treated their patients and the nauseous doses and frequent bleedings which they inflicted upon them. Horatio C. Wood said that the success of homeopathy was due to the fact that, at the time of its promulgation, the regular practice was doing more harm than good. The main good, however, that homeopathy has accomplished is in teaching the profession that they have for centuries overtreated and overdosed their patients. Hahnemann also taught simplicity and accuracy in prescriptions. Had the early homeopaths not been so bigoted or so ignorant as to ignore surgery, their cult would have made much greater and more enduring advances in popular favor. Now like the *a priori* theories which preceded it, it is gradually vanishing away.

Throughout the nineteenth century many able medical men were found in the United States. Of Jacob Bigelow (1787–1879) Dr. Holmes has said that his book "On Self-limited Diseases" (1835) did "More than any other work or essay in our language to rescue the practice of medicine from the slavery to the drugging system, which was a part of the inheritance of the profession." Gerhard (1809–72) of Philadelphia worked out the differential diagnosis between typhus and typhoid fever (1837) which is a masterpiece and settled definitely, at least for American students, the question of the separate status of the two diseases. His monograph on tuberculous meningitis in children also became a classic. Daniel Drake (1785–1852) was a great physician. He was the first after Hippocrates and Sydenham to study and write upon medical geography. He grew up in abject poverty, educated himself, and did magnificent pioneer work in establishing medical colleges and an important medical journal. He wrote several valuable works on medical education, on the history of the early days of the republic and on medical topography, climatology, and so forth.

Scientific Medicine.—The nineteenth century will ever be memorable for its great advances in embryology, biology, zoology, physics, chemistry, in short in all the natural sciences. Those first in the above list naturally have a direct bearing upon the development of medicine. After the great morphologist Müller, the trend of German anatomical studies was mainly along histological and functional lines. This development depended chiefly upon three main factors, the foundation of the science of embryology by von Baer (1827–28), the improvement of the achromatic microscope in 1830 by Joseph Jackson Lister, father of Lord Lister; and the development of the cell theory by Schleiden and Schwann (1838–39). von Baer established the modern theory of the germ layers and the beginnings of histogenesis, organogenesis, and morphogenesis. He recognized four layers of the developing ovum, reduced to three by Remak, who showed that the middle layer is in reality made up of two sheets. The three layers are the well-known ectoderm, mesoderm, and endoderm described by Remak in 1845. von Baer discovered the mammalian ovum in 1827 and the chorda dorsalis

or notochord at the same time. He and Cuvier were the founders of modern morphology. What he accomplished with the crude microscope of his day without the aid of a microtome is really remarkable.

The development of the cell theory, a fundamental principle of modern science, we owe mainly to the botanists. Schleidin (1804–81), professor of botany at Jena, Dorpat, and Frankfurt-a.-M., proved that plant tissues are made up of and developed from groups of cells, of which the nucleus (or cytoblast) is the important feature. He taught "There is one universal principle of the development of the elementary parts of organisms, however different, and that principle is the formation of the cells." Schwann (1810–82) was a great physiologist and microscopist. He discovered the sheath of the axis cylinder of nerves, which bears his name. He was the first to investigate the laws of muscular contraction by physical and mechanical methods. He demonstrated experimentally that bile is essential to digestion and showed the organic nature of yeast. A number of learned and talented men followed these great investigators. One of whom, Max Schultze, in 1861 showed that the resemblance between animal and vegetable protoplasm is not only structural and chemical but also physiological. Thus the cell came to be recognized as the structural and physiological unit of all living organisms, whether animals or plants, simple or complex, embryonic or adult, healthy or diseased. While the cell nucleus is now regarded as the chemical "center of oxidation" and the chromosome as the transmitter of inherited characters (Garrison). Thus the study of anatomy was extended by histology and microscopy and the "seats and causes" of disease came to be referred to the cellular elements and the unicellular organisms attacking them.

The great Henle (1809–85), a Hebrew, was the greatest German histologist of his time and one of the greatest anatomists of all time. He ranks with Vesalius and his discoveries and demonstrations make too long a list to be given here. He gave the first clear idea of a contagium animatum in 1840. Remak (1815–65) was the first to point out that the proliferation of cells to form tissue is accomplished by cell division (1852) and not as Schleiden and Schwann had taught by endogenous formation. Remak was also a pioneer in electrotherapy, substituting the galvanic for the induced current.

Purkinje (1787–1869), a Slav, was a great microscopist and physiologist. He was the founder of laboratory training in connection with German university teaching. He started a laboratory in his own house and did such good work that the Prussian Government finally erected a physiological institute for him at Breslau in 1842. Purkinje was the first to use the microtome, Canada balsam, glacial acetic acid, potassium bichromate and the Drummond lime light (1839). von Kölliker (1817–1905) was probably the most distinguished histologist of the period after Henle. He taught that the ovum of invertebrates is a single cell and its segmentation is a normal cell division only. In 1847 he first demonstrated the true development of the spermatozoa, showing that they are no extraneous bodies but originate in the testicular walls and fertilize the ovum. He demonstrated the smooth muscular fibers in the walls of the blood-vessels. His "Microscopic Anatomy" and "Handbook of Human Histology" were the first formal text-books on the subject.

A number of great names in histology, anatomy, and physiology follow those we have considered. They were still more or less distinctly divided into the chemical and physical schools. The work of the former reached its acme in Claude Bernard and Pasteur. The pioneer in experimental physiology in France was Majendie (1783–1855). He was the founder of modern experimental pharmacology and, like Müller, employed both physical and chemical experiments in his studies. He did not, like Bichat, indulge in any theorizing whatever, but regarded medicine as a "science in the making." He did not strive to explain his discoveries by an hypothesis or string them together in a theory. His greatest achievement was the experimental proof of Bell's law that the posterior spinal roots are motor and the anterior, sensory. He started physiology on its gradual march toward the systematic elucidation of the great questions concerning the life, growth and decay of the human body. Before his time, according to Claude Bernard, these studies were *rêveries systématiques*. He was the first to demonstrate experimentally a state of anaphylaxis (1839) which, however, Jenner had already observed in various inoculations in 1798.

Legallois, Flourens, and Poiseuille were the three leading French physiologists between Majendie and Claude Bernard. Of these Flourens (1794–1867) discovered the bilateral center of respiration in the medulla in 1837 and the so-called "vital spot," which has not yet been definitely located, although its existence cannot be doubted. He also demonstrated that the cerebrum is the organ of thought and will power, while the cerebellum coordinates bodily movements. He denied cortical localization of function, now generally accepted. Poiseuille (1799–1869) took up Hales' blood-pressure experiments of 1733, substituting a mercurial manometer for the former's clumsy tube. To this Carl Ludwig in 1847 added a float, which he caused "to write on a recording cylinder and thus gave us at once the kymograph or wave-writer, and the application of the graphic method to physiology." The brothers Weber of Wittenberg did valuable work in applying the methods of laboratory physics to investigations in the physiology. One of them discovered the inhibitory power of the vagus nerve in 1845. Although Ludwig and Schneideberg afterward showed that the vagus contains accelerator as well as inhibitory fibers, the original discovery still stands as one of the beacon-lights of physiological research. The Webers also corrected Bichat's error of claiming that pulsation is synchronous in the entire arterial system, by showing that it is delayed from one-sixth to one-seventh of a second in transmission. Their researches on touch and temperature sense also opened the way for the psychophysics of Fechner and Wundt.

Wilhelm von Brücke (1819–92) was the first to teach that normal urine may contain sugar. He was a brilliant, all around investigator. The leading English exponent of the physiological experimentation of this period was Marshall Hall (1790–1857) whose memoir to the Royal Society on "The Reflex Function of the Medulla Oblongata and Medulla Spinalis" (1833) determined the difference between actions under control of the will and unconscious reflexes. Descartes in 1644 had made the original suggestion that impulses from the periphery can be reflected outward from the nerve centers without the intervention of consciousness. Hall demonstrated that reflex movements are more readily produced by stimulating the nerve endings than the nerves themselves, and that there is a reflex contraction of sphincter muscles. His work gave reflex action a permanent place in physiology, although he did not realize that volitional and reflex processes are interchangeable and many nervous phenomena are intermediate in character.

In 1828 Wöhler, an associate of Liebig, succeeded in forming urea synthetically. This was the first time that an organic substance had been built up artificially from inorganic constituents, without the intervention of vital processes, and from this and similar experiments it soon became clear that there is no essential difference between the structural chemistry of living bodies and that of inanimate nature. Following this discovery came a remarkable series of advances in

synthetical chemistry, which reached its acme in the work of Emil Fischer. Wöhler's experiments also overthrew the idea that while plants can synthetize their constituents, animals have to receive their's already synthetized. Liebig and his distinguished pupil inaugurated what has been called the qualitative period of the experimental investigation of metabolism.

John R. Young of Maryland in 1803 did much to start the study of physiology of digestion by showing that the solvent principle of gastric juice is an acid, which softens bones into a pulp, and which does not arise from any venous or other fermentative stomach action, but is part of the normal gastric secretion. He wrongly assumed that this acid is phosphoric acid, which was disproved by William Prout in 1824 who showed that it is hydrochloric acid. Much important knowledge regarding stomach digestion was obtained by William Beaumont, a surgeon in the United States Army, who in 1825 and subsequently studied and experimented upon a Canadian half-breed, who had a traumatic gastric fistula. Beaumont overthrew Majendie's teaching that the secretion of gastric juice is constant. He showed that it contains free hydrochloric acid and some other active substance, which Schwann in 1835 proved to be pepsin. Beaumont deserves more credit than he seems to have received for his highly important work carried out under great difficulties. It was the most important work on gastric digestion up to the time of Pavloff, and was followed by much corroboratory work by German, French, and some English physiological chemists.

In the second half of the nineteenth century medicine had passed into the scientific stage, the dogmas, superstitions, and old wives fables which had hampered the real advance of the art had, practically all, been overthrown. They had died hard and even to-day the laity and the so-called irregular practitioners still harbor many of them. But the number of unbiased thinkers in medicine, as in the natural sciences, is so large and their influence is so great, that no idle theorizing and no figments of the imagination will ever again direct or distort medical instruction, unless indeed the world shall relapse again into barbarism, in which case no doubt the long drawn-out struggle between scientific medicine and human conceit, credulity, and superstition will be reenacted. The monumental discoveries of Pasteur led directly to Listerian or antiseptic surgery, with all that that implies. Great improvements in medical and general education, in public hygiene and military medicine followed or accompanied these advances in surgical procedure and knowledge and all of them show the futility of the mental attitude of the medicus of the middle ages, who tried to separate medicine from surgery, and to look down upon the practical surgeon as a mere mechanic. The great increase in the means of communication and in the facility by which knowledge is spread, the multiplication of scientific journals and books and the general rise of the average intelligence and education all contributed to great advance in scientific medicine.

The enormous growth in the science of biology in our time was largely started by Darwin and Wallace between 1838 and 1859 who took some of their ideas from Malthus' book, published in 1803. Although the idea of evolution was known to the Greeks and was more or less definitely outlined by Bacon, Buffon, Erasmus, Goethe, Lamarck, Lyell, and Herbert Spencer, it became the salient fact of modern science through Darwin's work. It made an end to the anthropocentric theory that the universe was made for man. Huxley, practically a contemporary of Darwin, did good work in science and was the especial interpreter and champion of the Darwinian theories.

By the close of the last century embryology had become a highly complex science. The leading spirit in this study was perhaps William His (1831–1904). As Bichat dealt with the coarser aspect of the tissues, Henle and Kölliker with their microscopic appearances in health, Virchow with the same in disease, so His will always be known as the great exponent of their origin (histogenesis). A vast amount of embryological investigation, a great portion of which has been done in America, was summed up in the masterpiece of Francis Balfour of Edinburgh (1851–82) in which, as Locy says, "the speculations contained in the papers of the rank and file of embryological workers for more than two decades, and often fondly believed to be novel, were, for the most part, anticipated by Balfour and were also better expressed, with better qualifications." The masters of physiology in the second half of the nineteenth century were Helmholtz, Claude Bernard, and Carl Ludwig, with eight or ten more of second rank, who were nevertheless very able investigators. Helmholtz invented the ophthalmoscope in 1851 and demonstrated that the muscles are the main source of animal heat. He was a great musician but a greater physicist, where he took rank with the best. Emil du Bois-Reymond (1818–96) was the founder of modern electrophysiology. He was a professor at Berlin and under his supervision was constructed the palatial Physiological Institute (1877). The best equipped laboratory of its kind in the world. Kronecker showed in 1874 that heart muscle cannot be tetanized. In conjunction with Bowditch, he showed that the heart's contractions must be complete and cannot be partial, if there is any contraction at all. Bowditch founded the first physiological laboratory in the United States (1874.) He was able to show (1890) the indefatigability of nerve tissue. The starting-point of the neuron theory was the epoch-making experiment of Augustus Waller (1816–70) who showed that when a nerve is cut the distal stump (the axis cylinder severed from the nerve cells) will soon degenerate, while the proximal stump remains relatively intact. He also showed, by the same method, that the nutritive centers of the motor fibers lie in the spinal cord, while those of the sensory fibers lie in the posterior root ganglia. Gall and Spurzheim, from the theory that brain functions can be localized in the cerebral cortex, elaborated a system that they called phrenology, which had at one time a great vogue. They maintained that the brain consists of twenty-seven (later extended to thirty-seven) separate organs presiding over the different bodily functions. Thus again a scientific truth was distorted and elaborated out of all reason. It was perhaps as harmless a form of quackery as ever was devised and had its interesting side. Fritsch and Hitzig demonstrated the cortical, motor, and sensory cerebral centers. Their experiments were repeated and extended by a number of other observers. Finally Goltz (1834–1902) of Posen, showed that the effects of decerebration are the more profound the higher the grade of the animal, as proved by amentia in man. He also, by enucleation of the cord, showed that all reflex and sympathetic functions are abolished in animals although pregnancy, labor, and lactation can occur. He was also followed by a number of skillful workers who broadened the field and established the truth of Goltz's teachings.

The modern concept of reflex action was an outgrowth of the cell theory, with its most important adjunct the neuron theory; since, by the efforts of the different investigators from Dieters to Harrison, the winding paths by which nerve impulses travel from cell to cell were traced out and their structural continuity shown. Under the neuron theory the reflex mechanism of external stimulus, afferent path, nerve center, and efferent path became a reflex arc. This required a sensory neuron with its center in the ganglia of the posterior spinal roots or the cranial nerves and a motor neuron in the anterior horn of the cord or in the motor nucleus of a cranial nerve. This

complex, however, was soon recognized as a mere abstraction, since an isolated system of nerve cells functionating apart is unthinkable. It was seen that most reflexes are compounded or coordinated and that the nervous system functionates as a whole. Sherrington taught that a reflex action is seldom an isolated phenomenon, but one in which several reflex arcs are concerned. Much high-class work of this character marked the end of the nineteenth century.

Of the French savants of the last century, Claude Bernard (1813–78) should be mentioned as the leading physiologist. Having shown ability in his youth as a literateur, he went to Paris to seek advice about his career and was fortunately persuaded to take up medicine. In this his great talents soon showed themselves. So that it was said of him that he was not a mere experimenter in physiology but "physiology itself." He was the founder of experimental medicine, or the artificial production of disease by means of chemical and physical manipulation. His great discovery of the glycogenic function of the liver is perhaps his most important contribution to physiological knowledge, showing, as it did, that the animal body can build up and break down chemical substances. Also of great importance was his work on the pancreatic juice. His third great achievement was his exposition of the vasomotor mechanism. Among the Americans who have carried on this work Cannon and Harvey Cushing might be especially mentioned. The great Russian physiologist, Pavloff, received the Nobel prize in 1904 for his investigations. He showed the relation of the nervous system to the salivary, gastric, and pancreatic secretions.

The study of metabolism has been divided by von Noorden into three stages: First, the qualitative period, inaugurated by Liebig and Wöhler, in which the end-products of animal metabolism and the conditions of their formation were determined; second, the quantitative period of von Voit and von Pettenkofer, in which food values were carefully studied and the balance of nutrition determined; after which the thermodynamic relations of metabolic processes were calculated in terms of heat and energy units; third, the recent era of the study of the intermediate products of metabolism, which is again qualitative but already becoming quantitative. The original experiments in determining the metabolic processes were quantitative, to wit, Sanctorius' efforts to measure his own "insensible perspiration" on the steelyard and the attempt of Lavoisier and Laplace to establish an equation between the quantity of heat formed in the body of an animal and that given off by a burning candle, assuming the quantities of carbon dioxide formed to be identical in both cases. The latter has been styled by Jacques Loeb the beginning of scientific biology. All of Lavoisier's study of the exchange of gases in the lungs belongs, in fact, to the subject of metabolism, as we now understand it. The theories now accepted, regarding the ductless glands and internal secretions, especially in relation to metabolism, start in Claude Bernard's work on glycogen (1848–57) and on the pancreatic functions (1849–56), in his puncture of the fourth ventricle, and his description of the suprarenal syndrome (1849–56), and in the experiments of Brown-Sequard and Schiff. It is perhaps not too much to say that the hope of future medicine lies in a continuation of these studies.

Carl Ludwig (1816–95), one of the greatest teachers of physiology, did an immensely valuable work in the study of the circulation and in training investigators. He was professor of physiology at Leipzig 1865–95 where he founded the Physiological Institute in which so much of his work was done. All who met him "came under the influence of his enchanting personality" and the amount of good work which was done under his guidance and direction is immense. Under Pflüger's supervision (1829–1910) a new Institute of Physiology was opened at Bonn in 1878 and a great journal of physiology established. He was the founder of experimental embryology. Of all the great German teachers Virchow is perhaps the best known. With his name the rise of scientific medicine is inseparably connected. He founded his famous Archives in 1847 and, in its first issue, asserted that an improved hypothesis of any kind is a very leaky bottom for practical medicine to sail in or to trade upon, and scouted the idea that any one man can be infallible. This is a powerful and concise exposition of the real spirit of modern medicine. He was a man of wide culture and the deepest human interests. He had much to do with securing a good sewerage system for Berlin and was president of numerous medical societies. As Garrison says, in pathology he had only Morgagni, as a possible competitor, before him, and no one after him. His aphorism *Omnis cellula e cellula* is, of course, the keynote of the cellular pathology (1858) which started a new method of approaching these questions. The body came to be regarded as a "cell state in which every cell is a citizen" disease being "merely a conflict of citizens in this state brought about by the action of external forces." There are no specific cells in disease but only modifications of physiological types. The two striking errors in this hypothesis are the assumptions that the cell contents are the controlling feature of the whole organism and that there can be no diapedesis of blood cells; the latter postulate was subsequently disproved by Cohnheim. Virchow was the first to define leucocytosis, embolism, and the true relationship of thrombosis. His activities were without limit. He was one of the world's great men. In old age he became a reactionary in science, but was always liberal in politics. He served many years in the Reichstag and set a noble example, which has been but too rarely followed, of actual participation of professional men of eminence in practical politics. As an evidence of his untiring industry it might be mentioned that he gave to the pathological museum which he had dedicated in 1899, 23,066 specimens, each one of which he had prepared, labeled, and placed on the shelves with his own hands. His generosity and nobility of mind and heart in his dealings with the memories of his predecessors and with public and professional questions are well known. Cohnheim (1839–84) Virchow's most eminent pupil, proved that his master's theory of the non-diapedesis of white blood cells, through the capillary walls is entirely wrong and that this process not only occurs, but is the essential feature of inflammation. Cohnheim's brilliant career was cut short by his early death at the age of forty-five. Another great microscopist and investigator was Weigert (1845–1904) known all over the civilized world for his "stains."

The founders of bacteriology were Louis Pasteur and Robert Koch; the former was also a pioneer in the great movement of preventive inoculation against disease. To the latter we owe the development of the correct theory of specific infectious diseases. Pasteur (1822–95) was the son of a local tanner in Dôle (Jura). On his tomb are inscribed his most notable achievements as follows—work on molecular dissymetry (1848), fermentation (1857), spontaneous generation (1862), diseases of wine (1863), diseases of silkworms (1865), microorganisms in beer (1871), virulent diseases, anthrax, chicken cholera (1877), and preventive vaccinations (1880), particularly of hydrophobia (1885). As Renan expressed it, "His scientific career is like a luminous trail in the great night of the infinitely little." His discovery of preventive inoculation, perhaps the greatest of his discoveries, was due to an accident, as was Paré's great discovery that wounds would get along quite as well if no boiling oil was poured into them. Pasteur having injected some chicken-cholera virus that had become inactive or attenuated, found that, while it would not convey the disease, it rendered the animal into which

it had been injected immune to that disease. About 1885 the Pasteur Institute was founded in Paris and Pasteur Institutes began to spring up all over the world.

Robert Koch (1843–1910) of Klausthal, Hannover, took his medical degree at Göttingen (1866) where he was greatly influenced by the teaching of the great Henle. He first worked out the complete life history and sporulation of the anthrax bacillus (1876). Cohnheim declared that this was the greatest bacteriological discovery yet made. In 1878 appeared his great memoir on the etiology of traumatic infections, and in 1882 he discovered the tubercle bacillus. In 1885 he was appointed professor of hygiene and bacteriology at the University of Berlin and had among his pupils such men as Welch, Kitasato, Pfeiffer, Löffler, and Gaffky. In 1905 he received the Nobel prize.

Edwin Klebs (1834–1913) was one of the early assistants of Virchow at Berlin; professor of pathology at various institutions and finally at Rush Medical College in Chicago (1896). He was, together with Pasteur, perhaps the most important protagonist of the bacterial theory of infection, and did the most to bring pathologists to accept this view. He discovered the diphtheria bacillus before Löffler and investigated the pathology of traumatic infections before Koch. His work had great heuristic value, undoubtedly leading Koch and others into the paths of discovery. Löffler (1852) shares with Klebs the honor of the discovery of the diphtheria bacillus and did much other valuable work. Elie Metchnikoff (1845), the eminent Russian biologist, should be mentioned for his studies in intestinal putrefaction and the action of the lactic acid bacillus and for his teachings in phagocytosis.

An enormous output of bacteriological and parasitological literature followed the work of the giants of whom we have just spoken. And this work is the chief glory of nineteenth-century medicine. It is most refreshing to contemplate these achievements after floundering about in the arid field of medical systems which form so conspicuous a portion of the medical history of the seventeenth and eighteenth centuries.

Nor should America be forgotten in enumerating the great bacteriologists and microscopists of the nineteenth and twentieth centuries. Of these Professor William H. Welch of Johns Hopkins University is looked upon as the father; he investigated acute edema of the lungs in Cohnheim's laboratory in 1877, discovered the *Staphylococcus epidermidis albus* and its relation to wound infection (1892), and the *Bacillus aërogenes capsulatus* (1892) and grouped the diseases which it causes (1900); he also made important studies of embolism and thrombosis and, collaborating with Flexner, showed the pathological changes caused by experimental injection of the toxins of diphtheria (1891–92) simultaneously with von Behring. Simon Flexner (1863) director of the Rockefeller Institute for Experimental Research has distinguished himself by his studies of terminal infections, his experiments in venoms and the etiology and therapy of cerebrospinal meningitis (1909), and infantile poliomyelitis (1910–13). Theobald Smith (1859), professor of comparative pathology at Harvard, has been a pioneer in the theory of infectious diseases. In 1886 working with D. E. Salmon, he proved that immunity from hog cholera can be secured by the filtered products of the specific organisms. This was the first experiment in immunization, and was soon followed by the work of Behring, Roux, and others. His demonstration of the parasitology of Texas fever was a great advance in the science of protozoan disease (1893). He also demonstrated anaphylaxis from the bacterial products of diphtheria prior to 1903; a discovery which Ehrlich called the Theobald Smith phenomenon. He made the first clear differentiation between the bovine and human tubercle bacillus (1898) and his results were confirmed by Koch, Spengler, and others. He was the first to observe pleomorphism in bacteria.

In England pathology was comparatively little studied after the time of Hodgkin, Bright, and Addison, although as clinicians the English have ever ranked as keen and careful observers and as leaders in therapeutics. Nor did the French rank as high as the Germans in pathology. Their claim to superiority in the medicine of the second half of the nineteenth century was based on their advances in neurology. With the exception of Charcot most of the prominent French physicians were brilliant expositors of internal medicine and not original investigators. In fact there were then no professional pathologists in the French medical schools. Of their great clinicians, Trousseau (1801–67) received the prize of the Academy of Medicine for his essay on laryngeal phthisis (1837). The Germans present a great array of clinicians and pathologists, including Frerichs, Traube, Kussmaul, Gerhardt, Ziemssen, Leyden, Naunyn, and Freidrich Müller. Of these Frerichs will ever be known for his studies in the liver, pernicious malarial fever, diabetes, and melanemia. Leyden did much good by his promotion of the movement for the hospitalization of phthisical patients in Germany. Sir William Gull, Sir Alfred Garrod, Sir Samuel Wilks, and Sir William Jenner, were great Englishmen, writers, students, but especially able practitioners.

The great neurologists of the period were mainly Frenchmen. Romberg (1795–1873), however, was a German, a native of Meiningen. He became professor at Berlin in 1838. He wrote the first formal treatise on nervous diseases and made the first real advance in the diagnosis of ataxia. His well-known "pathognomonic sign" is still a monument to his diagnostic acumen. Duchenne (1806–75) was the founder of electrotherapy in which he was followed by Ziemssen, Remak, and Erb. He was the first to distinguish lead palsy from that depending upon lesions of the brain and nerves. His name is permanently associated with spinal, progressive, muscular atrophy of the Aran-Duchenne type. Following him was the great Charcot (1825–93) whose clinic at the Salpêtrière was the greatest neurological clinic of modern times, and was frequented by students from all parts of the world. He was not only a great neurologist and diagnostician but a great clinician as well. Marie was Charcot's ablest pupil. He described acromegaly, pointing out the pituitary lesion, hypertrophic pulmonary osteoarthropathy, hereditary cerebellar ataxia (1893), and the so-called rhizomelic spondylosis (1898). Erb was the ablest German neurologist after Romberg. He was a great writer and syphilographer; traced the connection between tabes and syphilis, pointed out the diagnostic value of the knee-jerk in the former disease and described myasthenia gravis (1878) and other diseases of the nervous system.

Hughlings Jackson, Victor Horsley, and Gowers were the greatest English neurologists. Jackson (1834–1911) did much to introduce the use of the ophthalmoscope in the diagnosis of brain disease. His name is attached to Jacksonian epilepsy. Horsley (1847) was the first to remove a tumor of the spinal cord, in connection with Gowers (1888). The latter's text-book on nervous diseases was said a few years ago to be not only the best text-book in English on neurology, but the best on any subject.

The founder of experimental hygiene was Max von Pettenkofer (1818–1901), professor of hygiene at Munich, where in 1875 the first Hygienic Institute was opened. In spite of Virchow's opposition he drained the city of Munich and rid it of typhoid fever. The most important English treatise on hygiene is Parkes' manual published in 1864. In this work he was aided by Lord Sidney Herbert, English Secretary of War at the outbreak of the Crimean War. The latter was the man who sent out Florence

Nightingale with forty nurses to take care of the British wounded in that war. It is said that all the recommendations made by the South African Royal Commission in 1901 had been made by Lord Herbert fifty-five years before.

Mention must be made here of one of the most important discoveries in medicine, which came during the last decade of the nineteenth century, namely, the relation of insects to disease in man and animals. Ross, Grassi, Bignami, Marchiafava, Celli, Manson, and many others contributed to our knowledge of the instrumentality of the mosquito in the spread of malaria, and Finlay, whose work was confirmed by the U. S. Army Commission under Walter Reed, discovered that yellow fever was spread in the same way by another genus of mosquitos. Applying this knowledge, Gorgas of the U. S. Army succeeded in freeing first Havana and then the Isthmian cities of Panama and Colon, formerly hotbeds of yellow fever, from this disease. The same principle applied to the plague and other diseases has shorn them of their terror to humanity. The discovery of the malarial parasite by Laveran, that of sleeping sickness and allied human and animal diseases by Forde and Dutton and Castellani, coupled with the discovery of the insect transmission of disease, above mentioned, opened the way to the conquest of tropical diseases formerly so fatal to white explorers and settlers. Without these and similar discoveries vast areas of the earth's surface, now being developed, would still be closed to civilized man. Schaudinn's great discovery of the infecting spirochete of syphilis (1905) is one of the greatest achievements of the twentieth century so far, and is on a line with those earlier discoveries of Laveran, Todd and Dutton, Leishman, and others.

Of the great men whose work has borne so strongly on medical advance it remains for us to mention Mendel, Galton, and Pearson, who have shed so much light upon the origin of species and the laws of inheritance. They have applied the rules of mathematics, chemistry, physics, and actual experiment to the elucidation of these important themes and by their sensible and clear exposition of their conclusions have done much to eliminate those vestiges of fiat medicine which had survived the work of the surgeons, physiologists, and pathologists.

Emil Fischer received the Nobel prize in 1902 for his remarkable work in synthetic chemistry. He has shown that there is an amido group or nucleus, common to all the proteins. His study of the enzymes shows that they are specific in action, affecting only certain particular substances to which they are related, as he puts it, like a key to the lock, or a glove to the hand. Ehrlich has ingeniously used this analogy in stating his side-chain theory. His pupil, Emil Abderhalden (1877), has completed a marvelously extended series of studies on the metabolism of food stuffs, and in the integration and disintegration of albuminoids and nucleic acids in the animal body. He has recently taken up the study of the protective ferments of the animal body and has evolved a biochemical test for pregnancy and other conditions by a ferment reaction.

Ehrlich (1854) was a former clinical assistant of Frerichs and Gerhardt, privatdozent and professor at Berlin (1890) where he became an assistant in Koch's Institute. His well-known side-chain theory has proved to be almost as valuable a working hypothesis to the physiological chemists and bacteriologists, as Darwin's theory to the naturalists.

The hypodermic syringe was introduced by Francis Rynd (1845), Charles-Gabriel Pravaz (1851), and Alexander Wood (1855), and in America by Fordyce Barker (1856). The stethoscope was first mentioned in the Harvard catalogue in 1868–69, the microscope in 1869–70. Wilks says that a clinical thermometer was regarded as a novelty at Guy's Hospital as late as 1870. Neither Keen nor Tyson saw either a clinical thermometer or a hypodermic syringe during their army service in the American Civil War from 1862–65. Modern scientific bedside medicine may be said to have begun to be really effective with the introduction of these instruments of precision into routine practice nearly a half century ago. It has gradually advanced ever since and is still advancing with the aid of Röntgen ray diagnoses, laboratory examinations of sputum, blood, stomach contents, feces, and urine. Everyone now uses the ophthalmoscope, the stethoscope, the esthesiometer, sphygmomanometer, and so forth. In forty years also trained nurses have become indispensable and far more efficient.

As we conclude this sketch of the medical history of the nineteenth century, we would fain pay tribute to two men who have placed every one who cares to know aught of medical literature even down to its most minute branches under the deepest obligation. These are John Shaw Billings and Robert Fletcher. Billings (1839–1913) issued in 1880 the first volume of the Index Catalogue of the Surgeon General's library. He was assisted in its preparation by Fletcher (1823–1912). This work, the most exhaustive piece of medical bibliography ever undertaken has now reached its thirty-sixth volume and embraces the contents of a medical library of over 500,000 volumes, the library of the Surgeon General of the army of the United States, next to the largest medical library in the world. It has grown to this size largely through Dr. Billing's efforts, who took charge of it at the time of the Civil War when it consisted of 1,000 odd volumes. Besides this he edited jointly with Dr. Fletcher the Index Medicus.

Historical medicine began in Greece with exercise for symmetrical development of the body, the simplest possible style of living and the use of almost no drugs except purges, and little other therapy, except bleeding and fasting. Like the Greeks, we are now relying more and more on hygiene and exercise for proper bodily development and on sane and simple living and occupation for the mind as the best means to keep well. The overwhelming proof that consumption can not only be cured but can be prevented by simple hygienic rules and outdoor living; the demonstration that beriberi and scurvy, and perhaps pellagra, are entirely due to an unbalanced diet all point in the same direction. They all show that when we fully understand the rules of diet we shall be able to prevent the diseases of degeneration. If we shall ever be fortunate enough to discover the infecting agent in the exanthemata the triumph of preventive medicine will have been achieved. The hope of real progress in the general adoption of preventive medicine is the evidently increasing interest of the people, in this age of efficiency, in the proper safeguarding of their health. They have begun in earnest the study of the means of preserving their bodies intact, rather than allowing them to be injured, before taking medical advice. They will soon prefer to pay the doctor for his advice rather than for his medicine. The doctor, on the other hand, will advance from a time serving, inferior position, in the body politic, to that of a leader. Curative medicine is the negative phase, preventive medicine the positive phase of our art. Everyone's education, employment, habitation, and marriage should be under the direction of their medical adviser. The real doctor will presently hold the place that is his by right. He will no longer be at the beck and call of valetudinarians and hypochondriacs. An inferior class of medical men and women, to be known as clinicians, will look after these cases. But real doctors will be the scientists, men of broad culture and deep erudition, and will bear a leading part in the development and conservation of the entire State.

The health of the people will then be the highest law of the land and a state of civilization, development,

and efficiency will supervene such as has for centuries only been dreamed of. Much more permanent and broad than that which on a small scale was realized in ancient Greece. For the miseries of the world science is the only true remedy. It is the only true charity because it is only through a proper application of the rules of life, which have already been largely determined by scientific investigation, that the misery, destitution, waste, and oppression which make the poor man's lot so hopeless, under present conditions, can be met and overcome.

RICHARD COLE NEWTON.

Meibom, Heinrich.—Born at Luebec, Germany, June 29, 1638. He studied medicine at various universities—Helmstadt, Groninguen, and Leyden—and finally, in 1663, received the degree of Doctor of Medicine at the University of Angers, in the west of France. Already two years earlier, when he was only twenty-three years of age, he had been made a "professor extraordinary" at the University of Helmstadt; but, owing to the fact that he was almost constantly traveling for scientific purposes at this period of his life, he was unable to occupy the chair until 1664. His death occurred March 26, 1700.

Meibom was distinguished, not only for his researches in the domain of scientific medicine, but also for what he accomplished as an antiquarian and as an historian. To medical men he is known chiefly because his name is connected with the discovery of certain glands in the eyelids—the Meibomian glands. These are described in one of his published writings—"De vasis palpebrarum novis epistola ad V. C. D. Joelem Langelottum," Helmstadt, 1666. The varied nature of the themes upon which Meibom wrote his forty-six books, shorter treatises, etc., may be inferred from the following abbreviated titles (given in English): "On Hydrophobia;" "On Writing the Biographies of Physicians;" "On Epidemic Intermittent Fevers;" "On Renal Calculi;" "On Ancient Coins of the Roman Emperors;" "On the Drinking of Hot Water for Remedial Purposes;" "On the Excessive Employment of Mild Drugs;" "On the Happy Memory of Elizabeth, Queen of England;" and "On the Natural and the Abnormal Flow of the Blood."

A. H. B.

Meigs, James Aitken.—Born in Philadelphia, Pa., July 31, 1829. He received the degree of M. D. from Jefferson Medical College in March, 1851. His professional life was spent entirely in his native city. In 1857 he accepted the Chair of Institutes of Medicine in the Philadelphia College of Medicine and continued to occupy it until April, 1859. From 1861 to 1868 he devoted himself exclusively to medical and obstetric practice; and in the latter year, on the resignation of the late Prof. Robley Dunglison, he was elected by the Board of Trustees of Jefferson Medical College, Professor of the Institutes of Medicine and Medical Jurisprudence. In the same year he was chosen one of the physicians to the Pennsylvania Hospital. His death occurred November 9, 1879.

Dr. Meigs' contributions to literature, as well anthropological as medical, were very numerous.

A. H. B.

Meissner, Georg.—A distinguished German physiologist, the discoverer of "Meissner's corpuscles." Born at Hanover, November, 29, 1829. He studied at the universities of Göttingen, Berlin, and Munich, chiefly under the direction of Konrad, J. M. Langenbeck (uncle of the famous surgeon, B. R. K. Langenbeck), R. Wagner, Johann Mueller and von Siebold; received his doctor's degree in 1852 from the University of Goettingen; was appointed, in 1855, Professor-in-Ordinary of Anatomy and Physiology in the University of Basel; two years later he accepted a call to occupy the Chair of Physiology and Zoology in the University of Freiburg (in Breisgau); and finally, in 1860 he was appointed Professor of Physiology in Goettingen. He died in 1903.

The following are among the more important of his published writings: "Beiträge zur Anat. und Physiol. der Haut," Leipzig, 1853; "Untersuchungen über den Sauerstoff" (in association with Charles U. Shepard, of South Carolina), Hannover, 1863; and "Untersuchungen über das Entstehen der Hippursäure," Hannover, 1866. A. H. B.

Mel.—HONEY. "A saccharine secretion deposited in the honeycomb of the bee, *Apis mellifica* L. (U. S. P.). For the collection and sources of honey, the reader is referred to the article *Cera*. Freshly separated from young or "virgin" combs it is a pale yellow, or greenish-yellow, or light sherry-colored liquid, about as thick as glycerin, of peculiar odor, and of very sweet and slightly sharp taste. All these properties vary with the conditions of its collection, such as season, the prevailing flowers, climate and country, and (but not in commercial honey) the species of insect producing it. The honey of older combs is darker colored and more disagreeable. With age, after removal from the combs, it becomes darker, and granular from the formation of crystals of sugar in it. The following tests and reactions are from the Pharmacopœia:

A syrupy liquid of a light yellowish to yellowish-brown color, translucent when fresh, but gradually becoming opaque and crystalline, having a characteristic, aromatic odor, and a sweet, faintly acrid taste.

When recent honey is diluted with twice its weight of water, the resulting liquid should be almost clear, not stringy, and should have a specific gravity not lower than 1.099 (corresponding to a specific gravity of 1.370 for the original honey). When honey is incinerated in small portions at a time in a platinum crucible, it should not leave more than 0.3 per cent. of ash. Honey has a faintly acid reaction upon litmus paper, and is levogyrate.

If five grams of honey be dissolved in twenty grams of water, a clear or nearly clear solution will result, which should not be rendered more than faintly opalescent by a few drops of silver nitrate T.S. (limit of *chlorides*), or of barium chloride T.S. (limit of *sulphates*).

If 2 c.c. of a filtered solution of the honey (1 in 4) be placed in a test-tube one centimeter in diameter, and 1 c.c. of absolute alcohol be allowed to flow down the walls of the tube held in an inclined position, so as to form an overlying layer, this should remain clear, and the line of contact should not show more than barely noticeable opalescence, which soon disappears; a permanent milky zone should not be produced (absence of *starch sugar*).

If 2 c.c. of pure concentrated sulphuric acid be placed in a test-tube of one centimeter diameter, and 0.5 c.c. of a solution of honey (1 in 4) be allowed to flow upon it so as to form a distinct upper layer, no colored line of contact should show at once, and at the end of one hour the zone of contact should be at most yellowish or clear brown; a brownish color becoming nearly black at the end of half an hour should not develop (absence of *cane sugar*).

On boiling one part of honey with five parts of water, the resulting solution, when cold, should not be rendered blue or green on the addition of iodine T.S. (absence of *starch*).

COMPOSITION.—Honey is a solution of several sugars in water, together with minute quantities of several acids (lactic, acetic, etc.), coloring matter, mucilage, albuminoids, and the odorous principles. Occasional

pollen cells are seen in it, and, when old, crystals of sugar. The sugar of honey is principally *levulose*, or uncrystallizable fruit-sugar, but *dextrose* and even sometimes *saccharose*, or cane-sugar, are also present; *mannit* has been observed. In old honey these crystalline sugars (which perhaps increase in it with age at the expense of the levulose) are the cause of its granulating. The result of six analyses by König were: fruit-sugar, 78.74 per cent.; cane-sugar, 2.69 per cent.; nitrogenous substances, 1.29 per cent.; water, 16.13 per cent. (Hager).

Poisonous substances are frequently found in honey, apparently collected by the bees. Their origin has sometimes been traced to *Rhododendron* and other members of the *Ericaceæ*, but no method of detecting them, except by eating, has been found. The poisoning is usually mild, but numerous fatal cases have been recorded.

Uses.—The employment of honey as an article of food and luxury, as well as a medicine, is of great antiquity, and extends over nearly every temperate country on the globe. In the tropics the bees are less provident, and honey is not so regularly collected. But, in spite of this popularity, honey has no medicinal value beyond that of sugar or syrup, and can be considered only a vehicle for other medicines. Partly as a convenience on account of its taste and consistence, and in part from deference to tradition, it has been used in numerous preparations; it is still official in the Honey of Rose (*Mel Rosæ*, U. S. P.), made by mixing twelve parts of a fluid extract of red rose (vehicle, diluted alcohol) with eighty-eight of honey. It is simply a pleasantly astringent vehicle. Confection of rose contains twelve per cent. of honey.

H. H. Rusby.

Melancholia.—Melancholia (from Greek μέλας, black, χόλη, bile; from the ancient view that the depression was due to an excess of black bile in the system) presents exactly the opposite condition from mania, since its characteristic features are depression and psychomotor retardation, along with which, in well-developed cases, there are delusions of a depressive character. As was stated in connection with mania, however, since the majority of cases show an alternation or an admixture of exaltation and depression, the Kraepelin school prefers to class together both these conditions under the name "manic-depressive insanity" (see under *Psychosis*), making an exception only of states of depression occurring about the climacteric, which are given a special description as "climacteric" or "involutional" melancholia.

Though Kraepelin is of the opinion that the features of this involutional melancholia differ enough from those of the depression forming a part of the manic depressive psychosis to warrant its consideration as a separate disease, this view is not universally accepted and it will be best here to describe melancholia as a symptom-complex, alluding in passing to its differences as it appears in early life and in the presenium.

Occurring for the first time in early life, the probability is that an attack of melancholia is a phase of the manic-depressive psychosis and will recur, though this recurrence may not appear for a long time, perhaps not until the climacteric, but that the prognosis as to recovery from the attack is good. An attack of depression coming on between thirty and forty-five years of age, without a history of previous mental disturbance, should however be regarded with suspicion, as it is often a phase of some severe psychosis arising upon an organic basis, particularly of general paresis.

The causes of melancholia in early life will be considered in the article *Psychosis, Manic-depressive*.

In the presenium we have to do with such changes as are the accompaniment of passage from the period of reproductive capacity to that of old age, among which modifications of the internal secretions, particularly of those of the genital glands, and cardiovascular and renal degeneration have been chiefly accused as causal factors for changes in the brain. Also at this time the stresses of life, griefs suffered, losses sustained, and the sense that it is becoming more and more difficult to repair misfortunes and even to continue to play an adequate part in the work of the world, begin to bear heavily especially upon those who through hereditary or personal makeup have always found life's duties more or less of a burden, so that it is not surprising that they break under the strain.

Apart from beginning senile changes, climacteric melancholia has no pathological anatomy and it is quite certain that these changes are in no way specific.

Symptoms.—Melancholia may begin with few prodromal symptoms, or may be preceded by a period of more or less vague complaints. The onset of the climacteric variety is apt to be gradual.

The characteristic symptoms are mental and motor retardation with morbid depression. The associations are slowed.

Melancholia may be divided into (1) Simple depression or hypomelancholia. (2) Acute melancholia. Further divisions are anxious or agitated, atonic, stuporous, and hypochondriacal melancholias.

In the simple form the patient is entirely oriented and is free from false perceptions or delusional ideas, but the mental and motor retardation and the depressive effect are plainly marked. Everything looks blue to him, he has lost his initiative, takes no interest in anything, often speaks of his soul being dead within him and while conscious of his morbid condition is unable to throw it off.

In acute melancholia all these symptoms are intensified, the retardation may dominate the picture so that the patient is incapable of either mental or physical exertion. He sits brooding in one position or will not get out of bed, his face expresses the mental distress, the brows are drawn into a frown—the melancholic omega.

His muscles may be relaxed—passive or stuporous melancholia, or on the other hand in a state of tension—melancholia attonita, passing sometimes into a cataleptoid condition (see also *Catatonia*). Again the depressive affect may predominate. The feelings of insufficiency and internal unrest lead to the bitterest self reproaches, the patient accuses himself of all manner of offences, attributes his condition to the sins of his past life, sometimes going back to the most trivial occurrences of his early youth, to self abuse practised at that time, to disrespect of his elders, neglect of religious duties, to slothfulness and lack of appreciation of his opportunities, etc. With increase of the depressive affect, orientation and sense of proportion are lost, hallucinations and illusions of sight and hearing develop and the patient expresses the most varied depressive delusions having mainly to do with the sins which he has committed, with the misery to which he himself, his family, and the whole world have been reduced through his fault. He is the wickedest person in the world, forsaken by God, his prayers are no longer heard, through him his family is reduced to beggary, the whole world must suffer for his sin, he has devoured all the food or drunk up all the water in the country and all must perish, his house has burned up and his children have perished, they are turned out naked into the cold, his daughters are being ravished, he hears their cries, a mob is without which is coming to lynch him, the whole world is being burned up; or his delusions are of a hypochondriacal nature, his bowels are stopped up and nothing can go through, his heart is turned to stone, etc. On account of such delusions on the one hand and from the feeling of unworthiness or the idea that by eating he is depriving others of food and they will starve, refusal of food is

frequent and often absolute. Also this is favored by lack of appetite, a desire to end it all by self destruction and sometimes by ideas of being poisoned—particularly in climacteric and senile melancholia.

The feeling of anxiety may increase from a vague sense of fear and unrest to overpowering intensity, the patient babbles constantly, trembles, clings to every passerby, begging protection, and may give the impression that he has flight of ideas, but careful observation will show that there is retardation for all mental processes except those connected with the depressive effect. In the most extreme degree the agitation may increase to a frenzy—"raptus melancholicus." (See also Agitated Depression under *Psychosis, Manic-depressive.*)

In many cases of melancholia there are no hallucinations or illusions, but with the rise of anxiety they usually appear and are mainly of a depressive and terrifying character. The patient hears threats, faces grin at him, flames appear, there are snakes in the room, he hears the voices of a crowd which is coming to harm him, the mother hears the cries of her perishing children, etc. With the decline of the depression, the fallacious perceptions and delusional ideas pale and disappear.

Thoughts of self-destruction are a natural result of such depressive ideas and emotions, and suicide is the greatest danger in melancholics, who should never be left alone for a moment, as the intention to destroy themselves is often cunningly concealed and may persist even after apparent recovery, so that many such patients have destroyed themselves after discharge from institutions.

While in mild cases of depression, ability to receive impressions, association, and memory may be little impaired, in fully developed cases of melancholia, retardation is so great and the patient's ideas are so much dominated by his affective condition that he pays little attention to his surroundings and does not note the name of the doctor who attends him or of those who care for him, so when he recovers the period of his illness may be for him a blank. Sleep is always more or less disturbed and often accompanied by dreams of a distressing nature. Where there is anxious excitement there may be complete insomnia. The tongue is coated, the breath foul, digestion slow, the bowels constipated, and there is usually loss of weight even without refusal of food. The heart's action is in general slowed but may be quickened upon agitation, the hands and feet tend to be cold as the peripheral arteries are often contracted, and the blood pressure has usually been found to be raised. Respiration is slow and shallow as a rule. Menstruation is often disturbed. There is generally complaint of weakness, pain in the limbs, headache or feeling of pressure in the head, and especially of uneasy sensations over the precordium, which greatly increase with the anxiety (precordial anxiety).

The question as to whether involutional melancholia is to be considered as a distinct disease or as a phase of manic-depressive insanity is discussed at some length by Kraepelin, according to whom while some cases of depression about the climacteric undoubtedly belong to the manic depressive psychosis, there are others, whose manner of onset, course, and clinical characters are such as to justify their consideration as a separate disease. According to him the characteristics which distinguish this last from the depressive phase are slow onset, uniform course, long duration, the preponderance of depression and unrest, over retardation, and the absence of inhibition.

In general, melancholia is considerably more frequent in females than in males. Its duration varies from a few months in mild cases to a year or more, and recoveries have been noted even after a persistence of four or five years. The course of the disease is usually marked by exacerbations and remissions and recovery is gradual, being ushered in by decrease of the anxiety, improved sleep, lessening of the retardation, and increase of body weight.

Prognosis.—The prognosis as to recovery in early life is good, Ziehen estimating that it occurs in ninety per cent. of the cases, which is in contrast to Kraepelin's figures for involutional melancholia given above. While no symptom furnishes a positive indication, in general the persistence of senseless delusions of being influenced from without, or of those of a hypochondriacal character, are of unfavorable import, especially at the climacteric. A small percentage of the younger cases instead of recovering assume a chronic form, while the older ones pass into senile dementia.

Death, when it occurs, is usually due to suicide, or to intercurrent diseases, among which tuberculosis and other pulmonary complaints and chronic inanition are most frequent.

Diagnosis.—Stuporous forms of melancholia in early life are likely to be confused with catatonic stupor. In the first, however, the condition is one of depression and retardation, while in the second there is inhibition and frequently stereotypy, negativism, and cataleptoid conditions while there is affective dullness not depression, and as the patient clears up the mental weakness is apparent. There may be depression in acute confusional conditions, but it is only as a reaction to the hallucinations and illusions which predominate and is seldom lasting, since these false perceptions vary greatly from time to time. There may also be depressive phases in paranoid conditions but the delusions are more systematized than in melancholia and the affective condition is less marked and persistent, while the previous history of the case is different. In people between thirty and fifty years of age, in whom there is no history of a previous psychosis, an attack of depression should always suggest the possibility of general paresis. The presence of some of the somatic symptoms of this disease, such as pupillary rigidity to light, stumbling speech, tremor, incoordination, or ataxia with pronounced mental failure, should make the diagnosis clear, while in doubtful cases a positive Wassermann reaction, decided globulin reaction, and increased number of cells in the spinal fluid will enable us to decide. In the later presenium, there is always the question as to a senile psychosis. Depression is in fact often a phase in senile dementia and involutional melancholia not infrequently passes over into this. Great absurdity of the delusions, the unmistakable mental weakness and the somatic signs of old age would point to senile dementia.

Treatment.—In the treatment of melancholia, the chief indications are the prevention of suicide, the removal of all conditions likely to keep up the anxiety of the patient, the seeing that he takes sufficient nourishment and gets a fair amount of sleep. The first-mentioned indication requires the constant observation of the patient day and night—even in the bath and toilet rooms. Many melancholics do well in the observation ward, but these with the anxious form of the disease sometimes are much afraid of their fellow patients and are best put in a single room, but always under the eye of an attendant since their ingenuity at self-destruction is great. A patient should never be discharged until it is felt that his self-control is regained and he no longer desires to destroy himself. Even then he should be under surveillance for some time. Refusal of food can sometimes be overcome by gentle but firm insistence and by a reassuring manner, but the obstinate cases will require tube feeding. It need hardly be insisted that all well-developed cases of melancholia are best treated in an institution for the insane. In the agitated form of melancholia the prolonged warm bath may be of use, but in general it finds less application here than in

mania. From time immemorial opium in one form or another has been considered the drug par excellence, in relieving the anxious affect in melancholia. It can be given quite freely and the general impression seems to be that as the patient improves it can be withdrawn without trouble. Probably it can be dispensed with in all but the severe cases. The milder sedatives and hypnotics should first be tried. Melancholic patients in the more acute stage had best be kept in bed, but as the severe symptoms pass away they will have to be encouraged to get up and to make some exertion. At this time tonics and mildly stimulating hydrotherapeutic procedures will hasten the progress toward recovery. In younger people particularly, the family should be warned as to the probability of a recurrence, either as another attack of depression or as one of excitement, so that one impending may be recognized and precautions against suicide may be taken.

CHARLES LEWIS ALLEN.

Melanins.—In the skin, hair, retina, and in pathological conditions in the blood and urine occur certain brown or black pigments—the so-called melanins. At present the chemistry of melanins is in confusion but it is probable from recent investigations that there are a number of similarly colored substances possessing a variety of chemical structures. Thus it has been shown that some melanins contain iron, others do not and some are relatively rich in sulphur while others contain none. They also possess radically different solubilities. It has been a matter of controversy as to whether the melanins were direct derivatives of hemoglobin. There is undoubtedly a close connection between tyrosine and certain of the melanins for by the activity of a plant oxidase, tyrosinase, melanin-like products may be produced. It is exceedingly probable that the origin of the melanins is in the cyclic components of the protein molecule if not in tyrosine itself for an extract may be prepared from melanotic metastases of primary tumors of the adrenal which forms a dark brown pigment from adrenalin and p-oxyphenylethylamine but not from tyrosine. Both of these substances, however, are closely related chemically to tyrosine. It is the presence of melanin that gives character to certain of the tumors of the melanomata.

FRANK P. UNDERHILL.

Melena.—The strict definition of melena is "darkening of the feces by blood pigments," but it is generally included in the term "enterorrhagia," or intestinal hemorrhage. Melena neonatorum is an extravasation of blood into the stomach and intestines of the new-born infant, occurring most often in the first few hours of life.

From a therapeutic standpoint hemorrhage from the intestines may be placed in the inaccessible class except that from the rectum and part of the colon. This loss of blood may arise from many morbid conditions, especially anatomical lesions of the intestines. It may occur in the different kinds of ulceration, in acute catarrhs, in toxic inflammation of the intestine, in irritation brought about by excessive use of laxatives, in injury, neoplasm, hemorrhoids, in embolism of the mesenteric artery, in general venous hyperemia of the intestine due to disease of heart or lungs, in stasis of the portal system, most frequently in cirrhosis of the liver, in volvulus and intussusception, and sometimes after reduction of a strangulated hernia. Occasionally small venous varicosities in the small intestine may produce intestinal hemorrhage with consequent melena, and as the patient suffers from no other disorder of the digestive system, it presents a very puzzling condition. That this same accident may happen in small arterial aneurysms is claimed by some; also is mentioned aneurysm of the branches of the hepatic artery. Naunyn reports several cases in which cholelithiasis was the immediate cause of the rupture of an artery. Associated with certain hemorrhagic diseases or diatheses, such as purpura and scurvy, and in some infections, as septicemia, yellow fever, and pernicious malaria, hemorrhage may occur without preceding ulceration in the mucous membrane of the bowel; and under these conditions there may be an extravasation into the mucosa from which the hemorrhage arises.

An interesting case of hemorrhage from the intestines caused by carcinomatous polyposis of the colon has been reported by Niebruegge and Fisch of St. Louis. In this instance there was a more or less constant discharge of blood from the bowel for about three years. Shortly before death the appendix was removed, but a positive diagnosis was not made until the autopsy.

Other clinically important causes are severe icterus, phosphorus poisoning, and morbus maculosus. Bayer reports a fatal case following the disappearance of an attack of facial erysipelas.

Though some writers disbelieve that enterorrhagia and consequent melena ever manifests itself as a vicarious menstruation, the writer has seen one instance that clearly proved its occurrence. This, however, is rare.

Leichtenstern has argued ingeniously that intestinal hemorrhage is caused in most cases by a nutritional disturbance in the vessel walls, brought on by failure of one of the most important factors in metabolism —the functions of the liver. His theory, though plausible, is hardly convincing.

The tendency to excessive hemorrhage during typhoid fever is correlated by Wright and Knapp with diminished coagulability of the blood, even apart from the actual ulceration.

Bamberger has arranged an interesting table showing the frequency with which intestinal hemorrhage occurs in different diseases. His deductions seem to prove that it is most frequent in hemorrhoids, dysentery, typhoid fever, and carcinoma of the colon in the order mentioned. Other etiological factors are clinically important, but much less frequent.

Bériel describes a condition he calls "hematemesis from the lower bowel," in a case of hour-glass stomach, in which there was a large gastric ulcer on the distal side of the contraction. In this connection Rolleston reports hemorrhage from the bowel to the extent of a pint without hematemesis in a patient with a rapidly growing and ulcerated carcinoma invading the cardiac orifice of the stomach.

From the foregoing it will be seen that in loss of blood from the bowel, the origin or causation may sometimes be easily placed, or there may be extreme difficulty in determining where the trouble lies. One caution as to hemorrhages of obscure origin: always bear in mind that there may be distended hemorrhoidal veins high up in the rectum, a lesion which may give rise to frequent and alarming hemorrhages in otherwise healthy individuals.

DIAGNOSIS.—Where there is sufficient loss of blood into the intestines to produce marked melena, the diagnosis is generally self-evident. However, it should be remembered that the iron salts, bismuth, dark-colored berries, or discoloring material in the intestine may so pigment the feces that they present the appearance of melena. The tarry stools with accompanying clinical history are generally sufficient, but in case of doubt the approved tests for occult blood should be employed.

TREATMENT.—Some general principles may first be laid down applying to severe hemorrhage above the rectum. Physical and psychic quiet must be maintained, and anything tending to increase peristalsis, raise the blood pressure, or cause decomposition of

intestinal contents must be sedulously avoided as much as possible.

In this connection the writer wishes to condemn the use of cold applications, and to indorse the views of Leube, who says "The application of cold to the abdomen, either in the form of an ice-bag, ice-compresses, or Leiter coil, is essentially valueless, for the cold cannot possibly exert any direct influence on the bleeding spot." The possible reflex benefit to be obtained from cold is more than counterbalanced by the probable excitation of peristalsis; besides, few patients find these applications comfortable.

Should there be sufficient strength to admit it, no food should be given by the mouth or rectum for forty-eight hours, and no fluid except cracked ice sparingly. After this time only liquid foods should be allowed for a week or longer, in the discretion of the physician.

Opium, formerly considered a sheet-anchor in the treatment of inaccessible hemorrhage, should be used sparingly, if at all, and then only in the form of morphine hypodermically to calm bodily restlessness. To give enough opium to "lock" the bowels, thereby permitting their contents to undergo putrefactive decomposition, will defeat the main object in view.

Ergot, also, is an idol that should be taken from its pedestal. In addition to the writer's experience with this drug, which has been wholly unsatisfactory, permit a quotation from Cushney: "In other forms of hemorrhages from the stomach, intestines, kidneys, lungs, or uterus (excluding postpartum hemorrhage), in which the bleeding point cannot be reached, ergot is often advocated in the belief that it contracts the walls of the vessels, and thus arrests the flow of blood. These hemorrhages so often cease spontaneously that it is difficult to estimate the value of any remedy, but it may be questioned whether ergot merits its reputation in these cases." Rolleston and Stengel are also on record with similar views.

The collapse or anemia, as from any other hemorrhage, may be combated by external heat, counter-irritation, or transfusion with alkaline solution.

To control bleeding from the rectum, as it is possible to reach the lesion, enemata of ice-water may be used, and to these, if desired, may be added styptics as tannin, alum, acetate of lead, nitrate of silver, or adrenalin. The writer has used with satisfaction the following suppository:

℞ Pulv. suprarenal,
Iodoform ..... āā gr. xxxvi.
Ichthyol ..... ♏ xxiv.
Ol. theobrom ..... q. s.
M. Ft. suppos. No. 12.
Sig.—One suppository half an hour before bowels are to be moved, and one after movement.

Further treatment is surgical and need not be described here.

Hemorrhages high up in the rectum or descending colon may be reached by ice-cold or astringent injections, but these are not to be employed until other methods fail, as they tend to keep up undue peristalsis.

Tampons of iodoform gauze, as recommended by some writers, are only mentioned, as being liable to inflict much indirect harm and accomplish but little direct good.

When the hemorrhage arises from the transverse colon on up to the duodenum, remedies to control it must be given by the mouth or hypodermically. Where there are slight and more or less frequently recurring hemorrhages, the bismuth salts, preferably the subgallate, in doses of thirty grains three to six times daily, are generally effective. Slightly more energetic in their action are tannic acid, tannigen, or tannalbin, in doses of ten or fifteen grains four to six times daily; but these often upset the stomach when continued more than three or four days.

When the bleeding assumes an acute form, and active measures are necessary, the remedies most efficacious are adrenalin, gelatin, and calcium chloride, in the order stated.

Since 1901 adrenalin has been recognized as possessing important hemostatic properties, and, while its action in inaccessible hemorrhages has been fairly well understood, its effect on inaccessible intestinal hemorrhages has been in some doubt. Following some careful investigations by Wiggers, it may be concluded that large doses of adrenalin (0.05 to 0.1 milligram) cause a preliminary increase of hemorrhage, and are contraindicated. Small doses of adrenalin (from 0.01 to 0.02 milligram) cause little or no preliminary increase, but shorten the course of the hemorrhage. As they save the blood cells in every way, they are therapeutically desirable.

The method of introducing adrenalin determines its effect on blood pressure and hemorrhage. No results are obtained by subcutaneous administration, but by continuous intravenous injection of weak solutions a slight elevation of pressure can be maintained, and bleeding is simultaneously checked. This can also be accomplished by intramuscular injections.

Adrenalin is not indicated in all intestinal hemorrhages, and blood pressure is the criterion for its use. In hemorrhages of short duration, where the pressure has not fallen to any extent, a judicious use of the nitrites proves of more benefit than adrenalin. When the bleeding has been profuse, however, and a low pressure exists, it becomes vital that hemorrhage should be checked without further reduction of pressure. Adrenalin finds its use in this field.

In 1896 Dastre and Floresco demonstrated that blood drawn from a dog into which a five per cent. solution of gelatin had been injected intravenously solidified almost immediately, and that the same results would be obtained by adding gelatin to the blood outside the body. In 1898 Lancereaux and Pauleseo found that subcutaneous injections of gelatin were quite as efficient. Taken internally the unaltered substance has a marked local hemostatic effect, but it is doubtful if this can be obtained from the products of gelatin digestion. For this reason it is best that entire peristalsis be not checked when this agent is administered by the mouth. When thought advisable, gelatin may be given hypodermically (three to five fluidrams), and also by the mouth (one to eight fluidrams) in a ten per cent. normal salt solution. It is fair to state, however, that DaCosta deprecates the use of gelatin hypodermically, rather, in the opinion of the writer, overestimating the danger of thrombosis.

The chloride and lactate of calcium have seemed to give good results by increasing the coagulability of the blood, though there is some skepticism in high quarters regarding the absorbability of the calcium salts by the intestinal surface. Kemp recommends either the chloride or the lactate of calcium (gr. 10), well diluted, every two hours. The chloride of calcium and gelatin may be given together, if desired, an eligible form being Tremolier's solution—a five per cent. solution of gelatin and a two per cent. solution of calcium chloride. The writer has alternated Tremolier's solution and gelatin with satisfactory results.

Another hemostatic agent of merit is the lactate of strontium, which may be administered by hypodermoclysis in doses of fifteen to thirty grains.

A recent remedy for intestinal hemorrhage, according to Klemperer, is estalin, an albumin preparation. Four or five tablets of estalin are dissolved in 100 c.c. of water, and taken early in the morning on an empty stomach.

Atropine, as a hemostatic, is being investigated at present, but the beneficial effects so far do not rest on a physiological basis.

It is well, especially in bleeding from duodenal ulcer, to endeavor to keep the bowel contents alkaline by

the ingestion of some efficient antacid, such as sodium bicarbonate in full doses.

After the active hemorrhage is arrested, it is advisable to continue these agents, either in smaller doses or at longer intervals for several days, during which time rest and strict dietetic precautions should be enjoined.

Should all the measures mentioned fail, surgical aid will be demanded, for in the case of malignant neoplasms, erosion of large vessels by ulceration or otherwise, or even some forms of hemorrhoids, medical therapy or local applications will necessarily be futile.

If, however, the suggestions indicated in the foregoing are intelligently and methodically followed, the cases of intestinal hemorrhage requiring surgical intervention will be reduced to a minimum.

GEORGE W. NILES.

Melilot.—SWEET CLOVER.—The dried herb of two species of *Melilotus*, *M. officinalis* Desr. and *M. altissimus* Thuill. (fam. *Leguminosæ*). These are tall, upright, or straggling biennial herbs, with small trifoliolate leaves and axillary spikes of minute clover-like flowers. Both plants are fragrant, having the pleasant odor of Tonka beans, which is increased by drying. They contain also the same odorous substance found in Tonka beans, *cumarin* (cumaric anhydride), as well as the related substances, *melilotus oil*, *melilotic acid*, and *cumaric acid*.

Melilot is a mild and pleasant aromatic of no special value in medicine, and is fairly obsolete. The infusion was formerly employed to a considerable extent as an eyewash. Dose indefinite. W. P. BOLLES.

Melissa.—LEMON BALM. "The leaves and tops of *Melissa officinalis* L. (fam. *Labiatæ*). This is a perennial herb, from one-half to one meter in height (twenty to forty inches), with several branching, leafy stems. The branches are quadrangular, the leaves opposite, petiolate, about five centimeters long, ovate, obtuse, rounded or subcordate at the base, crenate, somewhat hairy, glandular; flowers in about four-flowered cymules, with a tubular, bell-shaped, five-toothed calyx, a whitish or purplish bilabiate corolla, and four stamens; fragrant; somewhat astringent and bitterish.

The plant is a native of Southern Europe, and is frequently cultivated in Europe for the sake of its oil. It is now and then met with in American gardens.

The botanical description, given above, will serve for that of the drug, which, it may be remarked, loses very much of its fragrance in drying. Its principa constituent is the agreeable oil of balm, *Oleum Melissæ* (not to be confounded with the East Indian oil of citronella, which resembles it), of which it contains a small percentage (one-eighth to one-fourth per cent.).

Melissa has, in sufficient doses, the stimulant properties of the order, but as usually used is scarcely more than a flavor. An infusion of the herb can be given *ad libitum*, and when taken hot and in large quantity, like other mints, with the aid of hot water and plenty of coverings, is sudorific. The dose of the oil is ♏ iss. ad ♏ v. W. P. BOLLES.

Mellita.—A medicated honey (*mel*) is a thick liquid preparation very much like a syrup but with honey as a base. Honeys have no obvious advantage over the syrups, and it is not always an easy matter to obtain pure honey. There are three honeys official in the United States Pharmacopœia, and two in the British Pharmacopœia.

		COMPOSITION.
MEL (Honey).	U. S. P.	A saccharine secretion deposited in the honeycomb by the bee.
MEL BORACIS (Borax honey).	B. P.	Borax, 1 ounce; glycerin, ½ ounce; clarified honey, 8 ounces.
MEL DEPURATUM (Clarified honey).	U. S. P. B. P.	Honey, a convenient quantity; distilled water and glycerin, each, a sufficient quantity.
MEL ROSÆ (Honey of rose).	U. S. P.	Fluid extract of rose, 120; clarified honey, a sufficient quantity to make 1,000.

R. J. E. SCOTT.

Memory.—This concept is defined in Stedman's Medical Dictionary as "the power of retaining in subconsciousness and of reviving an impression or idea of which the mind has once been conscious; recollection." It seems clear, however, that memory and recollection are not exactly synonymous, because the former has in it more of retention than has the latter, and the latter more of recall than has the former. Inasmuch (as William James pointed out in his keen way) as retention has so far in our psychology and physiology little meaning save as a liability to recall, the two terms are of great similarity. The tendency at present, perhaps, is to broaden the usage of the term memory to include all impressions of whatever kind made on an organism, whether the mind in the orthodox, traditional sense be implicated or not; indeed the habits into which every complex metallic machine is sure to get sooner or later with use and wear require the development of conditions indistinguishable logically from memory conditions.

Few are the neurologic topics with further-reaching relations than "memory," a symbol merely by which our minds may handle a process which in fact involves every mode of the action of the nervous system and of the mind, if not of the entire body. The theory of memory therefore extends deeply into and ramifies everywhere in physiological psychology, and constitutes an essential corner-stone, of course, of all educational theory and practice both. In medicine, as we unravel further the hidden shadowy deeps of the subconscious does memory appear more and more important. This is true especially of *affect-memory* ("the memory of a psychic trauma, the emotional element recurring whenever the original experience is recalled," Stedman), which Freud has made an important part of mental pathology. Here only the simplest outline sketch of certain of the phases and aspects of memory is expedient; especially inadequate must our account be of its far-reaching interrelations with the subconscious phase of mind and with the conscious phases of the nervous system.

One reads in scientific treatises continually of "memory-traces," and we talk about them as if we were intimately acquainted with them instead of not quite certain yet that they even exist! The most recent "authoritative" account of this matter, published only a few months ago, is that by my colleague, Morton Prince, in his "The Unconscious" (New York, 1914) and from this we may advantageously quote at some length. We may, however, apparently well venture to omit consideration of all metaphysical and purely animistic theories of the retention and recall of psychophysical experiences, not because they are inherently unscientific, for they are not so; and certainly not because we would suggest their improbability, for the philosophic tendency at this time seems to be distinctly animistic (see William McDougall's "Body and Mind," for example); but

simply because there is nothing to say about them (even less than about the physical residue theories) save that they suppose the retention of ideas as ideas, feelings as feelings, etc., etc., *ad extremitatem*, in a range of mentality quite beyond our present scientific ken. But even did these processes, thus mistaken for entities, thus exist in some realm of individuated mind, there would still be their obvious relations to (and perhaps dependence on?) complex bodily processes to be accounted for. It is economical, therefore, not to say medical and physiological, to discuss or at least to mention only theories of memory which start with the protoplasmic basis. "Now, according to the psychophysiologic theory of memory," says Morton Prince, "with every passing state of conscious experience, with every idea, thought, or perception, the brain process that goes along with it, leaves some trace, some residue of itself, within the neurones and in the functional arrangements between them. It is an accepted principle of physiology that when a number of neurones, involved, let us say, in a co-ordinated sensory-motor act, are stimulated into functional activity they become so associated and the paths between them become so opened or, as it were, sensitized, that a *disposition* becomes established for the whole group or a number of different groups, to function together and reproduce the original reaction when either one or the other is afterward stimulated into activity. This disposition is spoken of in physiological language as a lowering of the threshold of excitability—a term which does not explain but only describes the fact (?). For an explanation we must look to the nature of the physical change that is wrought in the neurones by the initial functioning. This change we may speek of as a *residium*. * * * * It is sufficiently accurate to say that every mental experience leaves behind a residue or a trace, of the physical brain process in the chain of brain neurones. This residue is the physical *register* of the mental experience. * * * * The neurones in retaining residua of the original process become, to a greater or lesser degree, *organized into a functioning system*, corresponding to the system of ideas of the original mental process and capable of reproducing it. When we reproduce the original ideas in the form of memories it is because there is a reproduction of the physiological neural process. * * * *

Although we assume newly arranged dynamic associations of neurones corresponding to associations of ideas, we do not know how this rearrangement is brought about, though we may conceive of it as following the physiologic laws of lowering of thresholds of excitability. Nor do we know whether the modifications left as residua (by which the thresholds are lowered) are physical or chemical in their nature, though there is some reason for believing they may be chemical." Professor Prince then briefly discusses three chemophysical theories of neuroresidua, the anaphylactic, the autocatalytic, and the accumulator theories, respectively.

1. The anaphylactic theory might imply, for one notion, "that sensitization consists in the fixing of the cells of the tissues with these antibodies. This may or may not be correct—probably not—and I am far from wishing to imply that sensitization of the neurones, as a consequence of functioning, has anything in common with the mechanism of sensitizing the body in anaphylaxis. I wish merely to point out that sensitizing nervous tissue through chemical changes is a physiological concept quite within the bonds of possibility; and, as all functioning is probably accompanied by metabolic (chemical) changes, such metabolic changes may well persist in neurones after brain reactions produce sensitization. If this hypothesis of sensitization should be proven it would offer an intelligible mechanism of the phenomena of memory."

2. T. B. Robertson's autocatalyzing theory starts with that still somewhat mysterious property of certain substances to excite a transformation of energy. The inversion of sugars by acids, the decomposition of hydrogen peroxide by platinum-black, fermentation, zymolysis (Leduc), steps in the production of ether out of sulphuric acid, are examples of catalytic action. "In autocatalysis one of the products of the reaction acts as a catalyzer. Now Robertson concluded, as a result of experiments carried out on frogs, that the processes which accompany the excitation of the cells of the neurons are of the nature of catalysis; for he found that they have as one effect the production of an acid; and he also found that acids accelerate such processes which he concludes to be probably of the nature of oxidation. 'The chemical phenomena which constitute the activity of a neurone cell,' he says, 'seem to us, then, *an autocatalytic oxidation*, that is to say, an oxidation in which one of the products of the reaction acts as a catalyzer in the reaction,'" the production being proportional to the catalyzing activity. Upon calculating the amount produced in brain cells, it was found to correspond to the memory span of recalling, for example, a group of nonsense syllables in some of the well-known tests of Ebbinghaus and Smith. As Prince points out, however, Robertson's catalytic theory accounts not at all for retention, and suggests only a possibility of a method of recall. Ramon y Cajal also entertains and has to some degree elaborated a notion of chemotaxis as a basis of neuronal growth and association, but I am not aware of any comprehensive application of it to the physiology and psychology of registration, retention, and recall.

The third memory-theory noted in "The Unconscious" is one we have termed the accumulator-theory; its essence lies in a well-supposed analogy of the neurones to the units of an electrical storage battery; the notion is credited to Eugenio Rignano, who set forth its fundamentals in a treatise on biological inheritance (published in English by the Open Court Co., 1911). I quote again from Prince: "Now, according to the hypothesis, the specific nervous current set up by any stimulus forms and deposits in the nucleus of the cells (through which the current flows) a *substance* which adds itself to the others already there without changing them and which is capable under appropriate conditions of being discharged and restoring the same *specific* current by which it was produced. Each cell thus becomes what Rignano calls an *elementary nervous accumulator*. He points out that 'both the conception of accumulators of nervous energy in tension, and that of accumulators of a specific nervous energy constituting their specific irritability' which the hypothesis includes, are not new, but 'an ordinary conception very generally employed. * * * * * The only new thing which the above definition includes is the hypothesis that the substance which is thus capable of giving as a discharge a given nervous current, was produced and deposited only by a nervous current of the same specificity, but in the reverse direction, and could have been produced and deposited only by such a current. * * * * * In just this capacity of restoring again the same specificity of nervous current as that by which each element had been deposited one would look for the cause of the mnemonic faculty, in the widest sense, which all living matter possesses. And further, the very essence of the mnemonic faculty would consist entirely of this restitution. * * * * * The preservation of memories is to be ascribed to the accumulations of substance,' while the reawakening of these memories consists in the restitution of the same currents (by discharge of the substance) as had formerly constituted the actual sensation or impression.'"

We know nothing of any "specificity" in the neural influences as yet, but, none the less, there is obvious in recent writings a distinct tendency toward

some one or another phase or aspect of this accumulator or reservoir hypothesis, the grey matter being from this point of view a kind of dynamic mediator between its always energetic environment and various faculties of body and of mind.

The present writer, for example, has for some years been approaching a tentative belief that the afferent and efferent neurones are in a degree comparable to the brass "condensers" of a frictional electric machine, exerting a kind of static pressure continually (though not constantly) on every one of the numerous other structures (neurones, muscles, gland-cells, etc.) with which each is uniquely in functional relation, whether by the elusive "synapse," "induction," or by whatever other still hypothetical means. Max Verworn has recently tended to strengthen greatly such a viewpoint by claiming that the principle of all-or-none is necessary as a law of the neurone's action. By means of these neuronal "condensers" the afferent neurones, the energy-transmitting environment keeps the great "grey" nerve-masses in continual kinetic strain, the energy "flowing" hither and thither as the "set" of the intake and outgo or other functional conditions (along Sherrington's "final common paths" more or less) requires. From this tentative theory of the relationship between environment and brain (and sinal cord), memories would be in the form of special neurokinetic strains and stresses and shears, representing tendencies to retention and equally well, if not better, tendencies to repetition of strains given in consciousness as recall. With our present ignorance still of the nature of the nervous "energy or impulse" it is pure but excusable speculation to go far into these conditions, but certainly all facts and relations known to the present writer at least suggest almost unanimously the dynamic nature of everything concerned with mind and nervous system, including inevitably the "traces" which metaphor and analogy have "put into" neurology. These traces we apparently must think as purely *dynamic tendencies to behavior*, neurokinetic strains. Such may be the basis too, then, of registration, retention, and recall,—in short, of memory.

If, under stress of internal effort or by influence from the dynamic environment, the neurones are capable of quickly extending or of growing extremely minute branches and in this manner of forming new associations, as some (Cajal, *e.g.*) have suggested may occur under some sort of indefinite chemotaxis, then the effort and the reflex attention both of which are clearly at the basis, somehow, of memory, would also, perhaps bring about new protoplasmic connections between the neurones. Because "grey matter" is eighty per cent. water this process is less difficult to understand than otherwise would be the case. Perhaps this quick constructive neural thrust occurs chiefly or wholly in those essential central neurones just now fashionably termed the adjustors.

As a function of coördination between the past and the specious present (analogically well termed dischronation in C. S. Minot's exposition of the biologic functions of consciousness), memory would seem to depend more or less on some integrative elementary condition or process in the neuronal fields and may therefore be said to be more or less innate. It may be not unreasonably the congenital *complexity* of the neurones and, in consequence, of their mutual association, that determines intelligence, ingenuity, genius, etc.; including memory. On this basis we should find the perfection of memory a matter varying widely in different individuals and conditions. Although there is nothing in such a notion which would make the supposition necessary that memory should not be developable or improvable, there is, none the less, a widespread belief among psychologists that such is the case. Experiment many times has shown that a person's memory-span cannot be widened by practice or by effort. But, none the less, for practical purposes, since habits of interest, of attention, and all the other factors which condition memory, are subject to improvement and development, memory as an actual indispensable "faculty" of mind may be improved, and this clearly is seen to amount to the same thing, save theoretically.

The relations of memory to other physiological and especially to pathological conditions are indistinct as yet, but much research by neurological clinicians, psychologists, educators, etc., are rapidly developing a mass of facts which time will surely integrate. In general terms, retention seems to be in proportion to the *biological interest* of the impression. If we exclude early childhood's memories, impressions seem to be lost in general in senescence in the inverse order from that in which they were received—a process dependent doubtless on the involution or degeneration of the finer branches of the cortical neurones, perhaps of the middle ("granular") layer of the cortex described in J. S. Bolton's well-known researches, (*"Brain,"* xxxiii, 129, 1910). There is a belief held by some that excessive masturbation "dulls" the memory, and this is by no means beyond physiologic good-sense when we recall the known close relation between the reproductive organs and the thyroid gland, the epiphysis, the pituitary, etc., and in turn their relations, especially the first's, still vague, to the nutrition of the nervous system (seen particularly in exophthalmic goiter). Multiple personality seems to offer for study a condition of sometimes sudden and wholesale loss of memory and of its quick recovery at various times. Such facts seem to *imply that somehow our general interpretation of the nervous system is in some sense wholly wrong thus far*, but how wrong even, no one as yet can say. Effort to remember details not indispensable is very often to most men actually wasteful of nerve-energy and of this force above all things else, there is never any excuse for waste. One has a certain definite memory-span apparently, and despite our indefinite knowledge of its practical or cerebral conditions, they appear to be in some way of such a nature that to some extent the memory may be, so to say, filled, so as to not readily hold more. If then needless things are actually remembered by strain of the wasteful effort of attention, other matters more important, such as concepts of relation, may be kept out of the memory, having no "room." Memory, then, as a "faculty" of the mind, should be as kinetic and dynamic as possible, a potential set of living interrelated principles or interests on what not rather than merely a repository for numerous unconnected impressions more or less dead and unrelated to the moving elements and processes of the mental life. The medical student, for example, who thinks to learn from lectures by remembering the principles which are expounded to him, ignoring detailed notes, is theoretically right, even if practically wrong owing to the enormous technical detail of modern medicine which no mind may compass without quite inexcusably wasteful expenditure of energy. Notes and talk and magazines and books are therefore indispensible to the progressive physician however "good his memory." The ideal treatise on the memory, in all its aspects and widespread ramifications, remains to be published. GEORGE V. N. DEARBORN.

Mendelism.—See *Heredity*.

Mendenhall Springs.—Alameda County, California.

POST-OFFICE.—Livermore. Cottages.

ACCESS.—Via Southern Pacific and Western Pacific Railroads to Livermore; thence by stage to the Springs. Mendenhall Springs are situated in a shady mountain nook, 1,800 feet above the sea level, ten miles from the town of Livermore.

The scenery is wildly picturesque; the atmosphere dry and exhilarating.

Mendenhall Springs are noted for fine mineral water—Agua de Vida—which flows from two springs about 100 yards from the main buildings and is piped all over the grounds and is also used for tub and shower baths.

The following analysis was made by Dr. Anderson:

	Grains per Gallon.
Sodium chloride	5.07
Sodium carbonate	2.25
Sodium sulphate	17.50
Potassium carbonate	Traces
Magnesium sulphate	8.70
Calcium carbonate	11.92
Calcium sulphate	4.35
Alumina	0.40
Silica	0.55
Organic matter	Traces
Total solids per gallon	50.74
	Cubic inches
Sulphureted hydrogen	2.74
Carbonic acid gas	9.25

Light saline sulphureted water

The water is found very beneficial in certain forms of dyspepsia, liver and kidney troubles. It is also a very pleasant drinking water. There are several sulphur springs in the vicinity.

Many forms of amusement are provided for the guests. EMMA E. WALKER.

Ménière, Prosper.—Born at Angers, France, in 1799. He received the degree of Doctor of Medicine in 1828. In 1832 he was appointed Chef de clinique of the Paris Medical Faculty, and afterward he was elected an Agrégé under Chomel. On the recommendation of Orfila he was made Physician-in-Chief of the Paris Deaf-and-Dumb Institute in 1838. He died at Paris, February 7, 1862.

Ménière, says Pagel, was a very broadly cultivated man, with a strong predilection for classical studies. His essays on the Roman poets and on Cicero are well worth reading, even to-day. Ménière, however, has won for himself an important place in the history of otology by his discovery of a peculiar affection of the organ of hearing. Shortly before his death he published an account of this affection under the title: "Mémoire sur des lésions de l'oreille interne donnant lieu à des symptômes de congestion cérébrale apoplectiforme." (A similar, but more detailed, account will be found in the *Gazette médicale de Paris*, 1861.) Ménière assumes, in this account, that the causative lesion is confined to the labyrinth, and consists of a hemorrhagic inflammation located in the semi-circular canals. He bases this hypothesis upon the findings in a single postmortem examination and upon the phenomena (vertigo and movements in a circle) observed by Flourens in certain animals after he had injured the semi-circular canals. A. H. B.

Ménière's Disease.—This disease is of especial importance in that it marks the first attempt to ascribe the production of vertigo and nausea to a lesion of the labyrinth of the ear. Flourens, to be sure, had already carried out a series of experiments on the semicircular canals of pigeons and other animals which demonstrated conclusively the importance of these canals in controlling equilibrium, but the function of the labyrinth as a whole was not well understood.

Ménière, an assistant in the faculty of medicine of the French Imperial Institute for Deaf Mutes, had made a number of interesting observations on his patients and with Flouren's results in mind he read a paper before the Imperial Academy of Medicine on January 8, 1861, describing a symptom-complex the cause of which he correctly ascribed to pathological changes in the internal ear. So acute and thoroughly painstaking were his observations and so logical were his conclusions that his original essay stands to-day a model of correct medical thinking.

Ménière stated that nearly everyone had seen persons in apparently good health who were suddenly stricken as if by an apoplectic stroke or epileptic seizure. The syndrome began with noises, followed by extreme vertigo, syncope, nausea, and vomiting, and concluded with severe impairment of hearing, even extreme deafness. These symptoms had always been ascribed to diseases of the stomach, kidneys, heart, or general circulation. However, in his cases the general health had always been very good. There was no discoverable hereditary cause. The attacks were sometimes frequent, gradually disappearing after months or years but leaving the hearing in one, occasionally in both ears, permanently damaged. Most surprising of all, examination of the ears revealed no actual lesion—the drums were normal and the Eustachian tubes were open. All tests save that for deafness were negative. In one case Ménière was fortunate enough to get an autopsy. The patient was a young girl, who during her menstrual period, rode in a diligence and acquired a severe cold. She had a sudden severe seizure of vertigo, nausea, and vomiting, followed by complete deafness. She was brought to the hospital but her symptoms were not relieved, and she died on the fifth day. Autopsy showed no lesion in the cerebrum, cerebellum, or spinal cord, but careful examination of the inner ear determined the presence of a bloody, fibrinoplastic exudate in the semicircular canals. The cochlea was said to have been free, but it is certain from the symptoms described that a microscopic examination would have shown changes in Corti's organ. This case was probably one of anemia or chlorosis with sudden hemorrhage into the labyrinth.

From his observations Ménière drew the following conclusions: (1) The auditory apparatus in perfect health may become the site of functional trouble consisting of noises continued or intermittent, accompanied by diminished hearing. (2) These functional troubles having their site of origin in the internal ear may give rise to symptoms reputed to be of brain origin, *i.e.* vertigo, uncertain gait, turning sensation, nausea, vomiting, and a state of syncope. (3) All these symptoms are commonly intermittent in form and are followed by diminished hearing, or even by complete deafness. (4) The conclusion, therefore, is that the cause of these troubles lies in the semicircular canals.

When various observers began to study cases presenting symptoms like those described by Ménière, confusion at once arose, in that all cases of labyrinth disease were classified under this heading. The unwisdom of naming a disease after an individual has ever been a potent cause of difficulty in pathological work from the earliest times. Unfortunately the tendency still exists, but if we must retain the phrase "Ménière's disease," let us confine it strictly to the type of case which the French observer so well described—namely, to those patients with previously normal ears who experience a sudden attack of noises, dizziness with turning sensation, nausea, vomiting, and disturbances of equilibrium. A better term such as apoplectiform labyrinthitis might be found. We would then avoid the possibility of confusing this type of labyrinthine lesion with acute serous and suppurative disease of the labyrinth, with circumscribed labyrinthitis, or with various injuries to the head in which all of the symptoms described by Ménière appear.

It is worthy of note that Ménière said nothing in his early reports about nystagmus. He does mention disturbance of the eyes, but the very important phenomenon of nystagmus seems to have escaped him.

Etiology.—The French clinician was of the opinion that certain disordered states of the blood are responsible for this condition, but he does not wish to ascribe them to "circulatory change," by which he probably meant diseases of the heart and blood-vessels.

Bertrand, writing later, speaks of an "hereditary predisposition" to these attacks. Axenfeld found the condition in persons of an "apoplectiform temperament and in nervous irritable individuals." Knapp thought that syphilis, rheumatism, scrofula, puerperal fever, and acute exanthems were probable causes.

In an examination of 100 cases Gruber found that a secretory exudate was much more common than hemorrhage into the labyrinth, a fact which seems to explain the improvement in hearing which in some cases takes place after a few months.

Causes within the labyrinth are syphilis, leukemia, anemia, hyperemia, toxemia, and extravasation of fluid. Outside of the labyrinth there are a number of extraneous disorders such as impacted cerumen, middle-ear disease, meningitis, tumors, abscesses, and diseases of the nuclei or trunks of the facial and auditory nerves.

Types of Ménière's Disease.—Lannois and Chavanne have classified the disease according to its onset and general course into five principal groups: (1) The Apoplectiform. (2) The Paroxysmal. (3) The Attenuated. (4) The Incomplete. (5) The Psychic. That known as the apoplectiform variety is either traumatic or non-traumatic, the traumatic form being the rarer and coming on as a result of attempted suicide, fracture of the skull, or operations upon the head. The non-traumatic is the classical type. Preceding such an attack there may be an aura such as headache, or noises and spots before the eyes. It is ordinarily followed by complete, permanent deafness.

The paroxysmal form is chronic with continuous remissions. It has been known to persist for ten years and longer. Here there may be no premonitory symptoms. There is no loss of consciousness and complete deafness is uncommon.

The attenuated form is said to be very common, and has been ascribed to disease of the kidneys, stomach, uterus, anemia, etc. The symptoms are slight and are chiefly noticeable on getting up from a prone position, sudden turning of the head, mastication, and the like.

Incomplete forms (formes frustes) show very slightly diminished hearing which is only temporary. The syndrome is without subjective noises or vertigo of any severity; one or more of the so-called triad—vertigo, noises, and deafness—may be lacking.

Finally, the fifth or psychic form may resolve itself into disturbances of the mind or will; phobias such as agoraphobia, degeneracy, dextrophobia or fear of all objects on the right side of the body, fear of water, and psychoses consisting of auditory hallucinations, delusions of persecution, and attempts at crime.

While this classification is of interest and importance to the neurologist, it has less significance for the otologist, who must consider all these varieties as manifestations of labyrinthitis whatever be the cause.

Diagnosis.—This should offer no difficulty to the trained clinician as the history alone is often sufficient basis for an accurate opinion. The condition is sometimes confused with cerebellar disease, hysteria, and neurasthenia. To be sure in cerebellar disease there may be the same ataxia and dizziness, but there is usually severe headache, paresis of the limbs, and mental impairment which does not obtain in Ménière's disease. Moreover, in the latter cranial nerves other than the auditory are not involved, while in cerebellar disease optic atrophy is common. Hysteria and neurasthenia can be absolutely ruled out if the proper functional tests are applied. Unilateral deafness can be determined by testing the involved ear while shutting out the good ear with Bárány's noise apparatus. Irrigation of the affected ear with water hotter or colder than the body will determine whether the vestibular nerve is functionating (caloric test).

Treatment.—An expectant plan of treatment is rarely satisfactory. Ablation of the labyrinth by operation may be indicated in extreme cases.

Erdtmann of Brooklyn has outlined a plan of treatment which was very satisfactory in one case. He used pilocarpine, gr. $\frac{1}{4}$, three times a day gradually increasing the dosage. Quinine, gr. ii, was given three times a day and increased up to gr. xxx. Nitroglycerin, gr. $\frac{1}{100}$, was increased very slowly. Iodine was used as a counterirritant over the mastoid Occasionally the pilocarpine was stopped and bromides and tincture of belladonna were substituted. The bowels were kept open and all alcohol was prohibited.

Various French writers including Ménière himself have administered salicylic acid. Blood-letting and purgations have also been used by them.

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Meningism.—*Synonyms:* Meningeal irritation, meningeal reaction, the syndrome of Dupré. This may be defined as a condition simulating meningitis but in which the pathological evidences of the latter are not present. It is observed most frequently in association with the acute fevers in children, and with pneumonia and typhoid fever. It is also a frequent accompaniment of acute alcoholism and of acute otitis media.

In the light of recent studies, chiefly with the aid of lumbar puncture and the examination of the cerebrospinal fluid, the term meningism appears to be a misnomer, for in most if not all of the conditions in which it is present there are vascular or toxic changes in the meninges. These constitute a distinct meningeal reaction, the clinical evidences of which may be identical with those of any of the varieties of true meningitis. In the so-called meningism of pneumonia or typhoid fever lumbar puncture reveals an increased pressure in the cerebrospinal fluid, which in itself is evidence of some disturbance in the meninges resulting in an increased production of this fluid. This condition is really one of serous meningitis.

Until quite recently an important distinction between meningitis and the so-called meningeal reactions was based upon the supposition that the presence of leucocytes in the cerebrospinal fluid signifies an infection of the meninges, even though the causative microbe may not be detected. But Widal has called attention to certain cases of what he has termed "aseptic meningitis," in which the cerebrospinal fluid contains such a large number of leucocytes as to appear purulent. But careful bacteriological examination with the aid of cultures and animal inoculations has shown the complete absence of bacteria and the presence of leucocytes which are intact and have normal tinctorial affinities and which cannot be differentiated from normal polynuclear leucocytes. Particularly in cases of otitis media in infants has there frequently been observed an aseptic cerebrospinal fluid containing a large number of normal polynuclear leucocytes. Undoubtedly in these instances the meningeal reaction is the result of the action of the disease toxins. But it has been found possible to evoke experimentally a similar reaction by injecting into the subarachnoid space such substances as horse serum, novocaine, and magnesium sulphate. Dopter has shown that in cases of heat stroke with meningeal symptoms such as headache, vertigo, convulsions, rigidity of the neck, and Kernig's sign, there is a cerebrospinal fluid under great pressure, and that in the most serious instances

of this condition the cerebrospinal fluid is rich in cellular elements, at first polynuclear leucocytes and later lymphocytes. In many chronic nervous and mental diseases similar meningeal reactions together with the associated changes in the cerebrospinal fluid have been observed; likewise in cases of lead poisoning ("la meningite saturnine" of Mosny and Malloizel), in uremia (the uremic meningitis of Lépine and Chauffard), and in carbon monoxide poisoning distinct meningeal reactions have been noted.

H. Paillard and J. de Fontbonne have recently made a clinical and cytological study of the meningeal reactions accompanying the intoxications. They differentiate four types: (1) There is an acute transient intoxication such as is sometimes observed in carbon monoxide poisoning and in some cases of uremia. There is evidence of a circulatory disturbance of the meninges rather than of the direct action of the poison upon the latter, a condition analogous to that described by Dopter in the case of heat stroke. There is a fugitive congestion of the meninges, with an abundant exudation of leucocytes (the "fluxion blanche" of Widal). (2) This type comprises a complex of symptoms of more prolonged evolution and of graver import than in the first group of cases. It is observed in cases of chronic lead poisoning and the clinical picture resembles so closely that of tuberculous or of syphilitic meningitis that the differential diagnosis from the latter is extremely difficult. (3) To this category belong those cases of chronic evolution in which there are pronounced psychic and organic changes, cases which have been recognized for a long time and described variously under the names toxic pseudoparesis, alcoholic pseudoparesis, and saturnine paresis. (4) The last group includes those cases in which there are no clinical symptoms but in which lumbar puncture reveals a latent meningeal reaction.

The meningeal reactions have been most closely studied in the case of four different types of intoxication, namely, saturnism, alcoholism, carbon monoxide poisoning, and uremia. The first has been studied by Mosny and Malloizel who distinguish three groups of cases: (1) The meningeal reaction is latent, being observed in recent cases of plumbism, and showing a moderate degree of lymphocytosis in the cerebrospinal fluid. Some cases are not entirely latent, a pronounced cephalalgia pointing to the meningeal irritation. (2) This group presents all the clinical manifestations of meningitis; the spinal fluid shows an initial polynucleosis and a secondary lymphocytosis. Two rare sub-types, psychic and spinal, have been described. (3) This group comprises the cases of so-called saturnine pseudoparesis.

The meningeal reactions of alcoholism include the acute type, as seen in delirium tremens in which there is a serous infiltration of the meninges, which are also the seat of congestion and hemorrhagic foci. Some authors have described cortical lesions in delirium tremens. In the subacute or chronic type of alcoholism there is a complete absence of cellular elements in the cerebrospinal fluid.

In carbon monoxide poisoning the cases which have come to autopsy have shown a congestion of the pia mater and occasionally the presence of hemorrhagic foci. The clinical syndrome is marked, comprising the following symptoms: contractures, exaggeration of the reflexes, incontinence of urine, cephalalgia, vertigo, and Kernig's sign. The cerebrospinal fluid shows at first numerous red blood cells and polynuclear leucocytes; later there is a predominating mononucleosis, and still later there is solely a lymphocytosis.

The meningeal reactions of uremia have been carefully studied within recent years and are subdivided into two groups, corresponding respectively to acute convulsive uremia and chronic uremia. In the former of these there is no true meningitis but rather a transitory meningeal reaction characterized by an abundant polynuclear exudation into the cerebrospinal fluid and a congestion of the meninges. In chronic uremia there has not been reported a single case in which the meningeal symptoms could be attributed solely to uremic poisoning. Bousquet and others have described instances of meningism observed in children with a neuropathic heredity and in cases of gastrointestinal antointoxication.

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REFERENCES

Bousquet, L.: Le meningisme, ses rapports avec la ponction lombaire. Gazette des Hôpitaux, 1910, p. 1025.

Carrière: Etude sur le liquide cephalo-rachidien dans l'urémie nerveuse. Société de Biologie, séance du Oct. 22, 1914, p. 239.

Chauffard: Urémie aigue et polynucléose rachidienne. Semaine Médicale, Nov. 13, 1907, p. 541.

De Massary et Weil: Réaction méningée aseptique au cours d'une otite moyenne suppurée; integrité des polynucléaires; guérison. Soc. Med des Hôp., Oct. 11, 1907.

Dopter: Le liquide céphalo-rachidien dans le coup de chaleur (9 cas). Soc. Méd. des Hôp. de Paris, séance du Dec. 4, 1903, p. 1396.

Gennari, G.: Acute meningismus of gastrointestinal origin. Gazzetta degli Ospedali, 1908, p. 469.

Janzo, Noshida: Über Meningismus der Säuglinge. Mitteilungen der medizinishen gesellschaft zu Tokyo, xxi., 1907, p. 14. Zentralblatt für Kinderheilkunde, xiii, 1908, p. 295.

Leenhardt, Mallet, and Ganjoux: Réaction méningée au cours d'une infection indeterminée chez l'enfant. Bulletins de la Société des Sciences Médicales, March 3, 1909. Montpelier Médical, April 25, 1909.

Lépine: Existe-t-il une méningite urémique? Semaine Médicale, July 31, 1907, p. 361.

Magnan, U.: De l'alcoolisme, des diverses formes du délire alcoolique et de leur traitement. Paris, 1874.

Marie, P. et Guillain, G.: Céphalée brightique traitée par la ponction lombaire. Soc. Méd. des Hôp., May 3, 1901.

Mosny et Pinard: Urémie chronique et leucocytose céphalo-rachidienne. Soc. Méd. des Hôp., séance du Dec. 11, 1908.

Mosny et Malloizel: Revue de Méd., 1907.

Mosny et Saint-Girons: Syndrome méningé aigu avec polynucléose cephalo-rachidienne abondante et fugace chez une alcoolique. Soc. Méd. des Hôp., Feb. 17, 1911.

Paillard, H. ex de Fontbonne, J.: Les réactions meningées dans les Intoxications. Gazette des Hôpitaux, Jan. 18, 1913.

Pinard: Méningite saturnine. Gazette des Hôpitaux, July 18, 1908.

Renaut, J.: De la paralysie générale d'origine saturnine. Ann. Méd.-psychol., 1867, p. 421.

Rouillard: Les pseudo-paralysies générales. Gazettes des Hôpitaux, June 7, 1888.

Vallon, C.: Pseudo-paralysies générales saturnines et alcooliques. Paris, 1894.

Meningitis, Cerebral.—Meningitis, in general, was first recognized as an affection separate from disease of the brain by Morgagni, 1760. Epidemic cerebrospinal meningitis first attracted the attention of Vieusseux, of Geneva, 1805, and of Strong, North, Fish, Hale, Miner, and Williams, of our own country, 1806–1814, and was at that early period easily differentiated from affections limited to the membranes of the brain. Parent-Duchatelet and Martinet, 1821, first distinguished inflammation of the dura and pia mater, and Guérin and Guersant, 1827–1839, first distinctly recognized and set apart the tuberculous, granular, or basilar form of the disease. The first clear descriptions of the exclusively "simple" meningitis, from a pathological standpoint, are to be found in the works of Cruveilhier, 1830, and from a clinical standpoint, in those of Andral, 1834, and of Rilliet and Barthez, 1843. The recognition of the fact that simple meningitis is always a secondary affection is the result of the more accurate postmortem observations of the last three decades, and contributions from rhinology and otology.

That the various forms of meningitis are caused by specific microorganisms was pointed out by Koch, 1882, who demonstrated the tubercle bacillus in tuberculous meningitis; by Leyden, 1883, who found a diplococcus in the cerebrospinal fluid and the pia,

which Fraenkel and later Hauser showed to be identical with the pneumococcus; by Weichselbaum, 1887, who showed the presence of the diplococcus intracellularis meningitidis in epidemic cerebrospinal meningitis; by Foà and by Bordoni-Uffreduzzi, who described a third and a fourth variety of the meningococcus.

Weichselbaum in Germany and Adenot in France, 1884, showed that meningitis occurring during or after an attack of pneumonia depended, as a rule, upon the same microorganism that caused the pneumonia. Later observers have found meningitis frequently due to the pneumococcus in the absence of pneumonia.

In twenty-five cases of suppurative meningitis reported by Netter the pneumococcus was found in eighteen, the streptococcus pyogenes in four, the diplococcus intracellularis in two, and the typhoid bacillus in one case.

Next to the tubercle bacillus, the typhoid bacillus is most prone to cause purulent meningitis. Next in the order of frequency is the *Bacillus coli communis*. A rôle in etiology has also been ascribed to the *Bacillus pyocyaneus*.

Among the pleomorphic bacteria that have been described in the exudates of meningitis are the *Cladothrix asteroides* of Eppinger, and the actinomyces.

Pachymeningitis, inflammation of the dura mater, presents itself in two forms, external and internal, purulent and hemorrhagic, representing entirely different disease processes. Pachymeningitis interna, the hemorrhagic form, is really the result of a degeneration rather than of an inflammation; but in the absence of definite knowledge regarding the genesis of this disease, the two forms may be best studied together.

Pachymeningitis Externa.—Accidents or injuries which directly expose the dura, or effect its separation from the bones of the skull, with consequent extravasation of blood, whereby is implied, at least, a "hidden crevice" or some communication of the dura with the air, lead at once to inflammation of the outer lamella which may extend so as to involve all the rest of the membranes of the brain. Carious processes of the ear constitute an even more frequent cause of this condition. A mere microscopic breach in the thin wall of bone that forms the upper covering of the tympanic cavity will bring pus from the tympanum to the dura. So, also, caries of the ethmoid bone (ozena) or other bones of the cranium (syphilis, carbuncle) may excite this form of meningitis; and purulent inflammation of the ethmoid and frontal sinuses may extend to the dura through the natural openings of communicating vessels. This complication has been noticed more especially in erysipelas after "mixed infection," whose nature it is to spread. As purulent pachymeningitis rarely remains confined to the dura, but extends, as a rule, to involve the pia mater, the symptoms and pathology of this condition will be further discussed with leptomeningitis.

Pachymeningitis Interna.—The disease of the dura which merits most consideration, from its frequency, limitation, and recognizability in life, is that affection of the inner layer which is characterized by the extravasation of blood and subsequent development of an adventitious membrane, commonly known as hematoma duræ matris, and technically described as pachymeningitis interna hemorrhagica. With these characteristics it is plain that internal pachymeningitis does not supply the requisite conditions, nor rise to the nosological dignity of an inflammation in the modern sense of the term. It develops oftenest independently of all infection, and should properly be discussed as a subvariety of cerebral hemorrhage.

Pathology.—The pathology of this affection remains as yet obscure. The early anatomists and clinicians were fain content with descriptions of the condition without venturing to express opinions concerning the nature of the disease. It was commonly held and taught that the disease consisted in the extravasation of blood, and the only question discussed regarded its situation.

That hemorrhagic pachymeningitis is not the expression of an ordinary inflammation is shown by the fact that no amount of irritation of the dura will produce it. Injections of ordinary irritants into and beneath the membranes of the brain of lower animals may be followed by purulent, but never by hemorrhagic, pachymeningitis. On the other hand, the injection of blood with all its constituents sufficed, in the experiments of Sperling, to produce the typical signs and lesions of the disease. The rôle of the fibrin in these cases is evidenced by the fact that a membrane was not developed after injections of defibrinated blood.

Internal pachymeningitis consists, then, in the extravasation of blood, the formation of a blood clot which, when the effusion is not too great or rapid, is flattened by pressure, to become subsequently organized into a membrane. In the first stage of the disease process, the thin layer of coagulated blood soon begins to show, in the separation of its fibrin, a meshwork which contains multitudinous blood corpuscles. At this time there is no apparent connection with the dura, whose epithelium remains intact. In the consolidation which continues, the clot assumes the appearance and density of a membrane, which now in reality develops, from the transformation of white blood corpuscles into spindle-shaped connective-tissue cells, whence the synonym, *P. fibrinosa*. The red corpuscles now gradually lose their coloring matter, which collects in spots on the surface, and in the texture of the membrane (*P. pigmentosa*) lose their regular contours, and finally become transformed into masses of protoplasm. Young vessels now connect the dura with the membrane, which becomes gradually more dense, thick, and adherent. In the meantime new layers of blood may be effused into the membrane already in process of formation, which consists thus of superimposed lamellæ. The effusion takes place chiefly upon the convexity of the brain, and is rather more frequently bilateral than unilateral.

The chief danger of these effusions is pressure upon the brain, which shows itself in proportion to the amount of the extravasation. The great evil of pressure is obviated in many cases by the latitude allowed by atrophy of the brain substance. The greatest contingent of cases is found in connection with paralytic dementia, and cases independent of some degree of atrophy are comparatively rare.

When, from any cause, a real inflammation is engrafted upon this hemorrhagic degeneration, serum or pus may be found in connection with the blood which forms the hematoma. Virchow describes a hydrocephalus externus pachymeningiticus, and Weber saw, in a lamellated hematoma, blood in one cavity and yellow-green pus in another.

Pachymeningitis is a much more frequent affection than is commonly believed. Savage records its presence in three per cent. of the autopsies made at the Bethlehem Hospital and when it is remembered that there are more cases of dementia and insanity, not to mention alcoholism, out of than in asylums, it is seen that this percentage is far too low. It is safe to say that most of the cases remain undiagnosticated during life; and death, when it occurs, though perhaps caused by this affection, is ascribed to the disease in the course of which this accident develops. All authors agree in noting three-fourths of all the cases in the male sex, a proportion which corresponds to the relation of the sexes to the affections which produce the disease. For the same reason hemorrhagic pachymeningitis is a disease of advanced life. Exceptional cases at early periods of life—six months to eight years—have been recorded, mostly in connection

with the venous stases from the strain of asthma, pertussis, etc., or the impoverished nutrition of blood-vessels from scurvy, leukemia, and more especially pernicious anemia; and cases have been more abundantly reported during adolescence and maturity in connection with tuberculosis, empyema, valvular lesions of the heart, the various forms of Bright's disease, the various infections, and more especially local injuries of the dura; but aside from these accidents, pachymeningitis remains a disease of age. The largest number of cases twenty-two per cent., in the collection of Huguenin, occurred between the ages of seventy and eighty.

Symptomatology.—Internal pachymeningitis exists at times without a symptom to mark its presence. Moses reports such a case in a child, aged seven months, who died of catarrhal pneumonia. Slight extravasations often show no sign because of absence of pressure, or, if slowly effused, because of tolerance, which the brain acquires often in astonishing degree. In other cases the accident is overshadowed by symptoms pertaining to the original disease. These are, however, exceptional cases.

In the majority of cases the disease announces itself suddenly and violently. The patient is stricken with apoplexy. The hemorrhage may be so great as to cause death by compression of the brain within forty-eight hours. The localization of the hemorrhage, is, as a rule, in such cases impossible to determine. The first attack is not, however, usually fatal. These symptoms vary greatly in individual cases, vary according to the locality and extent of the effusion, as well as according to the nature of the original disease; but they do not differ in essential characters from the symptoms of meningitis from any cause. Headache, stupor, which may at any time deepen to coma, monoplegias, hemiplegias, or, in the irritant stage, unilateral twitchings and convulsions, limited at times to one extremity, or confined to the area of distribution of the facial nerve; aphasia, when the region of the language center is compressed—these symptoms, together with an irregular or retarded pulse, vomiting, and more especially contracted or dilated pupils irresponsive to light, with little or no disturbance of general sensation, make up a group which as a rule distinguishes the disease.

But, as already intimated, it is not so much the symptomatology of the affection as its etiological relations which strictly define the disease. The general signs of meningitis refer especially to hematoma only when they occur in the course of general paralysis, chronic psychoses, alcoholism, chronic Bright's disease, pernicious anemia, traumata, the affections mentioned in the discussion of the etiology of the disease.

Another distinguishing, but by no means so distinctive, feature to indicate the nature of the affection, is the recurrence of the symptoms. Total or partial recovery from all the general manifestations of meningitis is followed in pachymeningitis, as a rule, by repeated attacks, and though the special symptoms may show great variety in relapses or recurrent attacks, the general character of the new signs is definitely sustained.

Diagnosis.—This is based upon two cardinal points: the existence of an underlying condition or causative disease, and the more or less rapid recurrence of the attacks. Cases are further characterized by suddenness of onset and rapidity of recovery. Dr. Whittaker had at one time under observation an individual affected with chronic alcoholism who was suddenly stricken with apoplexy on the streets. The patient was carried comatose to the hospital. The coma subsided in the course of a few hours, to leave a complete right-sided hemiplegia, which entirely disappeared in three days, leaving the individual in better physical and mental condition than for ten years. Many of the cases of so-called "serous" apoplexy, characterized by sudden onset, and more especially by speedy recovery, are really cases of pachymeningitis.

The predominance of symptoms indicating cortical lesion is another feature of diagnostic importance. Thus localized convulsions and contractions, monoplegias, contracted pupils, following an apoplectic attack in an individual predisposed to the disease by the factors already emphasized, point almost certainly to pachymeningitis.

Considerable diagnostic importance has been attached to rigidity of an extremity, which often develops as an expression of irritation of the motor center of the extremity, to become later manifest by convulsion or paralysis. Collins considers it rather characteristic that the cranial nerves always remain free. A point of differentiation from other forms of intracranial hemorrhages is that the symptoms come on gradually and the stage of irritation is prolonged.

The age and sex of the patient must not be overlooked.

Basilar meningitis is differentiated by the youth of the patient, the family history, the presence of tuberculosis elsewhere, by its long prodromes, its insidious approach, its general and special hyperesthesia, opisthotonos, boat-shaped abdomen, etc.

Cerebrospinal meningitis prefers winter, soldiers, and children, occurs at times in endemic proportions, shows opisthotonos, herpes, sometimes petechiæ, extreme hyperesthesia, and spinal lesions, and does not recur.

Prognosis.—Recovery without recurrence is possible, but not probable. The patient succumbs, as a rule, in a subsequent attack, if he does not fall a victim in the meantime to the original disease. The immediate prognosis is best established, as after any cerebral hemorrhage, by frequent observations of the temperature. A sudden or gradual elevation to a high grade (105° F.), independent of the original disease, is a sign of most ominous significance.

Therapy.—The treatment of pachymeningitis does not differ materially from that of any form of meningitis or cerebral hemorrhage. The application of an ice-bag to the head, the local abstraction of blood by leeches or cups behind the ears or over the temples, "derivation" by purgatives (calomel, senna, croton oil), constitute the routine plan, which is sanctioned more by time and use than by benefit based upon demonstrable proof. Tranquility of surroundings with all the measures which make up a more or less perfect hygiene, is the most effective agent in prophylaxis in the chronic psychoses; while abstention from alcohol addresses the "causa indicationis" in cases dependent upon its abuse. The underlying condition calls for appropriate treatment.

Pachymeningitis cervicalis hypertrophica is a peculiar subvariety of meningitis, produced by great thickening of the meninges in the cervical cord, and marked by severe pains in the back of the neck and both arms, with atrophy of the muscles of the neck and flexors of the hands, and final spastic paraparesis.

Leptomeningitis.—It is possible that a real inflammation may limit itself to the dura mater alone, but this is very rare. Inflammation of the dura extends, as a rule, so as to involve the pia mater. The same qualification applies to the pia mater, though a strict limitation to the pia mater is more frequently observed. The subsequent remarks apply more especially to inflammation of the pia mater, with which the dura is, or may be, secondarily affected in greater or less degree.

Leptomeningitis is always a secondary affection. Affections of the nose, accessory sinuses, and ear constitute by far the most fruitful causes of leptomeningitis. Chronic suppurative inflammations of the tympanic cavity, frequently lead to meningitis through caries of the osseous roof of the tympanum. A more or less open avenue is also offered in the course of the

facial and auditory nerves, and the vessels which penetrate the petrosal fissure. Communication by caries may be also directly established between the cavity of the cranium and the mastoid cells; while indirect involvement of the meninges may follow phlebitis and thrombosis of the cavernous, transverse, and superior petrosal sinuses, as revealed by dilatation of the veins and local edema in the region of the mastoid process. Every meningitis whose cause is not obvious should excite suspicion of disease of the nose, accessory sinuses, or of the ear.

Trauma or injury to the cranial bones constitutes a not infrequent cause of simple meningitis. When compound fracture has occurred, or direct penetration has been effected, the sequence is sufficiently simple. In other cases the meninges, though not directly exposed, become affected through phlebitis, thrombosis, or suppurations occurring in the patulous veins of the diploë, whereby is implied, as previously intimated, some hidden crevice or pre-existent communication with the air. A far more infrequent involvement of the meninges occurs at times when an abscess in the interior of the brain reaches its periphery, or bursts into a lateral ventricle to come in contact with inflections of the pia mater at the base of the brain.

Next in frequency to the direct invasion of the meninges are the metastatic processes from distant depôts of infection. Any one of the acute infectious diseases may be thus attended or followed by meningitis, which is justly regarded as a most serious complication. Of all the acute infections, pneumonia is the disease in which this complication most frequently occurs. Pyemia and septicemia may be said to vie with pneumonia in the production of metastatic meningitis, while endocarditis, empyema, acute articular rheumatism, the exanthematous diseases—more especially variola and scarlet fever (aside from ear disease), and very rarely typhoid fever—diseases mentioned in the order of frequency, furnish exceptional cases.

The *morbid anatomy* and *symptomatology* of leptomeningitis do not differ—aside from the fact that the convexity is more often involved than the base, when the inflammation is due to metastatic and traumatic causes—from the morbid anatomy and symptomatology of cerebrospinal meningitis (*q.v.*).

In a few reported cases, a paradoxical pupil reaction has been noted, the pupils being contracted to the size of a pinhead in the dark, and widely dilated in the light. The condition is rare and no satisfactory explanation of it has been given.

A change in disposition is an early symptom, the active and alert child becoming listless and inactive, or the phlegmatic child becoming irritable and fussy. Irritability is rather an early sign of meningeal irritation. In meningitis there results an acidosis of the tissues, manifested in the spinal fluid by varying degrees of acidity and the presence of varying amounts of lactic acid.

With increased intracranial tension there occurs, probably through stimulation of so-called vital centers, a progressive rise in the blood pressure. This may be noted by measuring the blood pressure repeatedly at short intervals.

The *diagnosis* of meningitis in connection with disease of the nose, of the accessory sinuses, or of the ear, or with a trauma of the bones of the cranium, is very easy, as a rule, but the diagnosis of metastatic meningitis is oftentimes exceedingly difficult. High fever and blood poisoning may be productive of symptoms which so closely simulate the signs of meningitis as to render an absolute diagnosis impossible, at least for a time. The persistence of these signs after subsidence of hyperpyrexia sometimes declares the disease. Tuberculosis, pyemia, scarlatina, variola, erysipelas, and typhoid fever are the affections which oftenest create doubts as to the diagnosis. But if close scrutiny be made of the etiological factors, and close attention be paid to the course of the disease, the diagnosis, as a general rule, soon becomes clear. In distinction from tuberculosis and typhoid fever, it may be said that meningitis develops quickly, almost suddenly, with violent pain in the head, active delirium, and often with stiffness of the muscles of the neck, or retraction of the head.

Sudden changes in peripheral circulation are common in tuberculous meningitis, the face rapidly becoming flushed and pale, the hands and feet changing from hot to cold. The reflexes in tuberculous meningitis tend to vary rather than to remain constant.

Brudzinski's Sign.—Brudzinski observed that if the neck is passively bent forward, flexion of the thighs and legs occurs in meningitis. The sign is dependent upon increased pressure of the cerebrospinal fluid and affords additional aid in diagnosis.

The Kernig Sign.—In meningitis, according to Kernig, of St. Petersburg, if the hip be flexed so that the thigh is at a right angle to the body, the knee may not, without undue force, be extended in some cases beyond 90 degrees, and not farther than about 135 or 140 degrees in any case. With the hip extended, the knee may be readily straightened. Thus, the ability readily to extend the knee, when the hip is flexed at a right angle, would speak strongly against the presence of meningitis.

Netter believes that the sign described by Kernig depends upon the inflammation of the meninges and consequent irritability of the nerves, which is increased by the stretching of the lumbar and sacral roots when the individual is in the sitting posture, so that the attempt to extend the knee is sufficient to provoke reflex contracture of the flexures of the leg. Such reflex contracture is not produced by extension of the knee when the thighs are extended upon the pelvis. The sign is not pathognomic, as was at first claimed, although it is of great value in diagnosis. Netter has observed it in forty-five out of fifty cases of meningitis. Cipollina was unable to find it in some severe cases of meningitis, and did find it in other affections without the symptoms or lesions of meningitis. Packard has reported three cases of meningitis in infants, with the diagnosis confirmed by autopsy, in which the Kernig sign had been persistently absent. The absence of the sign was ascribed by Packard to a diminution of normal muscular hypertonia in infants. In another case the sign was present but no anatomical cause for death was found.

Lumbar Puncture (Quincke).—Puncture of the vertebral canal, which was originally used as a therapeutic measure, has proven of great value in diagnosis. At first the method was used in the study of diseases of the vertebral canal; but with the knowledge of the communication between the subarachnoid spaces of the brain and those of the spinal cord, the method has come into much more general use in the diagnosis of diseases of the interior of the skull.

The bacterial invasion of the central nervous system results in the disappearance of carbohydrates from the spinal fluid, so that this fluid no longer reduces the copper test solution. Kopetzky lays emphasis upon this as probably the very earliest sign of the activity of bacteria in the central nervous system and found it invariably present in the examination of forty-two cases. It occurs very early in meningitis, except in slowly developing tuberculous meningitis. The exact bacteriological diagnosis of the various forms of meningitis is of fundamental importance in the proper selection of the various specific serum treatments.

Lumbar puncture reveals the spinal fluid under more or less pressure and apparently increased in quantity. This fluid is characterized by an increase of albumin, globulin, and fibrin. The clot forms sometimes almost immediately and always within the first twenty-four hours. Ninety per cent. or more of the cells are lymphocytes, which vary from twenty to 500 per cubic millimeter, averaging about 100.

Interference with the metabolism of the cellular

elements of the affected tissues leads to degeneration of their chief constituent lecithin and the consequent accumulation in the spinal fluid of the alkaloidal poison group characterized by cholin. This adds direct nerve poison to the toxic products of bacterial activity already present and increases the symptoms of toxicity and prostration. Incidentally, this affords an aid in diagnosis, since cholin is present in the spinal fluid in meningitis in larger amounts than are present normally or in diseased conditions which are not due to bacterial infection. Further decomposition of the lecithin elements leads to the appearance of neutral fat in the spinal fluid, amounting to more than one per cent. in some fatal cases.

Cerebrospinal meningitis is differentiated by the more prominent disturbances of sensation, by herpes, and by the occurrence of other cases. Basilar meningitis occurs more especially in children affected with tuberculosis elsewhere, or who come of tuberculous stock. It has long prodromes, and a longer duration. Its symptoms are less acute and intense. It more frequently implicates the membranes of the spinal cord. Pachymeningitis is a disease of age. It occurs in drunkards, and in cases of dementia paralytica, chronic insanity, etc. It shows a more fluctuating course. It must be repeated again and again that the various forms of meningitis are to be separated and recognized more by the etiological relations of the disease than by any difference in symptomatology.

The *prognosis* is grave but not so absolutely fatal as that of basilar meningitis. The majority of cases terminate fatally, in coma or convulsions, in the course of from two to ten days.

Influenzal meningitis is not infrequent during epidemics of influenza, and also occurs sporadically, when it is much more likely to confuse the diagnostician. It presents practically all of the reflex signs and symptoms of meningitis due to the meningococcus. The spinal fluid is not so purulent, though usually cloudy, increased in amount, under pressure, presenting an increase in globulin, albumin, and fibrin, and a high polymorphonuclear cellular count. The typical feature is the presence of the influenza bacillus, which may be observed in stained specimens. It is not intracellular and is gram negative.

Pneumococcus meningitis, as stated, may occur as a sequel of pneumonia, less often sporadically. The symptoms are much the same as in the fulminating cases of meningococcus meningitis. The spinal fluid is often thick, so that it may be withdrawn with difficulty through the ordinary needle. The characteristic feature is the presence of the pneumococcus in the spinal fluid. The organism is gram positive and is readily distinguished by its capsule and form.

Streptococcus meningitis has usually a very sudden onset and runs a more serious course with more severe signs and symptoms than the average case of meningococcic meningitis. The spinal fluid is usually quite purulent but is not so thick as in pneumococcic meningitis. The characteristic feature is the presence of the gram positive chain of streptococci. It frequently follows mastoid or oral infections and is usually fatal.

Poliomyeloencephalitis or the encephalitic type of infantile paralysis presents many of the symptoms of true meningitis. The onset is sudden and in the meningitic form there are convulsions, rigidity of the neck, exaggerated reflexes, Kernig's sign, the neck sign of Brudzinski, and ankle clonus. The cerebral and bulbar forms show affection of the respiratory center and often run a rapidly fatal course. The mental symptoms are prominent, unconsciousness, delirium, stupor, and labored respiration. There is often general muscular sensitiveness. In poliomyelencephalitis that does not promptly reach a fatal termination, the encephalitic and meningeal symptoms soon disappear and the characteristic paralysis ensues or the case clears up entirely.

In children especially it is not uncommon to find a meningeal affection variously known as encephalitis, meningismus, toxic meningitis, and traumatic meningismus. In this condition the onset is sudden with convulsion or marked prostration, collapse, and cerebral and meningeal signs and symptoms. The cerebral symptoms usually predominate, especially unconsciousness and restlessness. Changes in the reflexes, stiffness of the neck, Kernig's sign, and Brudzinski's neck sign are sometimes present. Early diagnosis is often difficult. There may be a slight increase in the quantity of the spinal fluid, which is clear and shows but a slight increase in globulin and presents little or no fibrin clot. Usually there is an increase in the cellular elements, thirty to fifty to the cubic millimeter, at times much higher, the mononuclear lymphocytes greatly predominating. Most of the cases rapidly recover though not always without permanent injury.

Serous meningitis is the title applied by Quincke to a form of meningeal inflammation characterized by serous effusion into the membranes and ventricles. This is one of the causes of acquired internal hydrocephalus. In at least some of the cases there is an inflammation of the ependyma. Cases show a great variation in onset and course. The affection often occurs as a sequel to diseases that depress or deteriorate the general health, the infectious diseases, alcoholism, chronic diarrhea, and traumatism. It shows a preference for childhood and youth. Fever is slight and irregular or entirely absent. There is little or no headache. Any rigidity of the cervical muscles is not prominent. The usual symptoms are mild delirium, insomnia, transitory attacks of stupor, vomiting, slow and irregular pulse, epileptiform convulsions, local palsies, especially of the cranial nerves, and optic neuritis. The latter is unfortunately a frequent symptom. The alcoholic type, occurring often after delirium tremens, is commonly known as postdelirious alcoholic stupor or alcoholic cerebral edema. In this condition there is immobility of countenance, contracted pupils, some muscular rigidity and muttering delirium with hyperesthesia.

In serous meningitis, lumbar puncture reveals a clear fluid under high pressure, with few cells and no bacteria.

Treatment.—A patient affected with this disease should lie upon a comfortable bed, not too hot, in a spacious, continuously ventilated room, the windows of which can be darkened if necessary while they still admit the air, as remote from the street with its offensive sounds as may be. The temperature of the room should be regulated, with a thermometer near the head of the bed, at 65° F., by an open fire, preferably in a grate. The physician and the necessary attendants should be the sole visitors. Quiet should reign supreme. In no other disease is continuous or officious ministration so meddlesome and mischievous. Even cleanliness or a more comfortable posture must be sacrificed to peace of mind. The diet is to be simple and light at first, but as nutritious as possible with returning health: beef-tea palatably made, soups of any kind, milk if it does not increase constipation, scraped raw meat with a little salt, and gruels, if not distasteful. Plain water, seltzer water, Apollinaris, or any simple carbonated drink, should be proffered at proper intervals, without oversolicitation or any anxiety should everything be refused. With the begi ning subsidence of the disease an egg may be dropped into the soup, or sweetbreads, fish, the white meat of fowl may for a few days preface the more solid meats.

Especial attention is to be paid to the bladder. The soft catheter, thoroughly cleansed, warmed above the heat of the body, and greased with pure vaseline, brings this organ, when refractory, under control. Constipation is overcome with calomel, two to ten grains, or castor oil, in preference to an enema, which causes too much disturbance.

The treatment proper is largely symptomatic, and

has reference to the two sets of symptoms, general and local. Of these the symptoms produced by the local lesions—pain, opisthotonos, hyperesthesia—assume prominence in the great majority of cases. For the relief of these symptoms no remedy equals in value opium. It acts solely by its anodyne influence. It protects, by obtunding, the nervous system until the force of poison is spent. Surprising amounts of the drug may be given in this disease without narcotic effects. When quick effects are to be had, or when the drug is rejected by the stomach, resort will be had, of course, to the hypodermatic use of morphine. Ziemssen gives expression to an experience made by every practitioner with this disease when he says that morphine is, without doubt, "indispensable" in its treatment. But "medicus systematicus periculosissimus vir;" that would indeed be a routine physician who would prescribe opium indiscriminately in every case.

Venesection in meningitis belongs to history, or is only at most to be practised in relief of intracranial pressure, as in apoplexy, in the most sthenic cases, and in these cases the same results may often be effected by milder means, as by purgatives, calomel, and jalap. But local blood-letting by cups along the spine, or by leeches behind the ears, may often relieve the headache and unrest. Cold in the form of bags of ice to the head or along the spine is of great value when the period of excitability, hyperesthesia, and jactitation may have given place to the state of sopor and indifference. Radcliffe claims that "the application of cold, to the head and spine either by means of ice or freezing mixture in Esmarch's (or Chapman's) india-rubber bags, has furnished by far the most satisfactory results of all direct treatment."

Vomiting is best relieved by ice, champagne, effervescent drinks, milk and lime water, bismuth, soda, carbolic acid, or creosote. No drug equals in efficacy sips of water excessively hot.

Hiccough is often brought under control by the same means prescribed for vomiting, by the administration of a few drops of the oil of cajeput, or by clysters of sodium bromide. More obstinate cases of either vomiting or singultus call for the subcutaneous use of morphine.

The hypodermic injection of an aqueous solution of corrosive sublimate along the spinal column has been recommended by Angyan in daily doses of one centigram for adults and 0.5 centigram for children, continued until the rigidity disappears. Angyan reports thirty cases treated in this way with twenty-one recoveries.

Quincke advises the use of mercury in all cases of serous meningitis. Iodoform inunctions, lumbar puncture, and counterirritation applied to the back of the neck constitute the treatment for the chronic form. Lumbar puncture may be of value in any case of meningitis in which the spinal fluid is under great pressure. The alcoholic type requires forced feeding and stimulation, best with strychnine and caffeine.

Kay lauds the virtue of permanganate of potassium in grain-to-the-ounce solution, a tablespoonful every hour, and reports four cases with three recoveries.

It is useless to encumber space in a work of this kind with more than a mention of other remedies lauded in the treatment of this disease. As to quinine, which was recommended by the committee of the American Medical Association, it is now admitted to be of no avail whatever, except in antipyresis, a call which is seldom made in this disease. But in the exceptional cases, in which high fever does occur, quinine in scruple dose, salicylic acid, or antipyrine in double the quantity, is more valuable than the cold bath, because of the commotion created by the bath. Blisters, moxa, ferrum candens, are brutal assaults in the height of the disease, but may be justifiable in the treatment of sequelæ. The same remarks apply to the use of electricity. Ergot, iodine, physostigma, mercury, the benzoates, the bromides (which may be substituted for opium in a very mild case), other anodynes, belladonna, with a host of other remedies, have been recommended on theoretical grounds, or praised as specifics by practitioners of the "experience" school, who for the most part remained untrained to eliminate "the personal equation," but none of them stands the test of time.

Lumbar puncture is of distinct therapeutic value in all forms of meningitis and also in meningismus and in the poliomyeloencephalitic type of infantile paralysis, since by this procedure there is at least temporary relief of the increased pressure and also the removal of part of the toxic and irritating substances present in the spinal fluid.

In general, we are justified in using the specific antiserum for the infecting organism, in meningitis. Pneumococcus antiserum has not produced brilliant results in pneumococcus meningitis. However, its use is justifiable. Antiinfluenza meningitis serum, produced by Wollstein has been tried satisfactorily experimentally and to a limited extent clinically and is worthy of further use. George E. Malsbary.

Meningitis, Epidemic Cerebrospinal.—Epidemic cerebrospinal meningitis is a specific infectious disease of the pia mater and arachnoid membranes of the brain and spinal cord. The term cerebrospinal meningitis refers to all the various infections of these membranes which may be caused by pathogenic microorganisms. There is a form of cerebrospinal meningitis which tends to occur in epidemics, and which is definitely associated with a particular microorganism, and it is to this form only that the term epidemic cerebrospinal meningitis is applied. It must not be inferred that this disease is necessarily of epidemic occurrence, or that sporadic cases of infection of the meninges with the same organism as is found in epidemics may not occur. The word epidemic is used only as a means of pointing to the particular bacteriology of such cases.

Etiology.—*The Organism.*—The bacteriological cause of epidemic meningitis is admittedly the *Diplococcus intracellularis*. This is the only organism found associated with the lesions of the disease in recognized epidemics. The organism is a gram-negative diplococcus which in morphology closely resembles the gonococcus of Neisser. It is found in the exudate of the disease, both free and included in the leucocytes. It can be cultivated on appropriate media outside the body, and such cultures are pathogenic for guinea-pigs. By inoculation, cultures of the *Diplococcus intracellularis* can be made to reproduce in monkeys both the anatomical and the clinical features of the disease as seen in man.

Until quite recently no fundamental biological distinction was made between meningococci, but the apparent resistance of meningococci in certain cases to the therapeutic action of the immune serum has lead to investigations which suggest that there are marked variations in the biological peculiarities of strains of meningococci obtained from different sources. Such differences as relate to the readiness with which the *Diplococcus intracellularis* can be cultivated artificially, to its survival in cultures, and to its power to ferment carbohydrates, have been found. Further, variations in the pathogenicity of the organisms to guinea-pigs have been demonstrated. Opsonic experiments have shown a varying facility of digestion by leucocytes, which is more dependent upon the strain of meningococcus, than on the kind of leucocytes or sera employed. All these biological variations, pointing to the existence of varying strains of meningococci, have an important bearing on the results of serum therapy.

A type of organism has been isolated by Dopter from cases of clinical meningitis, which is found to be wholly uninfluenced by antimeningitis serum, and

which presents such marked biological variations from the more common type that it has been described as a parameningococcus.

Epidemics and Distribution.—Infection with the *Diplococcus intracellularis* tends to occur in epidemics. The last epidemic occurred in the years from 1904 to 1909, and was so widespread, that it deserves the name of pandemic. First, apparently, northern Germany and eastern America were severely visited, and later Europe generally and the continent of North America. At the same time, the remoter countries of Australia, India, South Africa, South America, Greece, and Syria were swept into the epidemic. In Greater New York City alone there were no less than 5,000 victims in the winter and spring of 1904 and 1905. Various local outbreaks of the epidemic continued to arise both in Europe and America until 1910. In America the disease has been quiescent, only a few sporadic cases having occurred, since 1910, except for an active outbreak in Texas in 1912.

Sporadic cases may occur at all times. There has been no year since 1900 when I have not seen cases in Boston. It is probable that in some localities there is always a greater prevalence of such sporadic cases than in others, for in many parts of the country cases are never seen except when an epidemic exists.

Transmission and Contagion.—Nothing is known of the existence and distribution of the *Diplococcus intracellularis* outside the body of the host. Nothing definite is known as to the way in which infection takes place, that is, how the parasite enters the body of the host. The only known facts are, first, that the *Diplococcus intracellularis* has been found in the nasal and pharyngeal secretions of the patients suffering from epidemic meningitis, and second, that the organism has been found in the nasal and phayrngeal secretions of healthy persons in contact with meningitis patients. Owing to the rather difficult technique of isolating the *Diplococcus intracellularis* from the secretions of the nose and throat, it has not been determined whether or not the organism is always present in the nasal and pharyngeal secretions of meningitis patients or of persons attendant upon such patients.

This fact of the presence of the diplococcus in the nasal and pharyngeal secretions being the only evidence which we have bearing in any way upon the question of how the disease is transmitted, the most plausible hypothesis is that the parasite enters and leaves the body of the host through the nose and throat. It must be remembered, however, that the presence of a pathogenic microorganism in the nasal and pharyngeal secretions is by no means proof that infection ordinarily takes place by this route. It was at one time supposed that the further route of invasion was through the cribriform plate of the ethmoid bone. But this hypothesis has failed of support, and, accepting the theory of the nasal or pharyngeal cavities being the first point of invasion, it is probable that the further route is through the mucous membrane, or lymphoid tissue, into the circulation, and thence to the membranes of the brain and spinal cord, for which we must assume that the *Diplococcus intracellularis* has a selective preference.

The important question is, What is the importance of contagion in epidemic meningitis, or in other words, to what extent, if at all, is the meningitis patient a possible source of danger to others? We should know first whether infection with the *Diplococcus intracellularis* can be transmitted directly from an infected individual to a healthy person, and second, to what extent does such transmission play a part in the spread of the disease. The answers to these questions are still largely doubtful.

In many diseases in which the parasite is eliminated through the nasal and pharyngeal secretions, direct transmission plays an important rôle. On the other hand lobar pneumonia, in which the parasite is eliminated in the sputum expelled by coughing, is not very contagious, and in such conditions as epidemic streptococcus infection of the throat, the source of the infection has been more frequently found in contaminated milk than in contact with an infected individual. The fact is, we do not at all know the source of the infection in epidemic meningitis, and the only criteria by which we can judge its contagiousness are the number of instances of apparent direct transmission to be found in the reports of epidemics.

The epidemiology of meningococcus meningitis has not provided very much evidence supporting the theory of direct transmission, or of any high degree of contagiousness. It is true that in epidemics a large number of cases occur in some particular locality, and sometimes in a very small community. The distribution of these cases, however, is very unlike the distribution seen in such diseases as measles or scarlet fever, and does not suggest contagion as an important factor. Numbers of persons who are known not to have been in contact with meningitis cases, contract the disease, and at the beginning of the epidemic many persons are infected simultaneously. Instances occur in which more than one case is seen in a family, but these instances have no greater frequency than could be accounted for by the general prevalence of the disease, and by some unknown source from which both members of the family derived their infection. There are a number of instances in which a physician or nurse attendant upon a meningitis patient contracted the disease. These instances, however, attract a special amount of attention, and are given a prominence in reports which would lead one to suppose that they occur frequently, whereas they have not occurred more frequently than could be accounted for by coincidence. When meningitis is prevalent, it would be more strange if no patient and attendant were infected from a source foreign to both.

At the Children's Hospital in Boston, during the years from 1897 to 1907, the average number of cases of epidemic meningitis treated each year was twenty. In this hospital these cases have never been isolated, but are always kept in the open ward, and until 1905, no special precautions were taken, the cases being treated like lobar pneumonia, rheumatic fever, and similar conditions not regarded as contagious. There has never in the history of the hospital been a single instance of meningitis developing in a nurse, physician, or hospital patient.

On the basis of this evidence, it does not appear that epidemic meningitis is very highly contagious, if at all. We cannot say that direct transmission does not occur, but it cannot be very common. The epidemiology of the disease is highly suggestive of some other source of infection, and means of transmission, some explanation of the occurrence of epidemics which is as yet entirely unknown.

Lesions.—Except in those fulminating cases in which death occurs in the first forty-eight hours, the lesions of epidemic cerebrospinal meningitis are quite uniform. There is found over the surface of the brain an abundant greenish-yellow fibrinous exudate, which is widely distributed, but usually most marked at the base. It may be limited to the base, or, in rare cases, to the convexity. The quantity of cerebrospinal fluid is increased, and it is turbid, and sometimes even purulent. The ventricles are moderately distended. The brain substance usually appears normal, but is sometimes slightly reddened. A similar exudate is seen in the meninges of the cord.

On microscopic examination the exudate infiltrating the pia mater is seen to be composed of fibrin and polynuclear leucocytes. In the outer layers of the cerebral cortex there are minute hemorrhages, cell infiltration, and sometimes minute abscesses. A variable amount of degenerative change is observed in the nerve cells, and in the cells of the neuroglia, and there may be proliferation of the connective tissue about the blood-

vessels. The changes in the cord are similar to those seen in the brain, but in general, are less pronounced. Exudation is often found in the cerebral ventricles, and in the cerebral canal of the cord. The inflammatory process may extend along the cranial nerves, or to the nerve roots of the cord. In the nerve fibers, both of the brain and of the cord, a very variable amount of descending degeneration may be found.

In cases which have run a long course, or which have entered the chronic stage, the lesions represent a late stage of the inflammatory process. The pia mater is cloudy and thickened, with opaque spots formed of fatty degeneration and proliferated connective tissue. Often the meninges are adherent to the brain. The thickening of the meninges is most marked at the base of the brain. Hydrocephalus is often seen as the result of these changes, and sometimes the foramen of Magendie is closed by fibrous contraction. In very late cases there are marked degenerative changes in the brain substance.

Symptoms.—The symptoms of epidemic cerebrospinal meningitis are extremely variable, both as to severity and as to the presence or absence of any particular symptom or group of symptoms. The variations depend mainly on the virulence of the infecting organism in the particular case and upon the resistance of the patient. There is no essential difference in the symptoms of epidemic and sporadic cases, except that the very severe types are usually seen in epidemics.

It must be remembered that there is positively no symptom nor sign pathognomonic of meningitis. Any symptom or sign associated with meningitis may be absent in any particular case and the manifestations show every possible variety of grouping.

Headache.—Of the subjective symptoms, headache is one of the most frequent. When present it is usually severe and persistent, and is most frequently frontal.

General hyperesthesia is a fairly common symptom. Great pain is complained of either on passive motion of the limbs or body, or when some particular part of the body is touched. This hyperesthesia of the skin, while not very common, is a very significant symptom. Severe pain at the back of the neck and running down the spine is often complained of.

Chills occur in some cases, but are comparatively rare.

The objective symptoms are more numerous and important.

Fever is usually present in the acute stage of the disease. The greatest variation is observed in the degree of fever in different cases, and in the character of the temperature curves. In some cases, perhaps the most typical, the temperature is in general high, with only occasional and brief remissions in the early part of the disease. In other cases the temperature is very little raised above the normal, with or without occasional brief exacerbations. The temperature curves are very irregular in many cases, showing marked remissions and exacerbations. In cases which have run a fairly long course, the temperature may be normal for days together, with occasional rises of a few days' duration. In the late chronic stage of the disease it may be normal or subnormal for long periods.

Rigidity of the neck, while not always present, is probably the most frequently seen sign of epidemic meningitis. With it are frequently found tenderness to pressure at the back of the neck, retraction of the head, and great pain on attempting to move the head. In some cases the spine is so arched that the patient lies in a posture of rigid opisthotonos.

The mental condition is usually affected in epidemic meningitis, and this symptom is important not only as an aid in diagnosis, but in affording some measure of the severity of the case. In the milder cases there may be only apathy or irritability; in more severe cases there is marked clouding of the mentality or delirium; in severe cases there is stupor or complete coma. An important, but not constant feature in the epidemic form of meningitis is that the affection of the mental condition is apt to reach its maximum early in the course of the disease.

Vomiting is seen in the majority of cases. It is especially liable to occur at the onset, and again late in the course of the disease, with no vomiting in the intermediate period. The late vomiting is extremely difficult to relieve, and may be a serious feature. Vomiting may be projectile, especially in young children.

The pulse is usually rapid throughout the disease. It is occasionally slow and irregular, especially in the late stages of unfavorable cases. It may be irregular and weak at any stage.

The respiration is often much disturbed, especially in children. It is frequently irregular, and may be slow or rapid. Typical Cheyne-Stokes breathing is seen only occasionally.

Rigidity and Spasm.—Various muscular reactions are seen as a result of cerebral irritation. There may be only muscular tremor; there may be tonic spasm of various muscles or groups of muscles; there may be a general muscular rigidity involving all the limbs and the trunk. Convulsions are seen, but are absent in the majority of cases.

Kernig's sign is a special manifestation of muscular spasm. It consists in inability to extend the leg at the knee, when the thigh is flexed to a right angle with the trunk. It is present in about eighty per cent. of cases of epidemic meningitis.

Brudzinski's neck sign is present in the majority of meningitis patients. The patient lies on his back with his legs straight; the head is then lifted in an attempt to flex the neck; if the patient's knees are at the same time sharply drawn up, the sign is present.

The knee-jerks may be exaggerated, normal, or absent, most frequently the last. Ankle clonus is occasionally seen.

The fontanel, in babies, presents a sign of important diagnostic significance. It is tense and bulging in nearly all cases. The absence of this bulging is strong, but not positive, evidence against the presence of any form of meningitis.

Petechial Eruption.—Although from this symptom the name "spotted fever" has arisen, it is not very common. I have observed it in seventeen per cent. of a series of 120 cases. The eruption is hemorrhagic, and shows itself as small punctate purplish spots, which are not numerous, but which may be found upon any part of the body and limbs.

Paralysis is sometimes seen in epidemic meningitis. It should be remembered, however, that the persistent paralysis is an extremely rare symptom of this disease, and in any case in which paralysis is a prominent feature the diagnosis of epidemic meningitis is rendered much more doubtful.

The pupils are usually contracted in the early stage of the disease. Late in unfavorable cases, or toward the close of rapidly fatal cases, they are usually widely dilated. Their reaction to light is often sluggish, and in very severe cases may be absent. Blindness is a rarely seen symptom.

The Ear.—Early deafness is sometimes seen, but is rare. Deafness is most common as a sequela. Although otitis media often occurs as a complication, deafness in meningitis is usually due to a lesion of the optic nerve, or to changes in the brain itself.

The Digestive System.—Vomiting, as already described is the main symptom. Loss of appetite is usually marked. Constipation is usually present.

Wasting and emaciation are marked in all prolonged cases.

The following table shows the frequency of occurrence of certain meningeal symptoms in a series of 120 cases in which I have given meningitis serum:

TABLE I

Onset		Rigid Neck	
Sudden	89	Present	104
Medium	21	Absent	16
Gradual	10		
Temperature		Kernig's Sign	
High	70	Early	64
Moderate	42	Developed	10
Low	8	Absent	6
Cloudy Mentality or Delirium		Knee-jerks	
Early	79	Exaggerated	26
Developed	32	Normal	16
Absent	0	Absent	78
Unconsciousness		Paralysis	
Present	48	Present	7
Absent	54	Absent	113
Headache		Muscular Spasm	
Present	58	Present	63
Doubtful	26	Absent	57
Absent	36		
Convulsions		Petechial Eruption	
Early	13	Present	21
Developed	3	Absent	99
Absent	104		
Vomiting		Cheyne-Stokes Breathing	
Present	72	Present	14
Absent	48	Absent	106
Pulse			
Slow	19		
Rapid	101		

CLINICAL TYPES AND COURSE.—Cases of epidemic meningitis may be classified according to their severity under the following types:

1. *The Fulminating Type.*—This is most common at the height of an epidemic. The onset is very abrupt. There may be a short stage before unconsciousness comes on, in which intense headache, repeated vomiting, and very high temperature are the symptoms. In these cases coma comes on within a few hours, or the patients may suddenly become unconscious at the onset. The pulse is usually weak and rapid, but occasionally is slow and irregular. The respiration is irregular. Rigidity of the neck and all muscular rigidity may be absent in this type; in fact all the cases of my series in which the rigid neck was absent were fulminating cases. Unless serum can be given very soon after the onset, death usually occurs within twenty-four hours.

2. *The Severe Type.*—In this type the onset is abrupt, but not quite so violent as in the fulminating type. It may be accompanied by severe headache, vomiting, chills, fever, general rigidity, and hyperesthesia. Rigidity of the neck, retraction of the head, and pain at the back of the neck and along the spine are marked. There is active or violent delirium in the first twenty-four hours, and a varying degree of stupor after that. The pulse is rapid, sometimes irregular, and of poor quality.

The majority of these patients, when not treated with serum, die within a week, usually after a few days. Occasionally a case of this type survives for an indefinite number of weeks, remaining unconscious, with a great variety of irritative nervous symptoms, finally dying of exhaustion.

3. *The Common Type.*—In this form the onset and its attendant symptoms resemble the severe type just described, but the general condition of the patient does not become so serious. There is often delirium or marked apathy, but unconsciousness does not come on. The pulse is of better quality in the early part of the disease. The course is much longer. Apathy with occasional delirium persists; hyperesthesia, tremor, and muscular rigidity are common symptoms. The common posture, especially in children, is that of opisthotonos. There is rapidly increasing emaciation. The bowels are usually constipated, and there are occasional attacks of vomiting.

This type is characterized by a long course. While three to six weeks is the average duration, many cases last much longer, occasionally surviving for a number of months. There are periods of remission and exacerbation. The temperature often comes down by gradual lysis to the normal, after which brief periods of elevated temperature are seen from time to time. In the majority of untreated cases, the various symptoms persist, or keep recurring after brief remissions, and death finally occurs from exhaustion. Some patients recover, even when untreated. In such cases, the rises of temperature become less frequent and finally cease, while the nervous symptoms clear up one by one, muscular rigidity being the most persistent. Convalescence is very protracted.

4. *The Mild Type.*—In this type the patients are only moderately ill with fever, headache, and some rigidity of the neck. The onset is sudden, but not violent. The mind remains clear. Cases of this type usually recover fairly rapidly, but occasionally the nervous symptoms gradually increase, and although the temperature comes down, the chronic type may develop.

5. *The Chronic Type.*—This is a condition which develops as a sequela to the common type, and occasionally follows in a case which is mild at first. The temperature comes down to normal, and the general constitutional symptoms subside. The nervous symptoms, however, persist, and the patient remains unconscious, with a varying amount of muscular spasm. This type is caused by the organic damage which has been done to the cerebral tissues during the height of the disease. Although the infection may have been successfully combated, and the organisms may have died out, the lesions left behind may be sufficiently grave to cause a continuance of symptoms. Hydrocephalus is frequently found in cases of this type. Patients with this form or rather sequela of the disease may survive a number of weeks, but finally die.

COMPLICATIONS AND SEQUELÆ.—In considering the complications and sequelæ of epidemic meningitis, I shall neglect the common secondary infections of the respiratory tract, and those rare cases in which the meningococcus itself produces lesions in parts of the body other than the central nervous system.

Paralysis, both as an attendant symptom and as a permanent sequela, is comparatively rare. I have, however, seen cases in which permanent spastic paralysis followed epidemic meningitis.

Ear complications are numerous. Otitis media, while very frequent, is not serious, and recovery is usually complete. Far more serious is inflammation of the inner ear, which is comparatively common in epidemic meningitis, and which leads to permanent deafness. If it occurs in infancy, deaf-mutism is the result. Flexner considers that twelve per cent. approximates the average frequency of occurrence of this complication.

A great variety of eye complications occur. Muscular affections are common and tend to be temporary, except ptosis, which is rare. Iritis, iridochoroiditis, retinitis, keratitis, and similar conditions all are seen at times. The most serious complication is a metastatic ophthalmia, caused by the meningococcus.

Mental defects of permanent character occur, but only rarely. According to Göppert they are seen in from one to three per cent. of the recovered.

Hydrocephalus is comparatively common, especially in the young. Recovery may occur without mental defect.

DIAGNOSIS.—In epidemic cerebrospinal meningitis, *a positive diagnosis cannot be made upon the basis of the clinical features of any case.* Further, a diagnosis of epidemic meningitis based on the clinical symptoms *is of no value whatever.*

There are a number of varieties of cerebrospinal

meningitis other than the so-called epidemic form, and having different microorganisms as their cause. Among the commonest of these forms of meningitis are tuberculous meningitis, pneumococcus meningitis, streptococcus meningitis, and influenza meningitis. Still other organisms are associated with meningitis in rare cases. All these varieties of meningitis present clinical features which so closely resemble the epidemic form, that they cannot be differentiated without the evidence afforded by bacteriological investigation.

Not only do other forms of meningitis resemble the epidemic form, but a more or less typical picture of meningitis may be seen in a number of other diseased conditions in which no meningitis is present. The commoner symptoms and signs of epidemic meningitis enumerated above, such as the rigid neck, the muscular spasm, the cloudy mentality, the headache, the vomiting, and all the irritative nervous symptoms, may for convenience be spoken of as *meningeal symptoms*. Such symptoms may all be seen in a great variety of diseases, especially in children. In the years from January 1, 1907, to January 1, 1909, I was called to administer antimeningitis serum in 230 cases in which a diagnosis of epidemic meningitis had been made or suspected by the various attendant physicians. The diagnoses in these cases are shown in Table II.

Table II.—Diagnoses in a Series of 230 Cases Suspected of being Epidemic Meningitis on the Basis of Their Symptoms

Disease.	Cases.
Epidemic meningitis	60
Tuberculous meningitis	60
Lobar pneumonia	29
Gastroenteric intoxication	15
Pneumococcus meningitis	12
Poliomyelitis	10
Otitis media	9
Encephalitis	8
Streptococcus meningitis	6
Typhoid fever	5
Influenza meningitis	4
Rheumatic fever	3
Cerebral hemorrhage	3
Solitary tubercle	2
Cerebellar tumor	2
Measles	1
Tetanus	1

In these cases, there was no meningeal symptom which was not seen in at least one of the other diseases.

When meningeal symptoms are thus seen in the course of a disease not meningitis, the condition is frequently spoken of as "meningismus." Meningismus, however, does not include conditions in which the disease is one having actual lesions in the central nervous system, such as poliomyelitis, encephalitis, brain hemorrhage, and brain tumor, but refers to such conditions as lobar pneumonia and gastroenteric intoxication, in which there are no central nervous lesions. The cause of meningismus is that these diseases, either through toxins or through reflex activity, irritate the central nervous system. The instability of the nervous system in children accounts for the greater frequency of meningismus in young patients. The result of the irritation of the central nervous system is often an increased formation of cerebrospinal fluid, which probably causes some of the meningeal symptoms.

The diagnosis of meningitis can be established only by lumbar puncture. The cerebrospinal fluid obtained by lumbar puncture in the active stage of epidemic meningitis, escapes under pressure, is always turbid, and a fibrinous clot forms on standing. On microscopic examination, the prevailing cell is the polymorphonuclear leucocyte, and the diplococcus intracellularis can always be found in cover-glass preparations. The finding of the organism in cover-glass preparations is more reliable than the results of culture, as the growth in culture is sometimes uncertain. The organism is recognized by the facts that it is gram-negative and occurs in pairs with the long axes parallel, and organisms are found included in some of the leucocytes.

Table III shows the most important diagnostic characteristics of the cerebrospinal fluid in a number of conditions contrasted with epidemic meningitis.

The indications for, and the technique of lumbar puncture will be considered in connection with the serum treatment of the disease.

Serum Therapy.—*Experimental Basis.*—Epidemic cerebrospinal meningitis is obviously a disease of such a character that in an antiserum lies the only hope of therapeutic achievement. The outlook was not very favorable when Flexner began his researches at the Rockefeller Institute for Medical Research, because the pathological effects in the disease are due to endotoxic constituents of the *Diplococcus intracellularis*, and previous work had shown that endotoxins usually failed to yield active antisera of value.

On the other hand, there were considerations which increased the hope of a favorable result from the use of an immune serum. It was very possible that restraint of growth and multiplication at some periods in the course of the infection might be more important than the neutralization of free endotoxin. Some of the facts brought out by Flexner in his studies of the biology of the *Diplococcus intracellularis* were strong in support of this possibility, chiefly the fact of the great susceptibility of the organisms to unfavorable influences. Many agents, such as normal

Table III.—Diagnostic Characteristics of the Cerebrospinal Fluid.

Fluid.	Pressure.	Appearance.	Fibrin clot.	Number of cells	Kind of cells.	Bacteriology.
Normal	Normal	Clear	Absent	Normal	Lymphocytes	Sterile
Meningismus	Increased	Clear	Absent	Normal or Slightly increased	Lymphocytes	Sterile
Poliomyelitis	Increased	Clear	Absent, or slight web present	Increased	Lymphocytes Endothelial cells Polymorphonuclears in early stage	Sterile
Tuberculous meningitis	Increased	Clear	Present	Increased	Lymphocytes	Tubercle bacillus
Meningitis from other organisms	Increased	Cloudy	Present	Increased	Polymorphonuclears	Infecting organisms
Epidemic meningitis	Increased	Cloudy	Present	Increased	Polymorphonuclears	Diplococcus intracellularis

serum or sterile inflammatory exudates, can probably affect the powers of multiplication in the body. An antiserum, therefore, even if containing relatively small amounts of antibodies, as indicated by neutralization experiments, may be effective beyond this calculated value by restraining multiplication or reducing the number of organisms and by supporting the body's power of resistance.

The theoretical outlook was less discouraging from another fact, namely, that the lesions of the disease are limited to a localization where they can be brought directly under the influence of the curative agent, by injections into the spinal canal. This was a very great advantage, and its recognition led Flexner to waste no time experimenting with subcutaneous injections. It appeared from these preliminary theoretical considerations that there was a considerable prospect of success in combating infection with the diplococcus by means of immune serum.

Immune serum was first prepared from rabbits, goats, and monkeys immunized by the injection of various strains of diplococci, and with exudates from the peritoneal cavity of guinea-pigs. The most successful results were obtained with antiserum obtained from large monkeys, and clearly showed that this serum had a marked protective power when injected into the spinal canal of smaller monkeys which had been experimentally infected.

Method of Preparation of the Serum.—Monkey serum could never be obtained in sufficient quantities for use in man, and after these experiments, Flexner began to immunize a horse. At first, the inoculations consisted of subcutaneous injections of cultures of the *Diplococcus intracellularis*, heated to 60° C. for thirty minutes. Many different strains were used in preparing this vaccine. The doses were gradually increased, and when a certain dose was reached, intravenous inoculation was substituted. Later, subcutaneous and intravenous injections of an autolysate were used. Finally, intravenous injections were discontinued, and alternate subcutaneous injections of living and dead cultures were used at seven-day intervals, many different strains of the diplococcus intracellularis being employed.

It requires in a horse about eight months to produce a serum containing the maximum amount of antibody. After this stage is reached, the horse is "yielding," and is bled at intervals to obtain the antiserum. It is kept at the proper stage as regards the amount of antibody by continuing the alternate subcutaneous injections of living and dead cultures.

Results of Serum Therapy.—The results of serum therapy in epidemic meningitis are analyzed in detail in Flexner's latest report, which is based on a series of 1300 cases. It is difficult to estimate the mortality of any epidemic before the pandemic of 1904–1909 as the reports of earlier epidemics were not based upon adequate bacteriological diagnosis.

In the last-mentioned epidemic, however, comprehensive figures are available, by means of which we can contrast the mortality in cases treated with and without the antimeningitis serum. The following table compiled from Flexner's report gives a summary of the reported fatalities in various places:

TABLE IV.—MORTALITY OF THE EPIDEMIC OF 1904–1909.

	Per cent.
United States	
New York	73.0
Boston	69.0
Hartford	76.0
Ohio Cities	70–90
Porterville, Cal.	90.0
Great Britain	
Leith	74.7
Edinburgh	89.0
Glasgow	74.8
Belfast	70.0
Silesia	
Brieg	42.5
Breslau	62.3
Flatten's 3085 cases	67.0
France	75.0
Belgium	77.7
Italy	
Milan	55.6
Palestine	80.0
Greece	
Athens	58.6
The Transvaal	74.0

The following four tables are taken from Flexner's latest analysis of 1,294 serum-treated cases. In the table showing general mortality, fulminant cases are included, but a small number of cases in which serum was given to hopeless and dying persons who survived the injection merely a few hours—not more than twenty-four—are not included.

TABLE V.—MORTALITY OF SERUM-TREATED CASES. (Flexner.)

Number of cases.	Recovered.	Died.	Per cent. died.
1,294	894	400	30.9

TABLE VI.—MORTALITY ACCORDING TO THE PERIOD OF INJECTION OF THE SERUM. (Flexner.)

Period of injection.	No. of cases.	Recovered.	Died.	Per cent. recovered.	Per cent. died.
1st to 3rd day	199	163	36	81.9	18.1
4th to 7th day	346	252	94	72.8	27.2
Later than 7th day	666	423	243	63.5	36.5
Totals	1,211	838	373	69.2	30.8

TABLE VII.—MORTALITY ACCORDING TO AGE. (Flexner.)

Age.	No. of cases.	Recovered.	Died.	Per cent. recovered.	Per cent. died.
Under 1 year	129	65	64	50.4	49.6
1 to 2 years	87	60	27	69.0	31.0
2 to 5 years	194	139	55	71.6	28.4
5 to 10 years	218	185	33	84.9	15.1
10 to 20 years	360	254	106	70.6	29.4
Over 20 years	288	180	108	62.5	37.5
Age not given	18	11	7	61.1	38.9
Totals	1,294	894	400	69.1	30.9

The tables show the influence of the age of the patient and the period of injection of the serum on the mortality of serum-treated cases. They establish the fact that the earlier the serum injections are begun, the better are the results. The influence of the age of the patients on the results of serum treatment is strikingly shown. The most favorable cases for serum therapy are those between the ages of five and ten years, while the least favorable cases are those over twenty years of age. The mortality of infants under two years of age, in cases not treated with serum has always been very high, approximating 90 to 100 per cent. Table VIII shows strikingly the reduction of the mortality in infants under two years in those cases which were injected before the seventh day. The number of cases in which injections were not begun early is large, and shows how long was the delay in making the diagnosis of epidemic meningitis, even in epidemic years. I believe this delay was largely due to lack of general widespread familiarity with the technique of lumbar puncture, of bacteriological examination, and of serum therapy, and that it will be much less in future epidemics. The high mortality in the infants treated later than the seventh day is made more significant by the large number of infants in which the injections were begun late. This empha-

Table VIII.—Mortality According to Age and Period of Infection. (Flexner.)

Age.	Injected 1st to 3rd day.				Injected 4th to 7th day.				Injected later than 7th day.			
	No. of cases.	Recovered.	Died.	Per cent died.	No. of cases.	Recovered	Died.	Per cent. died.	No. of cases.	Recovered.	Died.	Per cent. died.
Under 2 years.....	13	12	1	7.7	37	28	9	24.3	159	81	78	49.1
2 to 5 years.....	30	24	6	20.0	66	49	17	25.8	93	63	30	37.3
5 to 10 years.....	55	49	6	10.9	69	61	8	11.6	77	61	16	20 8
10 to 20 years...	67	58	9	13 4	106	73	33	31.1	171	115	56	32.7
Over 20 years.....	34	20	14	41 2	65	39	26	40.0	164	101	63	38.4
	199	163	36	18 1	343	250	93	27.1	664	421	243	36.6

sizes the difficulty often encountered in making even a provisional diagnosis of meningitis in very young children, as in infancy the symptoms are often obscure.

Flexner's report brings out other results of serum therapy beside lowering the mortality. Abrupt cessation of the symptoms, or crisis, is an exceedingly rare mode of termination in cases not treated with serum, but occurred in quite a large proportion of serum-treated cases. The report shows that under serum treatment, the course of the disease is shortened, and relapses and unfavorable sequelæ are much less common.

Indications for Lumbar Puncture.—In any case in which meningeal symptoms are present, and in which in consequence the possibility of epidemic meningitis is suspected, the physician recognizing the advantages of the early administration of the antiserum must decide in the first instance whether or not lumbar puncture is indicated. If, as a result of a careful examination of the patient, he finds present positive evidence of the existence of some acute disease, not meningitis, which is an adequate cause for the meningeal symptoms, he is safe in assuming that the case is not one of epidemic meningitis, and lumbar puncture is not indicated. It must be remembered that in children meningeal symptoms are a much more common feature of various acute diseases than they are in adults. If an epidemic of meningitis is existent in a particular locality, and if the meningeal symptoms are pronounced, it is wiser to perform lumbar puncture even in cases in which evidence of some other cause is found, so that a coexistent meningitis may not be overlooked. If, as a result of his examination of the patient the physician cannot find positive evidences of a diseased condition adequate to cause the meningeal symptoms, lumbar puncture should be performed.

Technique of Lumbar Puncture.—The patient should be placed on his side, on a firm surface, with the region of the lumbar spine brought as near the edge of the bed or table as possible. Several needles of sizes varying from the ordinary antitoxin needle to considerably larger, two test-tubes with corks to fit, and the syringe are boiled. The hands of the operator and the lumbar region of the patient are disinfected in the same way as is done in thoracentesis. An attendant then places one arm across the patient's shoulders, and the other hand in the bend of the knees, and, drawing up the knees while pressing the shoulders forward, flexes the spine as much as possible without the use of unreasonable force. It is not necessary to count the lumbar spines, as the spinal canal can be entered anywhere below the level of the highest point of the crest of the ilium without danger of touching the cord. It is a good plan to try first the second space below this landmark, which leaves a margin of one space in either direction for trial in case fluid is not obtained. The needle may be entered in the median line and passed between the spines, or a little to one side of the median line and passed between the laminæ; for the latter case the needle must be inclined very slightly toward the median line so as to reach the center of the canal. The direction is horizontally forward, and the needle is pressed in until there is a sudden sense of diminished resistance, when the fluid should immediately begin to drop or spurt from the outer end of the needle. It should be remembered that in adults the distance may be as much as three inches; it is less in thin persons and in children. The fluid is caught in one of the sterile test-tubes.

Care should be taken that the needle is not pushed in too far; if it touches the anterior wall of the canal, the fluid is apt to be blood stained, which interferes with the diagnosis; and if it enters the tissues of the anterior wall, the fluid will not run. On the other hand, the needle must be pushed in far enough. If the needle strikes bone before entering the canal, either the direction of the needle is not right, or the spine is not sufficiently flexed. In young babies or in patients with very rigid spines, smaller needles have to be used, and occasionally anesthesia is necessary to obtain sufficient flexion of the spine. If fluid is not obtained, the physician should first clear the lumen of the needle by passing in the stylet. If fluid still fails to appear, the physician should try moving the needle forward and back, and if this fails, should repeat the puncture with careful technique. If it is still a dry tap, the intervertebral spaces above and below the one first chosen should be successively tried. A dry tap is rarely seen at the first puncture if the technique is correct, but occasionally occurs when the fluid is too thick to flow through the needle. Anesthesia under ordinary circumstances is neither necessary nor desirable in performing lumbar puncture.

Indications for the Use of Antimeningitis Serum.—The cerebrospinal fluid obtained by lumbar puncture is either clear, cloudy, or occasionally blood stained. When the fluid is cloudy, the diagnosis of some form of meningitis is confirmed, but it is impossible to know whether the case is one of epidemic meningitis, or of meningitis due to some other microorganisms, such as the pneumococcus, streptococcus, or bacillus of influenza. This question can be settled only by the subsequent microscopic examination of the fluid. Although the serum is ineffective against infections other than that with the *Diplococcus intracellularis*, a single injection does no harm. Moreover, with cloudy fluid the balance of probability is always somewhat in favor of the epidemic form, and in time of epidemic it is very strongly in favor of that diagnosis. It is very important that serum therapy be begun as early as possible in the course of a case of epidemic meningitis, and if the physician is provided with serum at the time of the puncture, the loss of time necessary for confirming the diagnosis by bacteriological examination should not be risked. *In every case in which diagnostic lumbar puncture obtains cloudy fluid, antimeningitis serum should be introduced immediately.*

Obviously, if the subsequent microscopic examination of the fluid reveals the presence of some microorganism other than the *Diplococcus intracellularis*, the introduction of serum is not repeated.

If the fluid obtained by lumbar puncture is clear, it

is only in exceedingly rare instances that the case is one of epidemic meningitis. Clear fluid usually means either meningismus or tuberculous meningitis. Of course, if subsequent microscopic examination of a clear fluid should reveal the presence of the *Diplococcus intracellularis*, serum can then be used. *But serum is not indicated at the time of the first puncture, when the cerebrospinal fluid is clear.*

If the fluid is blood stained, it is unfortunate, as no definite information can be gained until the microscopic examination. In such a case, one can be guided only by the clinical features in deciding whether to inject serum at the time of the first puncture. If an epidemic is prevalent, or if the patient is severely ill, or if the meningeal symptoms are at all pronounced or suggestive, the serum should be introduced immediately. Only in mild cases of doubtful clinical diagnosis, should one wait for the microscopic examination.

Technique of the Use of Antimeningitis Serum.—The serum must be introduced into the spinal canal. Subcutaneous injections are of no value whatever. The serum is introduced through the same needle by which the cerebrospinal fluid has escaped. When serum is to be used, as much cerebrospinal fluid as possible should always be withdrawn, and even after the fluid begins to drop slowly from the end of the needle, the withdrawal should be continued until the rate is not more than four or five drops per minute.

The serum may be introduced either by means of a syringe or by means of gravity. In the former case, the syringe is filled with the appropriate dose of serum and connected with the needle, which remains *in situ*. The connection is either direct or by means of a short rubber connecting tube; in the former case, a syringe is used with a ground glass nozzle, which fits by friction into the unthreaded end of the needle; in the latter case, the ends of the needle and syringe are threaded, to fit threaded connections at either end of the rubber tube. Both syringe and connecting tubes must be previously boiled.

Some authorities prefer to introduce the serum by means of gravity, on the ground that there is less risk of excessive raising of the intradural pressure, which is practically the only danger attending the intradural injection of serum. An experienced operator knows, in using the syringe, just when an abnormal sense of resistance is encountered, and stops the injection at that point. I have had difficulty at times, by the gravity method, in introducing as large a dose as I desired to give. Nevertheless, I believe the gravity method is safer in inexperienced hands. When it is used, a sterilized glass funnel and rubber connecting tube are attached to the end of the needle.

The serum should be warmed to about body temperature, before introduction. When the syringe is used, the injection should be made slowly, occupying about the time which the fluid has taken in escaping. An abnormal sense of resistance is a signal for ceasing the injection. If the size of the dose is properly regulated, symptoms of a dangerous increase in intradural pressure are, in my experience, rare. Such signs are first a change in the character of the respiration, which becomes irregular and stertorous, then slight cyanosis, cold extremities, a cold sweat, and finally failing pulse. I have never yet had a patient who died during or shortly after injection of serum, but have seen these pressure signs, which were immediately relieved by allowing some of the serum to run out again through the needle. It is a good plan to hold needle and syringe *in situ* for a few minutes after the completion of the injection, in order that if pressure symptoms develop, the excess of serum may be withdrawn without the necessity of repeating the puncture under the hurried conditions of an emergency.

After the completion of the introduction of serum, the needle is withdrawn, and the tissues about the puncture are kneaded with the finger to prevent leakage; then the puncture is covered with a little sterile cotton and collodion.

The Amount of Serum Introduced.—In the early days of serum therapy in epidemic meningitis, it was considered advisable not to introduce a quantity of serum larger than that of the cerebrospinal fluid withdrawn. It developed gradually that the larger the doses, the better the results, the limit being the point of dangerously raising the intradural pressure. This danger is not quite so great as was at first supposed, and does not preclude the use of large doses in cases where little fluid is obtained. In most cases, doses of 30 c.c. may be given without danger, no matter what the amount of fluid withdrawn. The only exception is in young infants. The best rule is to try to give 30 c.c. of serum at a dose at every injection in which the amount of fluid withdrawn is 30 c.c. or less. If the amount of fluid withdrawn is greater than 30 c.c., the amount of serum introduced should be equal to the amount of fluid withdrawn. In very severe or fulminant cases, an effort should be made to give at least 45 c.c. In infants, if the amount of fluid withdrawn is less than 15 c.c., that quantity of serum should be given. If the quantity of fluid exceeds 15 c.c., the quantity of serum given should equal the amount of fluid withdrawn.

Indications for Repeating the Introduction of Antimeningitis Serum.—The successful management of a case of epidemic meningitis depends largely on the proper repetition of the doses of serum. In the earlier days of serum therapy, the frequent rapid relief of symptoms which followed the first administration of serum, led to the practice of waiting before repeating the dose, until the symptoms began to show a tendency to recur. Experience soon showed that under this plan of treatment recurrence of symptoms was much more frequent, and the course and final result were much less favorable, than when repeated doses of serum were given at the beginning.

In general, in every case in which the microscopic examination of the cerebrospinal fluid reveals the presence of the *Diplococcus intracellularis*, the use of serum in the dosage described above should be repeated daily without reference to the clinical features of the disease. In very severe or fulminating cases, the injections should be repeated at least as often as every twelve hours. The guide as to how long the administration of serum should be continued is to be found in the microscopic examinations of the successive specimens of cerebrospinal fluid obtained at each injection of serum. Every specimen of fluid should be carefully examined microscopically, and *as long as the Diplococcus intracellularis continues to be found either in cover-glass preparations or in cultures, the daily administration of serum should be continued.*

At times under the influence of serum therapy, the *Diplococcus intracellularis* disappears rapidly from the cerebrospinal fluid and may not be found in the fluid obtained at the second or third puncture. In such a case it is wise to continue the treatment until four doses have been given. If after four doses the organisms have disappeared, one can omit the injections even if clinical symptoms persist. But if at any time the condition of the patient becomes worse, or if after a few days the condition is stationary, the injections of serum should be repeated, four daily doses being given, or more if meningococci have reappeared in the cerebrospinal fluid. It must be remembered that *the presence of the diplococcus in any specimen of cerebrospinal fluid obtained is always an indication for repeating the administration of serum the next day.* The persistence of symptoms after the diplococcus has disappeared is always an indication for occasional diagnostic puncture and the administration of serum, and only after a long period of persistent absence of the diplococcus should serum therapy be given up.

The Treatment of Relapses.—The course of epidemic meningitis is extremely variable even under serum

therapy, exacerbations and remissions of the symptoms being common. At times the temperature comes down to normal, the symptoms are relieved, the diplococci disappear from the cerebrospinal fluid, and the daily administrations of serum are omitted, but later a reappearance of symptoms takes place. This constitutes a relapse, and should be the signal for immediate lumbar puncture. If, as is usual, the meningococcus is again found in the cerebrospinal fluid, the relapse should be treated in every respect as if it were the original attack.

Occasionally the reappearance of symptoms is not accompanied by the presence of the meningococcus in the cerebrospinal fluid. This is suggestive of a rather serious condition, which will be discussed under the heading of resistant cases.

Resistant Cases.—Serum therapy will not cure every case of epidemic meningitis, as can be seen from the thirty per cent. mortality in Flexner's large series. The causes of failure are various, the chief cause being that in many cases serum treatment is begun too late in the of course of the disease. Various types of resistant cases are met with, the most common of which are the following:

1. Fulminating, or very severe cases are seen in which death occurs within twenty-four hours after the first dose of serum. Sometimes such patients survive long enough to receive a second dose. The cause of failure here is that the serum requires an appreciable time to exercise its full effect, and the infection is so virulent that death occurs before the lapse of this time.

2. There are cases in which, after one or more punctures, no fluid can be obtained from the spinal canal. The meningococcus was present in the last fluid obtained, but later its presence cannot be used to guide the treatment. In the meantime the patient's condition is not improving. One continues to introduce the needle and to administer serum, but in my experience, the course of such cases is not favorable. Probably the circulation and communications of the fluid are cut off by exudate.

Under such circumstances, if the patient's condition is serious, an attempt should be made to obtain fluid from the spinal canal and to give serum at a point higher than the upper limit of safety in the lumbar region, taking the risk of touching the cord. In a baby with an open fontanel, the cerebral ventricle may be easily punctured, the fluid withdrawn and serum introduced.

3. There are cases in which, under serum therapy, the *Diplococcus intracellularis* disappears from the cerebrospinal fluid, but in which all the principal symptoms persist or recur. In some of these the *Diplococcus intracellularis* is persistently absent, in others it is occasionally found. The continuance of fever and constitutional symptoms in these cases shows that one or more active foci of infection remain persistent in the central nervous tract. The absence of the meningococcus from the fluid suggests that such foci are shut off from communication with the spinal canal and cannot be reached by serum, while the occasional temporary reappearance of the organism suggests that at times organisms escape from the imprisoned focus. The shutting off of the focus probably takes place most frequently from closure of one of the various communicating foramina of the cerebral ventricles, such as the foramen of Magendie, by fibrin or by fibrous tissue formation. Under these circumstances the serum can disinfect only the spinal canal, or those parts of the ventricles which remain open to communication.

In my experience this class constitutes one of the largest groups of resistant cases, and is particularly seen in cases in which the injections of serum are begun comparatively late in the course of the disease.

In these cases, every few days a course of four successive doses should be given, even if organisms are not found. There is always a possibility that at some time the serum may penetrate to the focus of infection. In babies with an open fontanel, whenever the course of such a case is growing unfavorable, the intraventricular injection of serum should be tried. In older children and adults, when the clinical features suggest an unfavorable outcome, as a last resort the skull should be trephined, and the serum injected into the cerebral ventricles.

4. In some cases the serum appears to have little or no effect, either upon the clinical symptoms or upon the presence of the diplococcus intracellularis in the cerebrospinal fluid. The course of the disease appears wholly uninfluenced by serum therapy. Such cases are best explained by the biological variations recently found to exist among meningococci, which suggest the possibility of resistant strains being encountered. In such resistant cases, if after six daily doses of serum no effect on the appearance of the cerebrospinal fluid is observed, it is useless to continue serum therapy. But daily lumbar puncture and withdrawal of fluid should be continued.

5. In some cases, seen late in the course of the disease, the fever and constitutional symptoms have subsided, but the nervous symptoms persist. The same condition may develop as a sequel after serum therapy. In this condition, meningococci are not found in the cerebrospinal fluid. This is called the *chronic stage* of epidemic meningitis. The infection has died out, and the persistence of nervous symptoms is due to the organic damage worked upon the cerebral tissues by the preceding storm. Hydrocephalus is frequently present.

Serum therapy is of no value in this condition, which is a very unfavorable one. All that can be done is occasional lumbar puncture for the relief of pressure.

In considering resistant cases in general, I should say that they occur in greater proportion among the sporadic cases seen when the disease is not prevalent, than among the cases seen during an epidemic. This may be accounted for partly on the ground of greater delay in making the diagnosis, when the possibility of meningitis is not strongly suggested by the presence of an epidemic, and partly by the possibility of resistant strains of meningococci being more frequently found in sporadic cases.

Other Specific Therapeutic Measures.—No other specific method of treatment should for a moment be considered as an alternative to serum therapy in epidemic meningitis. Vaccine therapy affords no prospect of success as a therapeutic measure in a disease so acute as this, although its use may eventually prove to be of value in prophylaxis. The administration of hexamethylenamine has been recommended on account of certain evidence of its excretion into the spinal canal, but the evidence in its favor is very slight, and its use should never be considered as an alternative to serum therapy, but should be confined to certain resistant cases.

General and Symptomatic Treatment.—The general measures of nursing and nourishment in epidemic meningitis do not differ sufficiently from those employed in any acute infection of long course to warrant detailed discussion. When coma is so marked that the patients are unable to swallow, liquids must be given by means of gavage. The bowels should be kept freely open by calomel or saline cathartics. If these are vomited, enemata should be employed.

Among the general measures recommended in epidemic meningitis are the application of cold to the head, neck, or spine, the employment of baths, and counterirritation. The application of cold by means of ice-bags appears to be one of the first therapeutic measures thought of in meningitis. I do not believe that it should be used as a routine, as it certainly has no influence whatever upon the course of the disease; the physician should be guided by the sensations of the patient, and should relinquish this treatment

if it affords no relief or is unpleasant. Meningitis patients are so extremely sensitive that cool baths should *never* be employed. Although warm or hot baths have been highly recommended by some authorities, there is not sufficient evidence in their favor to warrant their use as a routine measure. There is no evidence pointing to any value from counterirritation.

Of the symptoms which call for special treatment, the principal one is pain, which when severe requires morphine, sometimes in fairly large doses. I believe, however, that in meningitis it is best not to use morphine unless positively required for the relief of pain. The nervous symptoms of the disease, such as delirium, restlessness, and muscular spasm are best controlled by the use of bromides, which should be given in doses sufficiently large to produce a visible result. Occasional alternatives to bromide are such drugs as veronal, trional, sulphonal and chloral. When the bromides are vomited, they may be given by rectum. Convulsions also are best met by the administration of bromide by rectum. Prolonged severe and repeated convulsions require chloral in addition to bromide, and sometimes require inhalations of ether.

As a stimulant, when the pulse is weak, rapid, or irregular, or when the respiration is stertorous, I believe that caffeine is the best. Strychnine should not be used, and as to alcohol, the weight of modern opinion is inclined to deny it any stimulant value.

Prophylaxis.—The question of what measures should be employed to prevent the possible spread of the infection in epidemic cerebrospinal meningitis cannot be finally solved until more knowledge is available as to the mode of infection and transmission in this disease. Although the evidence points to a low degree of contagiousness if any, nevertheless in a disease in which the mode of transmission and infection is unknown, precautionary measure should be taken. The same precautions as to the sterilization of all clothing and utensils and of the hands of the attendants should be taken in epidemic meningitis as are taken in such diseases as typhoid fever. In hospitals I do not think that complete isolation is essential, if all the proper precautions are taken. I do not think there is any risk in caring for meningitis patients in an open ward with other patients. In private families, however, in addition to the precautions as to clothing, utensils, and the hands of the attendants, the patients should be isolated from the rest of the household.

It is very possible that in future the use of a vaccine may play an important rôle in the prophylaxis of epidemic cerebrospinal meningitis. Its value has not yet been tested. Charles Hunter Dunn.

Meningitis, Spinal.—The membranes of the spinal cord, called meninges, consist of three well-defined layers, an outer or dura mater, an inner or pia mater, and a very delicate intermediate layer, called the arachnoid.

The dura mater is a dense fibrous sheath which loosely surrounds the entire cord and extends a considerable distance below it, enclosing the cauda equina and filum terminale. Above it is continuous with the dura enveloping the brain. It is very loosely adherent to the vertebræ which have an independent periosteum and between the periosteum and dura are found fat and a plexus of veins.

The pia mater is a fairly dense fibrous envelope which is closely adherent to the cord itself and carries the blood-vessels which supply it. It is continuous above with the pia of the brain and is continued downward as the filum terminale or central ligament of the cord.

The arachnoid is a very delicate membrane which divides the space between the dura and pia into two separate compartments, the subdural space and the subarachnoid space. The first contains a small amount of lymph and the latter a much larger amount of clear fluid, the cerebrospinal fluid. This membrane is also continuous above with the arachnoid of the brain and the subarachnoid space is continuous with the same space in the cranial cavity. There are delicate fibrous strands connecting the arachnoid to the pia mater and also a few attaching it to the dura. Both the subdural and subarachnoid spaces are completely lined with endothelium. All three of the membranes are continued over the spinal nerve roots.

In the various forms of meningitis, the inflammation may involve the dura, in which case we speak of a pachymeningitis, or the inner membranes, in this case it is called a leptomeningitis.

The meninges of the brain and cord both may be involved together and often are, especially in the acute forms of leptomeningitis, but in some cases, particularly the chronic ones the cord may be involved alone.

The diseases will be considered in the following order: acute leptomeningitis in its various forms, spinal pachymeningitis externa, and spinal pachymeningitis interna, this last including cervical hypertrophic pachymeningitis.

Acute Leptomeningitis.—The varieties of acute lepomeningitis have been arranged by Osler in the following order according to their etiology.

Primary: (1) Cerebrospinal fever which may be epidemic or sporadic and is due to the *Diplococcus intracellularis;* (2) pneumococcic in which the meninges may be involved alone or as a part of a general pneumococcus infection.

Secondary: (1) Tuberculous; (2) pneumococcic, as after pneumonia, endocarditis, etc., or after disease or injury of the cranium or its fossæ; (3) pyogenic, following local disease of the cranium or local infection elsewhere, or terminal infections in various chronic maladies, due to the streptococcus and staphylococcus; (4) miscellaneous acute infections, as typhoid, influenza, diphtheria, gonorrhea, anthrax, actinomycosis, and others. The first class of cases due to the *Diplococcus intracellularis* including the sporadic and epidemic cases of cerebrospinal fever are treated in a separate article and will be omitted here. Tuberculous meningitis is also treated separately. Here we will deal with the other forms under the general head of acute purulent leptomeningitis.

Acute Purulent Leptomeningitis.—This form of meningitis is usually the result of some form of acute infection. It most frequently follows some one of the acute fevers and the infection of the meninges occurs from the bacteriemia as in pneumonia, typhoid, influenza, septicemia, etc., or by metastasis from local infection in some other part of the body as erysipelas, osteomyelitis, tonsillitis, endocarditis, etc.

Acute meningitis often occurs as a terminal infection in chronic diseases, as nephritis, gout, arteriosclerosis, heart lesions, diabetes, and the prolonged wasting diseases of childhood. In cachectic children, infection may occur by direct extension through the lymphatics from an erysipelas or furunculosis of the scalp.

In empyema, the marked involvement of the spinal meninges in some cases would point to direct extension by way of the lymphatics through the intervertebral foramina.

With the exception of the meningococcus, the pneumococcus is the only infective agent that seems capable of producing a so-called primary meningitis. These two seem able to penetrate the normal nasal mucous membrane and so produce the disease.

Thiemich of Breslau reports the occurrence of purulent meningitis in a series of infants following severe syphilitic coryza and considers the infection to have entered from the nose because of the great involvement of the base, though he admits that there was also purulent otitis in each case.

Pathology.—The pia mater shows intense congestion

of its vessels and infiltration with leucocytes. The surface is often covered with plastic lymph and the subarachnoid space is full of a turbid fluid with numerous flocculi and later a distinctly purulent fluid. The amount of plastic lymph varies but is most abundant in the pneumococcus forms. The meninges at the cortex or the base may be mostly attached and the spinal involvement is variable. In those cases following pneumonia and endocarditis the cortex is usually involved and the disease is mostly bilateral while when it springs from an old otitis or sinus trouble it may be at first unilateral, or at the base and is sometimes complicated with sinus thrombosis or abscess in the brain tissue.

In the meningitis of the various cachexias and in the non-tuberculous forms in children, the base is often most implicated. The ventricles are not so apt to be diseased as in the tuberculous form.

Symptomatology.—There is a vast difference in the onset of the disease depending upon whether it sets in as a complication of an already severe disease or whether it strikes down a patient who was previously healthy or suffering only from some local trouble. If the patient is suffering from a severe pneumonia or empyema the onset of the meningitis may be completely overlooked and the same is true in the terminal infection of various chronic diseases. On the other hand in the primary form and in that secondary to local or mild disease the onset is usually stormy, there is a sudden rise of temperature with a chill or a convulsion, violent headache, and vomiting.

The symptoms may be grouped in two classes, irritative and paralytic, though they merge gradually from one into the other. Under the signs of irritation may be considered headache, restlessness, insomnia and delirium, hyperesthesia of skin and muscles as well as of the special senses. Twitching of the muscles of the face and extremities, rigidity and retraction of the muscles of the neck and spine, rigidity of muscles of abdomen and legs, and general convulsions also come under this class. Nystagmus and contracted or unequal pupils are irritative symptoms on the part of the eye, while the slow pulse shows vagus irritation.

The paralytic symptoms usually develop later in the disease and consist of somnolence, stupor, or even deep coma. Strabismus as a result of oculomotor paralysis and dilatation replacing the contracted pupil also come under this head, and the reaction to light and accommodation is lost. Spasticity of the muscles gives place to flaccid paralysis. The pulse becomes rapid late as the result of vagus paralysis. Constipation gives place to diarrhea and retention to incontinence of urine.

Severe headache is one of the most constant symptoms and is continuous in adults and older children, but in infants the same condition is evidenced by signs of distress in moving the head. There are usually loss of appetite, a coated tongue, and vomiting not in any definite relation to eating. Cervical rigidity is marked when the spinal meninges are involved, but this does not occur so frequently as in the epidemic and tuberculous forms of the disease; on the other hand, convulsive movements of a single limb or group of muscles are more common in this form. The muscles most often affected are the flexors of the fingers and the abductors of the hand. Associated with this, we often see trismus and gritting of the teeth. During the early stages, constipation is the rule, often of a very obstinate nature, but later with the deepening of coma both urine and feces may be passed involuntarily.

The temperature, is almost without exception, elevated to 103° to 104°, but in some of the terminal cases in debilitated children, or in chronic nephritis, fever is absent. Thiemich states that doubt of the diagnosis is justified if the temperature remains normal.

The pulse may be slightly increased at first but later its slowness in relation to the temperature is characteristic. In the later stages the pulse may be very slow and irregular or very rapid. Rapid emaciation takes place and is due partly to the difficulty of properly nourishing the patient but also to disturbance of the cerebral influence on metabolism. When the base is much involved, the various cranial nerves suffer. Optic neuritis is rare when the disease is cortical but not uncommon when it is basilar. Strabismus and ptosis may be present, or paralysis or anesthesia of the face due to involvement of the facial or fifth cranial nerve respectively. If the Gasserian ganglion is affected, trophic changes may occur in the cornea.

Herpes labialis is common in this, as well as in the epidemic form of the disease. Knee-jerks and other reflexes of the extremities may be at first exaggerated and later diminished or entirely abolished.

Kernig's sign is present whenever the spinal meninges are involved. With the patient on his back, the thigh is flexed on the abdomen and then the leg extended on the thigh. This can be done under normal circumstances but if the meninges are inflamed it is prevented by strong contracture of the flexor muscles.

Brudzinski's sign is also present. Flexing the head on the chest produces flexion of the legs at hip and knee-joints, and flexion of one leg on the trunk will produce the same in the opposite leg.

Lumbar puncture is of great value for diagnosis and this is the only means by which the different etiological agents can be definitely determined. The procedure is practically harmless and can usually be carried out under local anesthesia, though in children, a few whiffs of chloroform may be required. A slender aspirating needle is carried into the subarachnoid space through the third lumbar interspace where it is well below the cord. The cerebrospinal fluid will escape drop by drop or if the pressure is very high may flow with considerable force. Normally the pressure of the flow is about 120 millimeters while in disease it may reach 250 to 300 millimeters.

In this form of meningitis the fluid is always opaque, grayish yellow, or greenish, and on standing there is a precipitate of pus. If the amount of fibrin is in excess it speaks in favor of a pneumococcus infection.

Microscopically the fluid shows numerous pus cells of the polymorphonuclear type while in the tuberculous form lymphocytes predominate. By staining smears and by culture the definite organism can be determined. This is of great importance in ruling out the cases of meningococcus meningitis and also in the prognosis of the other forms. The pneumococcus gives more favorable outlook than other organisms, except the meningococcus, and is the most frequent organism found in this variety of the disease.

The staphylococcus and streptococcus forms are practically always fatal if the process has become diffuse. Recovery has been reported when it was localized, especially when of otogenic origin. These organisms are not always found in pure culture but are often present together or with the pneumococcus. When the *Bacillus coli* or *Bacillus lactis aerogenes* is found, the case is usually fatal. In one such case reported by Nobecourt and du Pasquier recovery took place. The influenza bacillus of Pfeiffer has been found repeatedly in late years, the first case being reported by Slavik in 1899, this case was fatal. Lange in 1901 reported a recovery. Of numerous cases since that time there have been a few recoveries Myà reports three cases of purulent meningitis occurring in the Spring of 1902 during an epidemic of inflammations caused by the influenza bacillus. The cerebrospinal fluid in all cases has been described as thick and purulent.

Course.—As most of these cases are fatal, there is a progressive increase in the symptoms as time goes on. The delirium gives place to deep coma and death occurs from collapse or circulatory or respiratory failure. In the rare cases in which recovery takes place after

several weeks of illness the symptoms gradually clear up, consciousness returns and a slow return to health occurs. In those cases complicating a severe illness, the patient may apparently die of the primary disease and the meningitis only be discovered post mortem.

Sequelæ.—The basilar involvement may leave numerous paralyses. Blindness or deafness may result from optic or auditory nerve injury. Hemiplegia and paraplegia may remain. In some cases headache is a persistent feature from localized thickening of the pia mater. Mental weakness may result but usually tends to clear up.

Diagnosis.—This has already been touched upon under the head of lumbar puncture, which is the only sure method of ruling out symptoms, identical with meningitis but due only to active congestion of the meninges, such as we have in the cerebral forms of pneumonia and typhoid. It is also the only method by which the different forms of infection can be differentiated and the sporadic cases of meningococcus meningitis distinguished from the other purulent forms.

Tuberculous meningitis may very closely resemble in its symptoms this form of spinal meningitis with central involvement, but usually there is a more marked prodromal stage and some preceding tuberculous lesion can almost always be found elsewhere in the body. Lumbar puncture gives a clear instead of a turbid or purulent fluid and the tubercle bacillus can usually be isolated.

Typhoid fever with marked nervous symptoms may be confused. The temperature chart is usually more regular in typhoid and the presence of the Widal reaction and absence of leucocytosis would speak for typhoid. Herpes and leucocytosis would speak against a diagnosis of typhoid. If it is remembered that this form is in the very large majority of cases secondary to some previous lesion, we have a very valuable aid in the diagnosis.

Prognosis has already been considered under the different forms.

Treatment.—There are no measures that in any way control the course of this disease. Lumbar puncture has been used and also spinal irrigation with salt solution. Some cases of pneumococcic and influenzal infection have recovered after this treatment but how much the treatment had to do with the recovery is problematical. Sydney Scott in 1913 reports a case with purulent fluid obtained by lumbar puncture which recovered promptly after drainage through the internal auditory meatus. The meningeal infection had followed operation on the labyrinth. No organism was obtained in smears or culture.

The surgical treatment is distinctly prophylactic, but if the symptoms indicate a localized process, especially after middle-ear disease, trephining is justified.

Ice caps to the head, saline purges, and local or general bleeding may help to relieve pain.

Warm baths and sponges help to control the fever and convulsions, especially in children.

Hexamethylenamine has been recommended as an antiseptic which Crowe has shown is excreted in the cerebrospinal fluid. Mercury and iodides in large doses with perchloride of iron have been recommended. Chloral and bromides by rectum, and morphine may be necessary for the control of convulsion and severe pain. Unguentum Credé in large doses should always be tried.

Pachymeningitis Externa.—This is found in two forms, acute and chronic. It is almost always secondary to disease or injury to the vertebræ.

The acute form may follow the erosion of vertebræ by a tumor or aneurysm or syphilitic disease of the bone. In some cases it may follow injury in the form of fracture or dislocation of the vertebræ.

The chronic form is much more common and is associated usually with tuberculous disease of the spinal vertebræ, but may result from any other of the above causes. The ventral surface is the one most frequently involved, as disease of the bone usually affects the bodies of the vertebræ. It may, however, extend laterally or even entirely surround the canal.

The internal surface of the dura may remain smooth while the external shows roughening with caseous masses, fibrous tissue in excess, or even pus in the acute cases. The symptoms are those of compression of the cord and the treatment is that of the causal condition.

Pachymeningitis interna is identical pathologically with the same process in the cranial meninges and their pathology will be described together.

There are three distinct forms: (1) pseudomembranous, (2) purulent, and (3) hemorrhagic. The first two varieties are not common, a pseudomembrane of the dura is not usually recognized, but Osler refers to a typical case following pneumonia. Purulent inflammation in this location may follow an injury but more commonly results from extension of a purulent leptomeningitis. The third form is important.

Pachymeningitis Hæmorrhagica Interna.—This is essentially a chronic process and is characterized by the formation of new tissue on the internal surface of the dura mater. This at first is in the form of a veil-like membrane composed of fibrin, spindle-shaped, connective-tissue cells, and leucocytes. It is readily removed in the early stages, but later organization of the membrane takes place gradually and connective-tissue fibers and new-formed blood-vessels penetrate it in all directions. These new blood-vessels readily rupture and cause patches of hemorrhage, in the membrane, which later are replaced by areas of blood pigment. At times a hemorrhage of considerable size may occur and it is then spoken of as hematoma of the dura mater. As the condition progresses the portions next the dura mater become fibrous and firmly bound to the dura. Patients dying in the early stages, from some intercurrent disease, may show the membrane in its early stages, light and veil-like with no trace of hemorrhage. This upholds Virchow's hypothesis that the vascular membrane precedes the hemorrhage. Later hemorrhage and membrane both are found and in some cases hemorrhage without any trace of membrane. In this instance it is possible that the hemorrhage may have destroyed the original fine membrane. At times laminated clots may be found forming a layer three to five millimeters thick as the result of repeated hemorrhages. It has been claimed by some authors that the hemorrhage precedes and is the cause of the membrane formation. This is not usually the case, but in those cases the result of trauma, it is logical to suppose that the hemorrhage is primary.

This condition occurs in the cerebral meninges most commonly in connection with cerebral atrophy, as in dementia senilis, dementia paralytica, and other chronic forms of insanity. It may occur also in prolonged illness from other causes, such as phthisis, and in chronic alcoholism. Cases have also been described in children in connection with chronic malnutrition and cachexias.

Pachymeningitis Cervicalis Hypertrophica.—The process described above may affect any part of the cord but is extremely rare except in the cervical region where it receives this special name and produces a well-marked clinical picture. It was described by Charcot and later by Joffray and is characterized by the formation of a membrane between the dura and pia mater. In this region it is usually more or less annular in form surrounding the entire cord and involving the spinal nerve roots. Compression of the cord is the rule and later, due to retraction of the fibrous tissue, the canal of the cord may show dilatation. The process may involve the whole cervical enlargement or only one or two segments. At times

it spreads up to involve the medulla and pons or downward into the upper dorsal region.

The exact etiology of this form is not known though the usual exposure trauma and syphilis are mentioned as causes.

Symptoms may be divided into three groups, as indicated by Charcot; those the result of irritation of nerve roots; those due to compression affecting the cord and nerves distributed from this area; and lastly, those resulting from interference with the conductivity of the cord. These three groups often overlap somewhat, thus complicating the picture.

The first symptoms to appear are caused by irritation and give rise to the so-called pseudoneuralgic stage. They consist of severe pain in the nerves that spring from the portion of cord involved, especially those of the arm, neck, and shoulders. Hyperesthesia, tingling, and numbness may appear in these same areas and be associated with tension or stiffness. Muscular tremor may follow.

This stage exists for four to six months, when the stage of paralysis begins, the pains quiet down, and areas of anesthesia develop. Muscular atrophy and paralysis of the lower segment type set in; these are confined principally to the distribution of the median and ulnar nerves the radial usually escaping. The muscles involved mostly, are the small muscles of the hand and the flexor group of hand and wrist. This produces, because of the unopposed action of the extensors, a sharp extension of the wrist and proximal phalanges with flexion of the middle and distal phalanges. This is the so-called preacher hand or claw hand. Why the radial nerve escapes is not known. The muscular atrophy of the neck muscles and of those already mentioned in the arm and hand are very characteristic.

The third stage often starts even before the second is well developed and is due to compression and infiltration of the cord destroying the pyramidal and other conducting tracts of the cord. This gives rise to a typical spastic paraplegia and anesthesia with often loss of control of bladder and rectal sphincters.

The course of the disease is usually two or more years and is steadily progressive, though a few cases have been reported where the diagnosis was fairly sure and yet recovery has occurred.

The differential diagnosis must be made from syringomyelia, amyotrophic lateral sclerosis, cervical Potts in an early stage, and tumors of the cord. The first two do not produce the severe neuralgic pains and the characteristic sensory syndrome of syringomyelia is absent. The pain in early cervical spondylitis may be very similar but usually the deformity will be obvious before any paralysis sets in.

The diagnosis from tumor in this location is often extremely difficult and sometimes cannot be made, for the growth really amounts to a tumor mass.

Treatment consists of counterirritation, especially with the thermocautery. Mercury and iodides even in non-specific cases should be used. Hot baths, massage and the galvanic current can also be tried.

HENRY LYNDE WOODWARD.

Meningitis, Tuberculous.—*Synonyms:* Acute Hydrocephalus, Granular Meningitis, Basilar Meningitis, Dropsy of the Brain.

DEFINITION.—Tuberculous meningitis is an acute inflammation of the pia mater of the brain and upper cord, due to infection by tubercle bacilli, and characterized by the deposit of miliary tubercles and an effusion of pus and lymph.

GENERAL OBSERVATIONS.—In 1768 the attention of the profession was first particularly called to this disease by Dr. Robert Whytt, of Edinburgh. His remarkable monograph, entitled "Observations on the Dropsy of the Brain," ranks to-day among the medical classics, and is highly commended by recent writers for its accuracy of description and fulness of detail.

Dr. Whytt, and the observers immediately succeeding him, framing their opinion as to the nature of the affection from the very prominent anatomical lesion—the ventricular effusion—unavoidably included, under the term *dropsy of the brain*, several diseases besides tuberculous inflammation of the meninges. No correct idea of its pathology could be attained until Göelis, in 1815, pointed out that acute ventricular dropsy was not a primary condition, but was always dependent upon some antecedent affection of the cerebral vessels or nerves.

The granular condition of the meninges had been previously noted by Guersant, but it was reserved for Papavoine, in 1830, to establish the tuberculous nature of these granules, and to point out their pathological relation to the meningeal inflammation.

The name of tuberculous meningitis, which has won its way to universal acceptance, was suggested by Bricheteau. Dr. Gerhard, of Philadelphia, was the first to call attention to the disease in this country. His most valuable paper[1] was based upon the reports of thirty-two cases, with autopsies (Minot). Tuberculous meningitis is one of the important and most fatal of the organic diseases of the cerebrospinal system. It may also be properly classed as one of the important phases of that protean malady, acute miliary tuberculosis. Among 1440 cases of tuberculosis of all kinds in the medical service of the Johns Hopkins Hospital in eighteen years there were sixty diagnosed as acute miliary tuberculosis, and of these twenty-nine were of the meningeal form.[2]

Two forms of the disease are recognized, a primary and a secondary form. In the former, although other organs besides the pia may be the seat of tubercles, the symptoms first noticed are those arising from the cerebral lesion, and these retain their prominence throughout the attack. In the secondary form, on the other hand, the brain symptoms are preceded by those arising from inflammatory affections of other viscera, also dependent upon the diathetic influence, and are only manifested toward the close of the illness.

The primary form is essentially a disease of early life, and occurs with special frequency between the ages of two and ten years. In a series of fifty-two cases studied by Koplik eighteen or thirty-four per cent. were under two years of age. The average was four and one-third years. Still's collection of 100 cases showed eighty-three to have been less than five years of age. Infancy and adolescence do not confer immunity, but at these periods of life the disease is almost always secondary to advanced pulmonary tuberculosis. Statistics indicate that males are more susceptible to the disease than females; according to Huguenin, this preponderance is much oftener observed in children under fifteen years of age than in adults.

ETIOLOGY.—The essential factor in the causation of tuberculous meningitis is the infection of the pia mater with tubercle bacilli. They may reach the brain through the lymphatics or blood-vessels.

Foremost among the predisposing causes must be placed the hereditary diathesis. The badly nourished and physically ill-developed children of consumptive parents are the most susceptible, but the apparently rugged and robust are not exempt; in the latter, however, a careful search will almost certainly disclose a taint in some collateral branch of the family, if not in the direct line of descent.

That the disease is with rare exceptions dependent upon foci of caseous degeneration in some remote gland or viscus, a suppurating joint, or tuberculous inflammation of bone, is generally recognized by modern pathologists. Seitz found such lesions in more than ninety-three per cent. of the cases tabulated by him. Holt states that "although it is not infrequent

to see meningitis without symptoms of tuberculosis elsewhere, I have never failed at autopsy to find other tuberculous lesions in the body." The records of Holt further show that forty per cent. of all deaths from tuberculosis in children have been due to meningitis.[3]

The exciting causes are obscure. Unpropitious external conditions of all kinds, such as impure air, unwholesome food, exposure, bad drainage, may kindle into activity a slumbering predisposition.

Blows upon the head, emotional excitement, exposure to the direct rays of the sun, and like causes exert a doubtful influence. Climate and seasons have no place among the etiological factors, although for obvious reasons, the disease is more prevalent in the changeable weather of winter and spring.

In older children, excessive study and worry, or the high-pressure system of modern schools, may possibly promote the disease in those predisposed by inheritance to tuberculous affections, and such children are, as a rule, precocious and ambitious to excel in their studies.

Morbid Anatomy.—The distinctive anatomical feature of tuberculous meningitis is a deposit of miliary tubercles in the pia mater of the brain and of the cord. These granules are found on the inner surface of the membrane, are grayish white, semi-transparent, and vary in size from an object just visible to the naked eye to that of a millet or hemp seed. The coalescence of several nodules may form tubercular masses as large as, or larger than, a pea. They are more numerous at the base, especially about the fissure of Sylvius the circle of Willis and the optic chiasm, but in rare instances are formed in greater numbers on the convexity. The distribution is generally symmetrical in the two hemispheres, but may be limited to any particular portion, even to the narrow area fed by the branches of a single artery. They are developed within the perivascular canals, and adhere to the coats of the arteries, giving somewhat the appearance of a string of beads. They may be few in number or so abundant as to impair the integrity of the coats of the vessels and completely obstruct the circulation.

Hektoen found tubercles in the intima, accompanied by extensive endarteritis. His investigations showed the intravascular lesion to be primary, due to the implantation upon the intima of bacilli from the blood. The number of the nodules does not determine the intensity of the inflammation, which may be slight in the presence of a large deposit, or severe with a few widely scattered granules.

The pia mater is thickened, opaque in appearance, more or less adherent to the surface of the brain, and often is studded with tubercles.

A seropurulent exudation covers the pia, especially at the base, and extends along the course of the arteries. It may be so copious as to embed the cranial nerves and fill up the natural depressions at the base of the brain.

The ventricles are almost invariably distended with fluid. The effusion into the ventricles, which was considered by the early authors to be the essential anatomical lesion, furnishes a common name for the disease. It varies largely in quantity, but is generally sufficient to distend the ventricles, flatten the convolutions, and render them dry and anemic. There is often bulging of the fontanel and sometimes even separation of the sutures when not completely ossified. The fluid has a specific gravity of about 1.010, is turbid from the admixture of epithelium and leucocytes, and is sometimes, though rarely, tinged with blood. The portions of the brain adjacent to the ventricles are softened. The fornix and septum lucidum may be almost diffluent, and the basal ganglia so altered in consistence as to fall into a shapeless pulp on being removed from the skull (Fagge).

The choroid plexuses are hyperemic. The convolutions are covered with purulent exudation, edematous and injected when the ventricular effusion is small or wanting, but dry, bloodless, and flattened when the effusion is large. Occasionally patches of red softening, punctiform hemorrhages, and, very rarely, large extravasations of blood are met with in the substance of the brain.

In tuberculous meningitis the lesions are rarely limited to the intracranial viscera. Tuberculous deposits almost invariably occur in other organs of the body, most frequently in the lungs; or there are remote depots of caseating material or other evidences of the cachexia.

Tubercles can often be demonstrated in the choroid coat of the eye and is an important aid in diagnosis. In doubtful cases they should be sought daily and early in the attack. Dr. Money found the choroid affected in fourteen out of forty-two cases of tuberculous meningitis. In one instance tubercles were observed in the eye, but not in the brain or its membranes; in another, the meninges were free, but there was a mass of crude tubercles in the cerebellum. On the other hand, Minot claims that choroidal tubercles are seen so rarely as to be of little avail in diagnosis. They are even less frequent than in general tuberculosis without meningitis. In twenty-six cases of tuberculous meningitis examined by Garlick at the London Hospital for sick children they were found only in one case.

Koplik[4] in a valuable diagnostic analysis of the eye findings in forty-six cases of tuberculous meningitis found the fundus normal at the outset in thirty-four per cent. of the cases. In sixty-six per cent. there was some change in the disc varying from optic neuritis to the presence of tubercle in the tissue of the choroid. In some the disc was simply swollen and indistinct in its margin, in others the veins were distended. Another interesting fact is that choroid tubercle was present in nine cases as early as the second day of the active symptoms, that is from the first to the sixth week of the disease. These tubercles in the choroid may be found at any period of the affection. They may be present in the fundus when the cerebral symptoms are insignificant.

Symptoms.—Tuberculous meningitis is nearly always preceded by premonitory symptoms which, if rightly interpreted, are of the highest value. In twenty-six cases collected by Dr. Gee there were only two in which prodromes were absent. These symptoms are usually so indefinite in character as to excite little attention until the developed disease leads the parents carefully to review the past weeks of the child's life.

This period probably corresponds with the deposit of miliary tubercles in the pia mater before serious structural changes have taken place.

The symptoms met with during the prodromal stage relate chiefly to the nutritive processes. The appetite is capricious, the breath offensive, and the tongue furred. Vomiting is not common. The bowels are slightly constipated, or diarrhea and constipation alternate. The child tires easily and will often be found alseep on the floor surrounded by his playmates and toys. At night, sleep is restless and disturbed by dreams. Headache is not a prominent symptom, but is rarely wholly absent. Frequent complaints of dizziness are made. Very rarely double vision is observed. Along with these symptoms will be noted an alteration in the child's disposition. This is one of the most important of the prodromes, and should never be overlooked in establishing a diagnosis in a doubtful case. The patient, before precocious and vivacious, becomes dull and listless, indifferent to his books or plays, moody, and petulant. Many grow very emotional, bursting into tears on the slightest provocation, or dispensing their caresses with annoying lavishness. Before the close of the prodromal period the effect of imperfect nutrition is apparent. The patient grows thinner and paler. The muscles become soft and

flabby, and he is day by day less inclined to exertion of any kind. The prodromal stage may last for from one week to three months.

The active manifestations of tuberculous meningitis may be classed under general symptoms caused by pressure, and focal symptoms through direct implication of nerve tissue.

For convenience of description, it is customary to divide the disease into distinct stages based upon the predominance of certain symptoms at different periods in its course, viz., a stage of *invasion*, one of *pressure*, and one of *paralysis*. This arrangement is purely arbitrary, and is rarely fully justified by clinical observation.

There are few diseases more irregular in the development or sequence of symptoms than tuberculous meningitis, and he who seeks at the bedside only the typical case of the books may long search in vain.

Stage of Invasion.—The onset is rarely announced by any sudden perturbation, like a chill or convulsion, but the symptoms of the prodromal stage are simply increased in severity and gradually reinforced by others characteristic of cerebral lesions.

Headache, vomiting, and fever are common initial symptoms. Of these, vomiting is perhaps the most constant. It varies greatly in frequency, is not usually troublesome after the first few days and seldom returns, after it has once ceased for twenty-four hours. It is especially provoked by the suggestion of food or drink, or by a sudden change of position, and, as a rule, is not preceded by nausea or accompanied with severe retching.

The headache constitutes one of the distressing features and is usually referred to the frontal region. The pain is aggravated by sudden movement, bright light, or loud noises, and is subject to exacerbations without apparent cause. It at times compels the child to make outeries, hold his head with his hands, or bury his face in the pillow. Fortunately, remissions of variable duration are not infrequent. Vertigo is occasionally present, manifested by unsteadiness of gait, or a sensation of falling, even when lying in bed. The complaint of headache in a child, especially when associated with causeless vomiting, should always awaken the gravest apprehensions.

There is no distinctive temperature curve. The fever is moderate in intensity, irregularly remittent in type, and rarely measures more than 103° F. in the evening, and 100° F. or 99° F. in the morning. Constipation is marked from the beginning of the illness, and is rebellious to the action of laxatives; yet cases are recorded in which persistent diarrhea has occurred without tuberculous or other disease of the gastro-intestinal mucous membrane (Huguenin). Anorexia and moderate thirst are present.

The pulse for the first few days is rapid and regular, but soon becomes slow, irregular, and variable. The variability in force and rythm is marked.

The respiration is changed in like manner, and after three or four days becomes irregular and sighing. These alterations in the pulse and breathing are by no means constant. They may be marked at one, and absent at several subsequent visits; in fact, fluctuations may be noted in the course of the same observation. Repeated and lengthy examinations must therefore be made before they are declared absent. It is important to make the examination of the pulse when the child is at rest, since a pulse which is slow and irregular during repose may be rapid and regular under excitement or after movement.

Sleep is fitful and disturbed. Mild delirium is observed at some period of the day or night. The pupils are contracted, and light is painful to the eyes.

During the early part of this stage, both special and general sensibility are increased, so that the child often receives with dread even the gentle ministrations of its mother. Later on, he becomes more passive, and will without a murmur submit to the protracted examination of the physician.

If the cranial bones are unossified, the anterior fontanel is distended.

Strabismus, double vision, and ptosis sometimes appear toward the end of the stage of invasion. Convulsions are not common. Muscular twitchings and rigidity of the muscles of the spine are rarely absent.

The child is dull, apathetic, and drowsy. At first he can be easily aroused, and although his mental operations are sluggish, he notices his surroundings and may at times amuse himself with his playthings. The somnolence gradually increases until, toward the close of this period, he will, if undisturbed, lie for hours in a deep sleep, with eyelids half-open, grinding his teeth, and at times uttering a sharp, piercing shriek—*the hydrencephalic cry* of Coindet.

The duration of this stage is from seven to fourteen days.

Stage of Pressure.—The signs of irritation now give place to those of pressure or exudation upon the surface of the pia and into the ventricles of the brain. The transition takes place gradually; in fact, there is usually a period of uncertain duration, which has been not inaptly named the *mixed stage*, in which the symptoms of irritation still linger and the symptoms of depression are just manifesting themselves.

Paroxysms of pain, great restlessness, irritability, and delirium are succeeded by periods of extreme drowsiness or even of profound stupor, out of which the child is aroused with difficulty, perhaps replies in monosyllables, or stares vacantly at the questioner through half-open lids.

The most characteristic feature of this stage when fully developed is loss of consciousness. The patient remains in a state of complete insensibility, and at times moans or shrieks out wildly. He commonly lies on one side, with the knees drawn close to the abdomen, one hand pressing his head and the other grasping the genitals.

The head is retracted, and the muscles of the nape of the neck are rigid. Opisthotonus is often pronounced. There may be rigidity or pendulum-like movements of one or more of the extremities, forerunners of the paralyses shortly to occur. The general reflexes are variable—Kernig's sign and the Babinski reflex can nearly always be demonstrated. Macewen's method of determining the presence of an internal hydrocephalus in young children by percussing the pterion is also available at this stage. Koplik found Macewen's sign present in thirty-four out of fifty-two cases and deems it of value in diagnosis. The pulse becomes slow—from forty to eighty beats in the minute. The irregularity of the pulse and respiration are more pronounced and more constant than before. Typical Cheyne-Stokes respiration is often observed. The temperature falls a degree or more and often becomes subnormal. Vomiting ceases, if it has not already done so, but constipation persists. The abdomen is deeply hollowed. The common term "boat-shaped" very accurately describes the sunken belly bounded by the unduly prominent symphysis, iliac crests, and ensiform cartilage.

The pupils are dilated, often unequally, and waver under light. The globe rolls fom side to side, the sclerotic is suffused, a puriform secretion collects in the angles of the eyes or glues together the edges of the lids. The ophthalmoscope shows ischemia of the optic discs or beginning neuroretinitis, and often miliary tubercles in the choroid.

The skin presents vasomotor disturbances. Small patches or spots of congestion appear on the cheeks, forehead, or ears, and quickly fade away, their bright color making a vivid contrast with the general pallor. If the finger-nail be lightly drawn across the abdomen or inner surface of the thigh, a bright-red line comes out slowly, persists for a few moments, and then gradually fades—the *tache cérébrale* of Trousseau.

Stage of Paralysis.—From twenty-four to forty-eight hours before death, some of the characteristic symptoms undergo a remarkable alteration. The period covered by these changes is known as the stage of paralysis. The child now lies completely comatose and irresponsive to external irritations. Only reflex movements can be excited, and these imperfectly.

The constipation which has marked the whole progress of the illness is replaced by copious, involuntary, liquid stools; the sunken abdomen becomes distended with gas; the slow pulse becomes rapid and feeble, numbering 160 to 180 beats per minute, and the mercury registers a temperature of 104° to 107° F. This second rise in pulse and temperature is a certain forerunner of speedy dissolution.

The capillary circulation is more and more interfered with, the respirations become less distinct, and death may occur quietly in deep coma or be ushered in by a convulsion. Death by coma is the more common mode.

Sometimes the death agony is prolonged for several days, to the great grief of the parents. Death occurs in from sixteen to twenty-one days after the appearance of the initial symptoms.

Tuberculous Meningitis in the Adult.—The course of tuberculous meningitis in adults varies sufficiently from that observed in children to deserve brief mention.

The disease is more common in men than in women, and occurs at all ages, but especially between the years of seventeen and thirty. It is almost invariably secondary to tuberculous disease in some remote part, the symptoms of which may mask those of the meningeal affection. The primary form of the disease is rarely met with in adult life.

Premonitory symptoms are usually absent, and when present never obtain the same prominence as in early life. Persistent vomiting and convulsions rarely usher in the attack, but local paralyses, hemiplegia, and aphasia—very seldom seen in childhood—are not infrequently the first symptoms to direct attention to the cerebral complication.

The disease ordinarily runs a much shorter course than in children. Death may occur within forty-eight hours after the appearance of brain symptoms, and is seldom delayed longer than fourteen days.

Diagnosis.—The diagnosis of typical, fully developed tuberculous meningitis can scarcely give serious trouble, but in the prodromal period, or in those cases which pursue an irregular course it is proverbially difficult.

Since the disease is almost invariably engrafted upon a tuberculous diathesis, a careful investigation of the family record and personal history should be at once instituted. It is, however, only by the exercise of the most painstaking care, by closely observing the physiognomy and actions of the child, and by noting the hourly variations in the symptoms, that an early diagnosis can be reached in doubtful cases. Ill-defined ailing in a scrofulous child which resists ordinary treatment, especially if accompanied with headache and cyclic vomiting, should awaken suspicion.

The diseases for which tuberculous meningitis is most liable to be mistaken are acute simple meningitis, hydrencephaloid disease, gastrointestinal disturbances, and typhoid fever.

Simple meningitis is ordinarily recognized by the sharper onset (without prodromes), more severe headache, more furious delirium, higher temperature—in short, the greater intensity of all the symptoms and its rapid course. The comparative rarity of the simple over the tuberculous form of the disease in young children should be remembered.

False hydrocephalus is usually readily known by the history of antecedent diarrhea or other exhausting malady, the prostration when the cerebral symptoms began, the rapid and feeble pulse, the depressed fontanel, the pallor, and the normal or even subnormal temperature.

All authors speak of the resemblance which certain cases of typhoid fever bear to the disease under discussion. It comes within the experience of every consultant to meet such mistaken diagnoses. The infrequency of typhoid fever in patients of the age most prone to tuberculous meningitis, the regular temperature curve, the diarrhea, the iliac gurgling, the rose-colored spots, and the splenic tumor will generally easily establish the nature of the disease. Lingering doubt can be readily removed by a Widal reaction and an examination of the lumbar fluid.

The subacute gastrointestinal disturbances to which cachectic children are so liable may lead to error. Feverishness, anorexia, vomiting, irritability, and headache are common to each, and in many cases the development of the symptoms must be awaited to clear up the diagnosis.

The more intense headache, the irregular pulse, the sighing respiration, the alterations in the pupils, and the graver aspect of the illness will generally speedily indicate its cerebral nature.

The diagnosis of meningitis having been made, the differentiation of the type is rarely difficult. The key to the situation is the examination of the fluid drawn by lumbar puncture. This fluid is usually quite clear when drawn but, on standing, a slight deposit is noted. Exceptionally it is turbid from the first. The cytology of this serum has been carefully studied by Widal, Sicard, Councilman, and other pathologists who attach much importance to their findings. This phase of the subject is not closed, and it is sufficient for our purpose here to note that a decided increase in lymphocytes or in the polynuclear leucocytes indicates tuberculous disease. The presence or absence of sugar in the fluid is a matter of little significance. The decisive thing, however, is the finding of tubercle bacilli in the spinal fluid and here we find a wide discrepancy in results. Most modern authorities assert that sooner or later their presence can be demonstrated in every case of tuberculous meningitis. Hemenway found tubercle bacilli in 135 of 137 consecutive cases in the Babies' Hospital; Koplik in twenty-four cases out of twenty-seven. Beyond doubt many failures are due to the faulty technique employed. Only recent researches in this field are dependable.

Prognosis.—The prognosis is absolutely bad. Tuberculous meningitis almost invariably marches steadily on to a fatal termination. Delusive lulls not infrequently occur, however, even in the advanced stages, when an unwary practitioner may doubt his diagnosis and raise hopes in the parents which are doomed to bitter disappointment.

The possibility of recovery from the early stages of the disease cannot now be successfully denied, although it is not, perhaps, uncharitable to doubt the correctness of the diagnosis in many of the recorded recoveries. Rilliet, Rousseau, and other equally eminent clinicians report cases in which death occurred from a relapse some time after recovery from the first attack; and at the autopsy, old and recent tubercles of the pia could be clearly distinguished. Huguenin does not accept the revelations of the post-mortem examination as conclusive, and remarks that "pathological anatomy furnishes no information the correctness of which it would not be possible to doubt."

The isolated exceptions who do survive an attack of tuberculous meningitis are nearly always left with impaired mental or physical powers, and sooner or later succumb to a recurrence of the disease.

The writer has seen recovery in one case which was well advanced in the second stage, and in which there could scarcely be a doubt as to the tuberculous nature of the disease; but the patient never fully regained his

mental faculties, and died in convulsions eighteen months afterward.

Dr. Pitfield has recently published a series of twenty-nine cases in which the most rigid requirements of diagnosis have been fulfilled. He concludes that recovery takes place in perhaps one in 200 cases.[5] Dr. Martin[7] in a much larger number of cases, but in many of which the diagnosis is questionable, reached the same conclusion.

Treatment.—There are no drugs that can control or retard the specific action of the tubercle bacilli on the membranes of the brain and an expectant profession awaits the discovery of a curative serum. The treatment is wholly symptomatic and palliative. Treatment should not, however, be abandoned too soon, as a positive diagnosis between the simple and the tuberculous form of meningitis is not always possible in the early stages.

In the present stage of our knowledge, the greatest good must come from the adoption of measures to prevent the development of the cachexia in those so predisposed. The bow of promise is in prophylaxis, not cure. It is not necessary for us to detail here the special means to be employed; they are set forth at length elsewhere in this Handbook.

The violent antiphlogistic measures formerly employed are now properly discarded. As soon as the nature of the disease is known or strongly suspected, the patient should be placed in a darkened room and all sources of cerebral excitement excluded. An active calomel purge should be at once administered, an ice cap must be applied to the head and upper portion of the spine, and warm applications made to the extremities.

Special symptoms must be met as they arise by the use of customary remedies. The bromides, iodides and opiates are still deemed indispensable by many practitioners.

In the dawn of the tuberculin era great good was hoped for from the routine injection of tuberculin. The practice is now followed by few authorities, and many, like Grinker,[6] conclude from their observation that patients with tuberculous meningitis are not only not benefited but that many are made worse by its use.

When the second edition of this Handbook was passing through the press, lumbar puncture as a curative and diagnostic measure in the management of tuberculous meningitis was just coming into use. This practice has gained more and more the confidence of the profession and is now generally employed. Aside from the possibility of cure, the whole clinical picture is often promptly changed for the better by the removal of pressure symptoms and an improvement in the general toxemia. The puncture may be made every other day for a week or longer if the symptoms show amelioration. It should be begun, promptly.

Surgical methods, such as trephining the spinal canal or aspirating the cerebral ventricles have not given results sufficient to justify their routine use.

Not a few clinicians favor the administration of full doses of hexamethylenamine. It is true that after its use free formaldehyde can be promptly detected in the spinal fluid, but the ultimate effect in controlling the disease is problematical. W. J. Conklin.

References.

1. Gerhard: Am. Journ. of the Med. Sciences, 1833–34.
2. Brown, Lawrason: Modern Medicine, vol. i., 1913.
3. Holt, L. Emmet: Diseases of Infancy and Childhood, 1912.
4. Koplik, Henry: Journal Am. Med. Assoc., 1907.
5. Pitfield: Am. Journ. of the Med. Sciences, 1913.
6. Grinker: Forchheimer's Therapeusis of Internal Diseases, 1913.
7. Martin: Brain, 1908.

Menispermum.—Canadian Moonseed. Texas sarsaparilla, Yellow parilla. The rhizome and roots of *Menispermum canadense* L. (fam. *Menispermaceæ*). This is a prostrate and twining herbaceous vine, with eccentrically peltate, angled or lobed, alternate leaves, and axillary panicles of pale yellow, diecious flowers.

Moonseed arises from a long, slender rhizome, which, with its adhering roots, is the official portion. It is dried in flexible, tough pieces, a meter or so in length, and about five millimetres in thickness, with a finely shrivelled brown bark and yellow section. Odor slight, taste bitter. It grows in most parts of North America, and was introduced into medical use, thirty or forty years ago, as a substitute for sarsaparilla in "scrofulous affections," etc. There is no evidence to show that it is anything but an inferior bitter tonic. Its composition—*berberine* and the white, crystalline, bitter alkaloid *menispine*, soluble in water—recalls its near botanical relatives *columbo* and *pareira*. The dose is ʒ i.–ij. (4.0–8.0), and a fluid extract is official.

The family *Menispermaceæ*, comprising about a hundred species, mostly woody climbers of tropical regions, is notable for the great number and variety of its bitter principles, on account of which a large number of its species are used as simple bitters. Among the most important of these are, in India, various species of *Tinospora*, especially *T. cordifolia* Miers, and the wood of *Coscinium fenestratum* Colebr., the latter known as Indian calumba and largely used in India as a calumba substitute. In South America, several species of *Abuta*, especially *A. rufescens* Aubl., and a number of species of *Cocculus* are similarly employed. Henry H. Rusby.

Menopause.—See *Change of Life*.

Menorrhagia.—This term signifies an excessive loss of blood at the time of the monthly period. The blood may be discharged from the uterus alone, or it may proceed from one of the other openings of the body, from the mouth, nose, or anus, or it may appear upon the skin in the form of numerous spots or petechiæ which may be no larger than a pin's head or may be as large as a five-cent piece. This latter variety is sometimes known as *vicarious menstruation*, which seems to me a bad term, and I have substituted the term atopomenorrhea (ἄτοπος, out of place, μῆνος, by the month, monthly, ῥοία, a flowing or discharge, from ῥεῖν to flow).

This form of hemorrhage has many elements in common with that which is known as metrorrhagia, and the reader is referred to the article under that heading for a comparison of the two conditions.

The simplest or typical form of menorrhagia is that which occurs merely as an exaggerated form of the customary monthly flow. It also occurs as an occasional accompaniment of the menopause or the impending menopause, as the result of disease of the endometrium, displacement of the uterus, pregnancy, neoplasms of the uterus, acute or chronic general disease, change of residence.

In all these varieties of menorrhagia we must remember that the underlying cause is the disturbance of an exceedingly sensitive function which is characterized by the monthly recurrence of congestion of the pelvic circulation with a decided increase of tension in the blood-vessels.

1. In the *simplest form of menorrhagia* we may have a great increase in the quantity of blood lost during the usual number of days of menstruation, or the duration of the flow may exceed the usual number of days, the quantity lost on each day not being much greater than is customary during an average menstruation. It may be unaccompanied with pain, its principal symptoms being the annoyance attending the prolonged use of the napkin and the weakness from an excessive loss of blood. The cause for this irregularity may be entirely obscure, it may be a peculiarity of an individual or family, and it may be im-

possible to trace it to any disease, either local or general. It may be continued for months and years, and it may make no apparent inroads upon the patient's health, if she is of a robust constitution, or it may result in constant anemia and weakness. It does not seem to me wise to allow such a condition to continue, and it has always been my practice to advise that measures be taken to remedy it.

The treatment of this condition is not usually difficult. An examination of the patient should be made in the dorsal position; a bivalve speculum having been introduced into the vagina, the condition of the portio vaginalis is determined by ocular inspection. If the os is eroded and granular and the lips are everted, this may be the source of the trouble and is to be remedied by the operation of trachelorrhaphy. A probe or a small dull curette should then be introduced into the uterus and gently drawn over every portion of the endometrium. If the latter is unduly soft or if bleeding is excited a curettage will be indicated. If none of these symptoms is present and there is no evidence of disease in the uterine appendages, I have usually found it good practice to make applications of Churchill's tincture of iodine or a strong solution of nitrate of silver to the interior of the uterus two or three times a week, except during the menstrual period. Such treatment may be necessary for a period of two or three months. If the patient is very anemic, it will sometimes be found useful to plug the uterine canal during menstruation, thus checking the flow mechanically. The patient should be kept in bed during the period of menstruation and a tonic of some approved preparation of iron, or strychnine, or cinchona administered until the strength is restored.

2. In the *menorrhagia which occurs during or just before the menopause* we usually have a decided hypertrophy of the endometrium, and this may be the case whether the menstruation continues after monthly intervals or after longer and irregular ones. The hemorrhage in such cases is often profuse and alarming, and it is neither good practice nor common sense to dismiss the matter with the opinion that it is the change of life and that therefore one must wait until it is over. The condition of the endometrium must be determined by careful examination. As a rule the operation of curettage with the sharp curette will be indicated, and this must be repeated should the hemorrhages recur, as they not infrequently do after the lapse of six months or a year. It is a useless waste of time to treat such cases by the internal administration of drugs, and the application of astringent or caustic substances to the endometrium is only a trifle better.

3. *Menorrhagia from Disease of the Endometrium.*—This is in distinction, of course, from the conditions which have been described, for the endometrium, may be the seat of disease apart from the menopause, and there are many conditions which may cause such disease. One of the most frequent of such causes is gonorrhea, by which an acute or a chronic inflammation may be produced. The inflammation of the endometrium is but an incident in the history of the disease, for when that tissue has been invaded other tissues have already been attacked. It is not pertinent to this article to refer to the other symptoms, the excessive bleeding with the monthly flow alone concerns us. The menorrhagia may be present with only one monthly sickness, or it may be repeated with an indefinite number of them, especially if the infectious elements of the disease progress to the uterine appendages and the peritoneum. Also when the appendages are affected with other diseases of an inflammatory nature the endometrium may be inflamed and menorrhagia be one of the consequences. Such inflammations are usually, perhaps always, of an infective character, and though the infection usually progresses from the endometrium to the appendages, the menorrhagia appearing after the appendages have become diseased, it may also proceed from the opposite direction, inflammation passing from the peritoneum to the appendages, and thence to the endometrium, and menorrhagia resulting. The hemorrhage in such cases may be of long duration; it usually ceases if the diseased appendages are removed, and it may continue for many months if such an operation is not performed. Curettage of the endometrium in such cases is only a palliative measure, the hemorrhage recurring for as long a time as disturbance in the appendages persists. Menorrhagia also results when the endometrium is diseased as the consequence of masturbation or excessive sexual intercourse. Prostitutes are especially subject to this form of hemorrhage, although it is a fact that in such cases the uterine appendages are usually the seat of gonorrheal disease.

4. *Menorrhagia due to Displacement of the Uterus.*—This condition arises from a disturbance of the pelvic circulation caused by the unnatural relations resulting from the displacement, stasis and overfilling of the veins being noteworthy symptoms. It is unnecessary to say that menorrhagia does not occur with all cases of displacement. The only variety with which it is at all frequent is the retrodisplacement. With retroversion it is less common than with retroflexion. The more complete the retroflexion the greater the disturbance of the circulation and the more probable the occurrence of menorrhagia. Hypertrophy of the endometrium frequently results, and it is not unusual that the physician is obliged to resort to curettage in order to afford the patient the desired relief. This relief, however, is apt to be only temporary. The only permanent relief is that which follows secure replacement of the organ by operative procedure with consequent restoration of the normal conditions of the circulation.

5. *Menorrhagia Resulting from or Coexisting with Pregnancy.*—It is not an unusual occurrence that a monthly loss of blood should persist during a portion of the period of pregnancy, or even during the entire period. This phenomenon has been explained by the assumption that in these particular instances the uterus has kept up the menstrual habit. While this explanation may occasionally be a valid one, it is more reasonable to believe that in such cases the endometrium, especially that of the cervix, is diseased or at any rate is so greatly congested that it finds relief in this manner. There is also the hemorrhage which arises with the vicious implantation of the placenta, known as placenta previa, which occurs during the later months of pregnancy, but which may deceive one by its occurrence at the time when menstruation was expected to make its appearance. It is needless to say that in all these cases a careful examination must be made, and it will usually be desirable to tampon the vagina to check the bleeding. The uterus should not be tamponed except as a last resort, for it will result in the dilatation of the soft uterine tissues, the production of contractions, and the expulsion of the uterine contents.

6. *Menorrhagia due to Neoplasms of the Uterus or of the Abdominal Viscera.*—A number of conditions produce this form of menorrhagia: myomata of the uterus, especially the submucous and intramural varieties; carcinoma of the uterus, especially that form which first invades the corpus; sarcoma of the uterus, tuberculosis of the peritoneum, carcinoma of the intestine, or of any of the abdominal viscera. The result in all these cases is a highly congested condition of the uterus with more or less hypertrophy of the endometrium, and the monthly period is characterized by an excessive loss of blood. The bleeding may not be limited to this periodical function, but may recur at irregular intervals, being then denominated metrorrhagia. The treatment for this condition is at best only palliative. Curettage of the endo-

metrium may check the bleeding for a time, but it will soon recur. The removal of the source of the trouble will alone produce radical results. With the benign diseases such an operation is most desirable; with the malignant diseases, especially those in which great areas of tissue are involved, a radical removal is usually impossible.

7. *Menorrhagia from some Acute or Chronic General Disease, including the Nervous Diseases.*—In the case of some of the general diseases the menses are unaffected. Even in the severe forms of paralysis we often see little variation from the normal. In hysteria, on the other hand, the uterus may be congested, and it is also likely to be so in acute and chronic diseases of the kidneys, liver, peritoneum, etc., in anemia, tuberculosis, and syphilis, and probably in certain cases of continued fever or of intermittent fever.

The treatment consists mainly in the treatment of the underlying cause. Occasionally curettage or the tamponade of the vagina will be efficacious, but such treatment fails to strike at the root of the disease.

8. *Menorrhagia from Change of Residence.*—This implies, of course, a change in the blood tension such as results when one removes to an altitude several thousand feet higher than that to which one is accustomed. Hemorrhage of this variety is usually not alarming and subsides when the equilibrium of forces has been reëstablished, *i.e.* when the patient becomes habituated to the new conditions. There is scarcely any occasion for treatment in such cases or for comment upon that phase of the subject. Finally, a few words should be said concerning the vicious hemorrhage which occurs in unusual or unaccustomed parts of the body (atopomenorrhea), either coincidently with the monthly hemorrhage or in place of it. The fundamental consideration, of course, is that during menstruation there is an increase in the blood pressure. If, for any reason, the resistance in the uterine vessels is too great to permit adequate relief for this pressure, the blood current will necessarily be diverted to other parts where the resistance is less. Such a part may be the mucous membrane of the anus, the stomach, the nose, or the mouth, or the blood may transude through the capillaries of the skin. The loss of blood in such cases may be considerable and always calls for an examination of the uterus. It may be that no anatomical fault in the uterus can be discovered, or there may be a flexion in the organ which can be relieved by appropriate measures. In some cases such a diseased condition of the blood or of the blood-vessels exists that the hemorrhage can be attributed to this cause, its occurrence during menstruation being only incidental.

Andrew F. Currier.

Menstruation.—*Synonyms:* Menses, Catamenia. The names most commonly used among the laity for the menstrual discharge are: unwell, sick time, period, monthlies, and monthly period.

Definition.—Normal menstruation, commonly understood, is a periodical discharge of blood from the interior of the uterus which first appears during puberty, between the eleventh and sixteenth years. Normally it continues with more or less monthly regularity except during pregnancy or lactation, until somewhere between forty and fifty years when the menopause occurs.

History.—No other phenomenon concerning woman has excited more vague speculation or is richer in superstitious traditions than menstruation. In all parts of the world savages commonly initiated the coming of puberty with religious rites covering various periods of time, in which tests of endurance both of body and mind were a prominent feature. Strange to say this excellent practice was rapidly lost with the advance of civilization and gave way to the predominating belief that the menstruating woman was being purged of her impurities and was therefore unclean. During this period it was generally supposed that she possessed an occult power for both good and evil and she was regarded with superstitious fear by primitive peoples. Gradually this fanaticism was modified to a sane tolerance. It is surprising even at this age of enlightenment how many absurd traditions of the past cast their shadows in the minds of well-educated people. The almost universal association of unmentionable disgust with the period of menstruation is probably largely due to the fact that the decomposed blood from the vagina and the heightened activity of the sweat glands increase the body odor. Coupled with this fact is the belief, even among the most refined women, that the tub bath is not only contraindicated at this time, but is positively a menace to her health.

Puberty.—Beginning with the eleventh year the physical and mental development of the child is modified to a marked degree. The straight child-form of the little girl assumes the rounded curves and characteristics of young womanhood. Hair appears on the axilla and mons veneris. The growth of the mammary glands and external genitals indicates the development of the reproductive organs and approaching maturity. The timbre of the voice changes. The psychology of the child becomes that of woman. She is conscious of shame when her nude body is exposed. She becomes reticent, shy, and modest when reference is made to the reproductive organs, yet, inconsistently, she is possessed of an insatiable curiosity concerning them. If she is not instructed by her parents in the mysteries of sex she will obtain this knowledge from precocious and vicious associates. It is the recognition of this fact which of late years has given the advanced educator much concern. The periodical discharge of menstrual blood from the uterus is the external signal that the female genitalia are fast approaching sufficient growth to receive an impregnated ovum, care for it during its development, finally assist in its expulsion, and give it nourishment after birth.

Cause of Menstruation.—So long as woman was singled out as a creature apart from the animal kingdom subject to menstruation, the scientific accounting for the phenomenon was singularly contradictory and unsatisfactory. One of the oldest and at one time the most generally accepted theory was that menstruation was caused by a monthly ripening of the ovum which was eventually discharged into the uterine cavity and was accompanied with a congestion that resulted in menstruation. It has been undeniably and repeatedly proven that ovulation occurs long before menstruation is established and long after it is abolished. Another theory which for a long time rivaled that of ovulation was that a ripe unimpregnated ovum had been discharged and in the absence of a stimulation for the uterus to form membranes of pregnancy a degeneration of its mucous membrane took place which was accompanied by a discharge of blood. This theory is now equally discredited because menstruation has been proved to exist without the slightest evidence of a ripe ovum.

It is universally acknowledged that the external manifestation of menstruation depends upon the general health. Any derangement of either the physical or mental welfare of the individual is liable to cause menstrual irregularity. Undoubtedly the internal secretions of the ductless glands and ovaries have a marked effect on the moral development as well as the physical growth of the body during puberty and adolescence. Complete castration of all young animals demonstrates the profound alteration that occurs both in the mental and physical characteristics when the internal secretions of the egg producing or fertilizing organs have been withdrawn from the animal

economy. It is yet to be discovered what effect these internal secretions have upon the cause of menstruation.

At present the catamenia is recognized as the evolutionary development of the "heat" or rut in lower animals, and, in all probability, the definite explanation of the menstrual phenomenon will be found by those research workers who direct their experiments along the broad lines of comparative animal physiology and plant chemistry and it will be found to agree with the fundamental laws that govern the ripening of seeds and eggs in the entire living world.

Ovulation.—By ovulation is understood the ripening and casting off of the matured ovum. The ovary consists of many thousand microscopic eggs which are held together by a connective framework or stroma. This stroma serves also to carry a rich supply of blood- and lymph-vessels. In the first step of the process of ovulation the ovum, lying in a viscid fluid within the Graafian follicle, sinks deeply into the stroma of the ovary. When the ovum is matured the follicle approaches the surface of the ovary. The external portion of the Graafian follicle protrudes and eventually bursts. The ovum is thus liberated and frequently finds its way into the Fallopian tube and from there into the uterus. The cavity of the Graafian follicle fills with blood which clots and becomes absorbed. The interior of the follicle shrinks and contracts into serried folds. In a few days after the discharge of the ovum, decidua-like cells containing a yellowish pigment appear upon the periphery of the collapsing follicle and finally fill its interior. At this stage the Graafian follicle becomes what is known as the corpus luteum, or the "yellow body."

If the ovum is unimpregnated in three months from its discharge the only trace left of the corpus luteum is a slight cicatricial scar upon the surface of the ovary. If conception takes place the corpus luteum persists for three or four months and does not finally disappear until several months after delivery of the fetus. (For a more detailed description of ovulation see the article on *Menstruation* in the second edition of this Handbook, by Jeannette Winter Hall.)

The Process of Menstruation.—In the first stage the capillaries in the endometrium become congested and when they are sufficiently distended blood escapes into the intercellular tissue and the subepithelial layer is raised into a shot-like appearance. Following this stage the accumulated blood is forced into the network between the epithelial cells. Part of the excess blood finds its way into the glands and from there into the cavity of the uterus. There is also an escape of blood from the epithelial layer of the endometrium. In the last stage of menstruation the congestion is decreased, the blood-vessels assume their normal tension, the endometrium shrinks, the excess blood in the intercellular tissue is absorbed, and the uterine mucosa gradually regains its normal blood supply and proceeds to the regeneration of the degenerated tissue.

The exact nature of the changes that take place in the uterine mucosa is still a much mooted question. Many scientists contend that the entire uterine mucosa is shed during each menstruation, others, that patches of surface epithelium only are thrown off, while many men of prominence insist that none of the uterine mucosa is destroyed.

"Progressive Medicine" for June, 1914, published some interesting experiments conducted by Hitchman and Adler which furnish evidence for the theory that during the catamenia there is an alteration of the endometrium to a decidua-like tissue. These scientists claim that in those animals which do not have a hemorrhage during the rut a similar histological change occurs in their pre-rut endometrium.

The Character of the Menstrual Discharge—The menstrual flow is initiated by from one to three days of leucorrheal discharge. Gradually the mucus becomes streaked with blood. When menstruation is at its height and the uterus is relieved of its engorgement the blood is comparatively clear, mixed only slightly with mucus and epithelial cells from the uterine cavity and vagina. At the decline of menstruation the blood again becomes mixed with mucus and is finally followed with a leucorrheal discharge for a day or more, similar to that which precedes menstruation.

Eminent authorities in the past have claimed that there is no essential difference between the menstrual blood and the blood in the general circulation and that clotting is prevented by the admixture of mucus and lactic acid secreted by the vagina. Recently Blaire Bell, in some ten cases of hematocolpos, made a careful analysis of the blood and found neither fibrinogen nor fibrin-ferment present. He advances the theory that their absence may be due to the vital activity of the endometrium which either destroys or extracts these properties. Considerable experimentation is now being made along these lines, but at present the reports are conflicting and inconclusive.

Macroscopic Changes in the Pelvic Organs.—With the onset of menstruation the pelvic organs take upon themselves the characteristics peculiar to general congestion. On inspection, with the use of the speculum or in case of an abdominal incision, the uterus, ovaries, and vagina are seen to be dark red in color.

On bimanual examination the swollen vaginal folds, bathed with an abundant supply of mucus, have a velvety feel and the pulsation of the arteries can often be elicited. The uterus can be distinctly outlined as enlarged and sensitive on bimanual pressure. The normal ovaries can usually be palpated. The uterus and its appendages hang perceptibly lower during the menstrual period. This can readily be demonstrated when a digital examination is made in the upright position. Immediately preceding the menstrual flow the digital findings are easily confused with the early signs of pregnancy.

First Appearance.—Menstruation first occurs at various ages with various peoples of different climates and degrees of civilization, and even different members of the same family mature at different ages. Generally speaking, in America, it makes its initial appearance in the neighborhood of the thirteenth or fourteenth year. Warm climates, indolence, luxurious city life, emotional stimulation, especially that which consists in the reading of erotic literature and the forced artificialities which exist between the sexes in social life, make for a precocious puberty and an accompanying early menstruation.

The periodicity and the duration in the normal woman have considerable latitude. The menstrual period usually occurs every twenty-six to every thirty-one days. The duration of the flow averages four or five days, although this time is by no means fixed. The amount of blood lost is from one to six, or even eight, ounces. Each woman is a law unto herself and therefore establishes her own standard. Whether she menstruates once in three, or four, or six weeks, or even at longer intervals; whether she flows for half a day or for eight days, it is normal for her if her general health is excellent. Girls in colleges and working girls usually give a history of marked irregularity and so long as their weight is not decreased, they experience no local discomfort, and show no physical signs of ailment, especially rapid pulse, dry cough, and hectic flush, which are suggestive of tuberculosis, no attention should be paid to the omission of the external manifestation of menstruation. The practice of bringing on a delayed period with emmenagogues and local treatment is relegated to the unenlightened physician. Persistent amenorrhea in the moral young woman calls for the careful

diagnostician in general medicine rather than the gynecologist.

Symptoms.—With the onset of menstruation there is a cyclic heightened metabolism. The thyroid gland increases in volume. The breasts are painful. The congested pelvic organs produce a bearing down sensation. The great sympathetic system transmits the local discomfort to various parts of the body, so that headache, indigestion, diarrhea, and, especially in younger women, one or more facial papules of acne accompany the catamenial flow. The temperature is slightly elevated, although the individual is easily chilled. There is an increase in the amount of urine and a frequency of urination. While the urea is probably diminished, the uric acid seems to be increased. Havelock Ellis in his masterly analysis of "Man and Woman" says that the breath as well as the skin of many women exhales a not unpleasant odor which is peculiarly aromatic. Even though this may be of a uremic character it certainly is suggestive of a heritage derived from the animal kingdom, where it is probable that all females possess a distinct odor when they are capable of impregnation which is recognized by the male as a signal that his advance will be received.

It is not strange that the general nervous system should participate in this periodical disturbance and that the average woman should be unusually irritable, depressed, readily moved to tears, and easily fatigued.

Bland-Sutton and Giles in the sixth edition of "Diseases of Women" state that in London about thirty per cent. of women menstruate painlessly. It is doubtful if the statement is meant to be taken literally. Woman's instinctive modesty, on account of the distorted traditions concerning herself during this period, forces her, almost reflexly, to conceal her condition and thus repress her discomfort until the pain becomes so unbearable that it forces her to cry out. Moreover, all women believe that pain is a necessary concomitant of menstruation and as long as it is bearable they are inclined to ignore its existence. Owing to the varying capacity of women for enduring pain no classical line of demarkation can be drawn between painful menstruation and dysmenorrhea.

Menstrual Hygiene.—The pelvis in man-like apes and in primitive women more nearly approaches man's in being long, narrow, and of strong build. As civilization advanced and the human head increased in size, the pelvis of the civilized woman became broader, shallower, and the outlet larger. The carriage of woman is distinctly more forward in movement than that of man. The contour of her spine, the shape of her bony pelvis and thighs, tend toward the conservation of the female organs of reproduction. Nevertheless, the customs of civilization more than overbalance Nature's adjustments for the purpose of modifying the ailments peculiar to woman that have been brought about by the upright position. The woman of to-day is a victim of traditional thoughts which associate unmentionable shame with menstruation and all functions which are concerned with fecundation. This in turn is largely responsible for the mock modesty she possesses which forbids her to husband her strength and energies during the catamenia. Added to this, the tendency of the times is for woman to insist upon her exact equality with man in all fields of labor and this ambition conspires to make her overlook the hygiene necessary to preserve her distinctive organs which have such a vital bearing upon her procreative possibilities and general physical and mental welfare.

Undue physical exercise, dancing to excess, violent athletics, and long hours in the upright position such as are required by clerks and others in standing occupations, predispose to prolonged congestion with functional disorders of the pelvic organs. This is manifested in displacements of the uterus and its adnexa, dysmenorrhea, metrorrhagia, and menorrhagia. The sequel of this pathology is an unstable nervous system in which hysteria and neurasthenia predominate. Thus a vicious circle is established which jeopardizes the future health of the individual.

During the first few years of menstruation it is indispensable for a girl during her menstrual period to rest frequently from the upright position. Her hours for sleeping and mental tranquility should be increased. Her food should be non-stimulating, simple, and nutritious. She should not tax herself either mentally or physically to her full capacity. The incorrect ideas about the ill effects of the bath will probably require many years of enlightment before they are overcome. During the active menstrual period there is more occasion for the bath than at any other time. The tepid, warm, or hot tub bath should be taken once or twice daily. The temperature chosen should be that which affords the most pleasurable response from the individual. Soap and water with frequent changes of clean napkins are all sufficient for cleanliness as far as the genitalia are concerned. The douche should never be administered except under medical advice. The knee and chest position, a tribute to our animal ancestry, should be practised several times a day during the entire menstrual period and is an invaluable routine practice as a prophylactic measure for congestive displacements.

Menopause.—With the cessation of woman's fruitage period, somewhere between the fortieth and fiftieth years, a senile atrophy takes place in the organs of generation which causes a decrease in their size. The uterus, tubes, and ovaries all participate in a degenerative process which is caused by an atrophy of the cytogenic tissue and glands. Fibrous tissue develops in the endometrium. The walls of the blood-vessels gradually take on a hyalin change and finally the surface epithelium disappears. The fat in the external genitalia is absorbed, the nutrition is impoverished, and the hair on the mons veneris becomes scanty and white.

In ideally normal women the cessation of menstruation should occur without much more general disturbance than was occasioned by the establishment of menstruation. The degenerative process that prevails during the menopause especially predisposes toward malignancy. Frequent and profuse discharges of blood indicate a pathological condition that requires the attention of the skilled gynecologist.

Emma Wheat Gillmore.

Mental Deficiency.—(*Feeble-mindedness, Amentia*). Mental deficiency is a specific term practically synonymous with amentia as used in England, and with feeble-mindedness as used in the United States.

Amentia has been defined by the Royal College of Physicians of London as—"A state of mental defect from birth or from an early age, due to incomplete cerebral development, in consequence of which the person affected is unable to perform his duties as a member of society in the position of life to which he is born."

Tredgold modifies this as follows: "A state of afflicted potentiality, or arrest of cerebral development, in consequence of which the person affected is incapable at maturity of so adapting himself to his environment, or to the requirements of the community, as to maintain existence independently of external support."

Both these definitions are somewhat faulty in that they apply to adults, whereas the term mental deficiency or feeble-minded is more commonly applied to children. Tredgold partially recognizes this in his expression—"potentiality or arrest of cerebral development," but the definitions are further faulty in that they seem to define a physiological condition in sociological terms. This is perhaps necessary in the present state of our knowledge of the problem.

Mental deficiency is a condition of intelligence that is below the normal; this of course leads to the question—what is normal? To which we should have to reply that normal intelligence is the intelligence of the average person. Inasmuch as intelligence develops with age from infancy onward, we should have to add the qualifications of age; inasmuch as the intelligence of the average person of a given age is not a fixed quantity, we must then allow a certain leeway for those who are almost as intelligent as the average. Binet has suggested that for young children under nine we should allow a leeway of two years; for those who are nine or over, three years are allowed. We would therefore say that any child under nine years of age who shows an intellectual deficiency of two years or more is mentally defective. If the child is nine or older he is mentally defective if he shows a deficiency of more than three years.

Mental deficiency is usually regarded as an arrest of development of the brain, due to some cause acting before birth, at birth or after birth; even though the cause acts before birth the complete arrest may not take place until some years after birth. It is now generally considered, on the basis of experience, that if this arrest does not take place before the age of twelve the individual is not mentally defective. It is thus seen that there are grades of mental deficiency. A classification adopted by the American Association for the Study of the feeble-minded, the authoritative organization on the subject in the United States, is as follows:

INDUSTRIAL CLASSIFICATION.

Mental.	Industrial capacity.	Grade.	
Under 1 year	(a) Helpless. (b) Can walk. (c) With voluntary regard	Low	Idiot
1 year	Feeds self. Eats everything	Middle	Idiot
2 years	Eats discriminatingly (food from non-food)	High	Idiot
3 years	No work. Plays a little	Low	Imbecile
4 years	Tries to help	Low	Imbecile
5 years	Only simplest tasks	Middle	Imbecile
6 years	Tasks of short duration. Washes dishes	High	Imbecile
7 years	Little errands in the house. Dusts	High	Imbecile
8 years	Errands. Light work. Makes beds	Low	Moron
9 years	Heavier work. Scrubs. Mends. Lays bricks. Cares for bath-room	Low	Moron
10 years	Good Institution helpers. Routine work	Middle	Moron
11 years	Fairly complicated work with only occasional oversight	Middle	Moron
12 years	Uses machinery. Can care for animals. No supervision for routine work. Cannot plan	High	Moron

In this classification the term moron is synonymous with feeble-minded as used in England. Moron is from the Greek word $\mu\omega\rho\acute{o}\varsigma$, which means stupid or foolish. The English definition of fool is—"one who is deficient in judgment or sense." In accordance with this classification any child whose arrest of development has occurred at a time such that he does not get beyond the mentality of that of a two year old child, is an idiot. If his mental development is arrested between three and seven then he is an imbecile; between eight and twelve, a moron.

It will be seen that in order to give a final diagnosis it is necessary to ascertain that the development has actually ceased. A child of seven would not be an imbecile if his mind is still growing, even though it is growing at a very slow rate. How the arrest is brought about in the different grades and types is not known. In some cases apparently the retardation exists from birth and the final arrest takes place anywhere from soon after birth to the age of twelve as above stated. In another type of cases it would seem that the child is perfectly normal in development for a longer time, possibly in some cases even up to the age of nine or ten. It does not seem likely that the arrest is sudden except in accidental cases, such as a blow on the head or a severe fall, but rather that there is a period of slowing down during which the child gets more and more backward and deficient until finally his mental development ceases altogether.

It will be seen that the foregoing classification is psychological, based entirely upon the stage of mental development of the individual. This is now determined by psychological tests of the intelligence. (See *Intelligence, Tests of.*) Mental defectives have also been classified on the basis of certain anatomical peculiarities, such as the size of the head, into hydrocephalic and microcephalic; also on the basis of peculiar physiological conditions such as cretin and mongolian. Under the new plan these terms are used as adjectives and a child is spoken of as a hydrocephalic imbecile, hydrocephalic idiot, or a microcephalic imbecile, and so on. The older classifications have given rise to considerable confusion because of the liability to unconsciously change the basis of classification, and secondly because the terms are not naturally delimited. For example, a hydrocephalic case may be idiot, imbecile or moron; the cretin may be of almost any degree of mental development; the hemiplegic or diplegic is not thereby separated from the normal person. The one exception to this is the Mongolian, who is practically always an imbecile although he may be of mentality of three or anything up to seven, but the Mongolian imbecile is a definitely marked type with very definite characteristics; once recognized it is never mistaken. To recognize a child as a Mongolian type is to know at once his possibilities within very close limits.

Mental defectives have also been sometimes classified on the basis of supposed cause, but in the past causes have been so carelessly determined that such a classification is of little value.

ETIOLOGY.—The causes of mental deficiency have in the past been divided into those acting before birth, at birth, and after birth. Under each of these heads many causes were recognized, though it must be said that they were generally accepted on very insufficient evidence. The fallacy of *post hoc ergo propter hoc* has been committed not only by parents and friends but by students of the problem.

It is not uncommon for example, to read that someone has made Wassermann tests on a hundred or thousand feeble-minded persons with the result that, say forty per cent. of them show hereditary syphilis; conclusion—"*therefore, hereditary syphilis causes feeble-mindedness in forty per cent. of the cases.*"

Similarly with alcohol, one reads that eighty per cent. of feeble-mindedness is caused by alcohol in the parents. This conclusion has been reached on no other basis than that eighty per cent. of the cases the parents use alcohol. More recently the suggestion has been made that the condition is hereditary, and studies into the family histories of cases of mental deficiency have shown, in the case of the

Vineland studies, sixty-six per cent. of the mental defectives come from families in which mental defect is so frequent that the conclusion that it is a matter of heredity cannot be escaped. Moreover, the studies have shown that the condition is transmitted in accordance with the Mendelian law. (See Feeble-mindedness: Its Causes and Consequences by Henry H. Goddard, Macmillan 1914.) Of the remaining thirty-six per cent., twelve per cent., while not showing other feeble-minded persons in the family, show so much neuropathic condition that in the absence of any other known cause it may well be surmised that the general neuropathic condition of the family is accountable for the mental deficiency.

The various causes that come under the head of accident are credited with nineteen per cent. of the cases; of these 4.6 per cent. fall under the head of "accidents before or at birth." These are mostly injuries to the mother such as a fall, a shock, serious illness, instrumental delivery, neglect at the time of birth, etc. Of the accidents occurring after birth 5.3 per cent. of cases are due to cerebrospinal meningitis; another 5.3 per cent. are distributed as follows: blow on the head, scarlet fever, beriberi, convulsions, infantile paralysis, typhoid fever, fall on the head, alcohol, drugs, whooping cough and measles. It must be noted that the alcohol and drugs referred to in the above list were given to the child in early infancy and are supposed to have caused the mental defect. In view of the exceedingly small percentage of cases ascribed to any one of these causes just mentioned, the question may be seriously raised as to whether they are causes at all, or whether a more careful study and better knowledge would not show us something much more fundamental. Of the various diseases cerebral or spinal or cerebrospinal meningitis is the only one that can be surely cited as a definite cause of mental deficiency. An accident like a fall or a blow on the head may also produce this result.

Older authorities ascribe a much larger rôle to these various "causes," but that is accounted for by the fact that these later studies have examined into the family histories more carefully than has ever been done, with the result that a very high percentage are found to be hereditary cases, leaving only a few to be accounted for by other causes.

The Relation of Mental Deficiency to some of its Supposed Causes. Alcoholism.—In the popular mind alcohol is supposed to be the one great and efficient cause of mental deficiency; the facts, however, do not at all bear this out. Pearson has shown in a statistical study that there are no more mental defectives among the users of alcohol than among non-users. Tredgold says—"the pronounced family history of alcohol was present in no less than 46.5 per cent. of my cases; it is to be remarked however, that in five-sixths of these there was a definite neuropathic predisposition also, while in most of the remainder there was a history of other morbid influences." In the Vineland study there was no evidence that alcohol causes feeble-mindedness; that is to say, when other known and acceptable causes were subtracted there was nothing left to be attributed to alcohol. In the 2.6 per cent. where no cause could be found there was also no alcohol. On the other hand, it does appear that there are approximately twice as many feeble-minded children from alcoholic parents as from non-alcoholic parents, from which it may be concluded that alcohol is at least a contributing cause; although this is not logically conclusive since the alcohol may even then be a symptom rather than a cause.

It is well to remember in considering such matters that if alcohol were a cause of feeble-mindedness vastly larger numbers of parents should have feeble-minded offspring than is actually found.

Probably the second most potent supposed cause of mental deficiency is syphilis; but here again, there is no evidence yet produced by anyone that is logically conclusive of the causal effect of syphilis. Congenital syphilis is indeed present among the feeble-minded in various percentages, ranging from 3.7 to 30 or even 40 per cent. But the presence of congenital syphilis as demonstrated by the Wassermann test is far from demonstrating that syphilis caused the condition. Indeed, if the common statistics given for the prevalence of syphilis in the population are to be accepted as anywhere near true, then the same argument holds as above mentioned for alcohol. There should be an enormous number of feeble-minded in the population, far greater than is actually found.

Tuberculosis.—That tuberculosis has no direct effect as the cause of feeble-mindedness is practically certain; whether it may be indirectly a cause cannot be stated; Tredgold thinks that sometimes it may.

Consanguinity.—The frequency with which people nod their heads—"the parents were cousins, of course the child would be defective" is well-known. As a matter of fact, the Mendelian law explains clearly why cousins sometimes produce feeble-minded children, and enables us to take the modern view clearly that consanguinity *per se* has no effect. If there is defect in the stock then the matings of the persons from the same stock tend to bring that defect to the surface. This accounts for the disastrous effect when they do occur. Tredgold quotes Langdon Down as saying—"I am by no means sure that by a judicious selection of cousins the race might not be improved."

Again it has been supposed that if the father or the mother or both were of advanced age at the time of the birth of the child that would account for mental deficiency. There is absolutely no evidence of this, and the view may be relegated to the old superstitions.

The Relation of Mental Deficiency to Brain Conditions.—It has frequently been assumed that definite brain lesions were at the basis of mental deficiency. It is true that brain defect is more or less prevalent among the feeble-minded especially in the lower grades, but it must be noted on the other hand that many feeble-minded even of the lowest grade show no gross lesions of the brain. The older view that size of the brain, or abnormality of form, such as asymmetry, or defective convolution is at all significant can be shown only through careful measurement and statistical presentation. That is to say, no single brain can be characterized upon inspection as the brain of a mentally deficient person except in rare instances. Examined under the microscope the correlation of defective brain and mental defect is considerably higher. Most of the low grades show a lack of brain cells or incompletely developed cells. Of the higher grade, the moron type, it is still uncertain whether even this will be found. From the psychology of these cases one is led to expect that careful histological studies of the association areas of the brain will probably when such studies are made show more or less abnormality. As yet nothing definite is known.

There are many indications that the trouble is physiological but whether functional or structural is not yet known, and whether the physiological condition is the cause of imperfect brain development and function or whether a primal defective brain is the cause of imperfect physiological function or structure is far from being answered.

Diagnosis.—The diagnosis of idiocy and low-grade imbecility is generally easy. It is usually so obvious that the child has not good sense, that no particular directions for diagnosing these cases are necessary. In the case of the high-grade imbecile and the moron the case is quite different.

Stigmata of Degeneration.—It is supposed by many persons that the mental deficients possess many and marked so-called stigmata of degeneration. These

are such things as the high-arched palate; abnormal, supernumerary or badly arranged teeth; peculiarly shaped or unsymmetrical ears, receding forehead, or peculiarly shaped head; protruding or receding lower jaw, thick, coarse prominent or unequal lips; tongue large or fissured, etc. In later works the discussion of the stigmata of degeneration is being largely omitted; not because many mental deficients do not show more or less of these stigmata but because in the first place many normal people show them, and in the second place many mental deficients do not show them. It is therefore not well to lay much stress upon these matters. It is safe to say that unless there are other satisfactory proofs of mental deficiency the presence of the so-called stigmata of degeneracy should not be taken as evidence. On the other hand in cases otherwise suspicious the presence of a number of marked stigmata may be more or less confirmatory. As an evidence of the danger of drawing conclusions from the presence of the stigmata, we may cite the case of the arched palate, still frequently quoted as evidence. Channing and Wissler, however, in one of the most careful and complete statistical studies made, through accurate measurements of the arches of a thousand feeble-minded and five hundred normal persons have shown that the presence of the high arch is of no significance as indicating mental defect; since, it is present among the normal people quite as much as among defectives. Their study may be taken as settling the question of the high arch palate.

We have said that the danger of drawing conclusions from the presence of the stigmata is for one reason due to the fact that many defectives do not have stigmata; this is particularly true in the high-grade imbecile and the moron. Many of these defectives not only lack any marked stigmata of degeneracy but throughout their whole organism present an appearance which is so decidedly like the average person that many people are unwilling to admit the possibility of their being mentally defective. It becomes necessary then to recognize that mental deficiency may be present in an individual who gives no outward evidences of it that can be recognized by any except those who are familiar with large numbers of morons, and who are sometimes able to see evidences of defect in the outward appearance of these individuals. Nevertheless, even the experts are often baffled along this line and can only be sure of a diagnosis by determining the family history, the individual history, and by making careful psychological tests.

The first thing to arouse suspicion of mental defect is the fact that the child is not like the average child in his behavior, his plays and games, his morals, his dealing with his school work. It must be emphasized that this is a broad and tentative statement. There are many reasons other than mental deficiency to account for a child being unusual in one or all of these lines. Nevertheless, these are often the indications of mental defect, proof of which can be found upon more careful examination.

School History.—For any child who has had fair school opportunities one of the most significant evidences of mental defect is failure to keep up with his class. A child that has had to repeat grades until he has become two or three or more years behind the grade that his age would warrant is very probably mentally defective. Parents often notice abnormalities of conduct which are not apparent to the casual observer. Except in the case of highly sensitive or overwrought or too ambitious parents these observations are very significant. By adroit questioning of the parents as to the character of the peculiar conduct one can usually decide whether it is the parent or the child that is abnormal. In all these cases the final diagnosis must be determined by a careful psychological examination by some of the standard systems of tests (see "Intelligence, Tests of"). In all doubtful cases the history of the child so far as accidents or disease will often give helpful evidence on one side or the other. Dr. Block has pointed out that the presence on a child of a good many scars or evidences of physical injury is often times very strong evidence of mental defect. Of course the child should be questioned as to how he came by the various scars or injuries and if he can give a good account for them showing that they were beyond his control then it would not be evidence of mental defect. If on the other hand the method by which he received these injuries was lack of judgment, lack of forethought, or in the words of the definition—"inability to avoid ordinary dangers" that fact should be taken into account. The discovery of what may be an adequate cause of the condition will often times satisfy the examiner of the correctness of his diagnosis. For example, if an investigation of the family history shows other mental defectives one may very naturally conclude that he is dealing with a case of hereditary feeble-mindedness. Likewise, the presence of insanity, epilepsy, alcoholism, etc., in the ancestry would point strongly toward a neuropathic ancestry. The importance of the various diseases and other accidents has already been discussed.

The examiner must constantly keep in mind the normal child of the same age as the case at hand. The standard must be an average normal child; it is not safe to conclude that because one knows of children of the same age who manifest similar symptoms that therefore the child under investigation is normal.

Often the parents are able to tell of some much younger child with whom their child delights to play; that is to say he chooses his companions from children who are of his mental age, which often reveals the fact that he is subnormal.

A defect of speech is often a very significant factor in the case, although more often than otherwise wrongly interpreted. The common argument is that the speech defect is the cause of his other defect and parents, often teachers, sometimes even physicians, say that if he is trained to speak he will be alright. As a matter of fact the speech defect is generally a clear evidence of mental defect, and the real argument is—he would speak all right if he had a normal mentality. So that whereas some normal children do have speech defects of one kind or another yet the presence of a speech defect in a child otherwise suspicious is as a rule corroborative evidence of mental deficiency.

The same argument holds in the case of foreign children. It is but natural to attribute the fact that a child does not get along with his studies in school to the fact that he does not understand the language, if he is of foreign birth. In such cases it should be recalled how rapidly the normal child of foreign birth picks up a new language. Failure therefore, to pick up the language promptly and readily is itself an evidence of slow mentality, which may amount to mental deficiency, although in some cases it may mean only a certain backwardness or slight dullness.

The Mongolian type already alluded to is one that is recognized by outward appearance. To the person who has once become familiar with the type they can be recognized at a distance; generally the rounded face with the slanting eyes giving them an appearance like the Chinese from whom they take the name. The short stubby fingers, the absence of occipital protuberance of the head giving the appearance of a straight line from the neck up, frequently but not always a deeply furrowed tongue, all go together to make a picture that cannot be mistaken. Such a child is in the great majority of cases mentally about four years; a few reach five and rarely one attains the mentality of seven.

The other physical abnormalities alluded to above need little discussion. The hydrocephalic case is

easily recognized, and while hydrocephalus does not always cause mental deficiency, as a rule it does, and in the presence of other evidences of defect this may be accepted as almost conclusive evidence.

The microcephalic child is even more certain to be mentally defective. The only question here is the relative size of the head. Because the head looks somewhat small is not evidence of microcephalus, but an extremely small head in a child who is old enough to have attained to a nearly normal size of head becomes significant. The presence of hemiplegia or diplegia is of course also significant.

The cretin with his absent or hypertrophied thyroid gland needs no discussion.

The presence or absence of epilepsy in the child or in his ancestors should be noted. Epilepsy may sometimes be a cause of mental deficiency—a person affected with epilepsy generally deteriorates mentally—or it may be only an accompaniment.

Much confusion may be avoided in an attempt to understand the problem if we picture what may be called pure feeble-mindedness, onto which any disease or accident or condition may be grafted. The feeble-minded epileptic is a good illustration of this.

We may have cases of pure feeble-mindedness who become epileptic just as any normal person may become epileptic. On the other hand there are cases who first develop epilepsy and the epilepsy seems to produce a degenerative condition of the brain so that they gradually become feeble-minded. This could probably be more properly called dementia.

Prognosis.—Once the diagnosis of mental deficiency has been reached there is no uncertainty about the prognosis. Mental deficiency is never removed; feeble-mindedness is never cured. This does not mean that such a child cannot be trained. The distinction between training and increasing the intelligence must be carefully noted. Increasing the intelligence means raising the intellectual level, starting again the mental development which has already stopped. Training means that he can be taught to do all of the things that any person of his intellectual level can do. This may be made clear from an analogy with the physical. A person whose physical stature has ceased to develop at the height of five feet cannot by any known method be made to start up and grow to the stature of, say six feet. But while a person of five feet may not be eligible for the army or cannot take any occupation that requires a person of six foot stature, there are nevertheless quantities of things that a five foot person can do. In an analagous manner a person whose mental development has been arrested at the age of ten can never do intelligently things that require eleven year intelligence, but there are a great many things that involve only ten year intelligence; these he may learn to do, as many as he chooses or has time to acquire; that is, he can be trained but he cannot be made more intelligent. It would not be correct to conclude that this is to be taken absolutely; it is true that as he lives on and has varied experiences and especially careful training he acquires a certain facility which makes him appear more intelligent and probably does to a very slight degree raise his level, but as a rule not to such an extent that it can be measured.

Treatment.—There is no treatment in the medical sense that can be applied to the mentally deficient as such. In so far as they suffer from disease or injury or accident the same as normal persons, treatment is indicated, but for the mental deficiency itself nothing can be done.

In the one case of cretinism there is an indication for treatment, or rather for special feeding; cretinism being due to the absence or hypertrophy of the thyroid gland, may be largely overcome by administering the thyroid gland of the sheep.

The Mongolian type which in some respects resembles the cretin has on account of this resemblance often tempted physicians to prescribe thyroid gland but careful experiments have failed to show that it has efficacy.

At the Vineland Training School fourteen Mongolians were given thyroid extract regularly for twelve months; their mental condition and their physical was carefully watched and measured, and the result of the experiment was that not the slightest effect was observable. Others have made the same experiment on a smaller scale and the results agree, so we may conclude that it is established that thyroid extract has no beneficial results with the Mongolian type; indeed with any type except the cretin.

The problem then of the true mental defective is an educational and a sociological one, but it is not on this account any less important or less difficult of solution. Untrained and uncared for the mental defective becomes a pauper, or a criminal, a vagabond, or a vicious, dangerous person, a menace to the community wherever he is found. Carefully and wisely trained he becomes a somewhat useful, partially self-supporting, pleasant, agreeable, harmless child, no matter what his chronological age. Whether the untrained defective becomes a pauper or a criminal seems to be largely a matter of temperament. We may leave out of consideration for the present those few cases that belong in families who take care of the individual throughout his life, so that he passes off the scene of action without having become a menace to society.

The great mass of defectives are not thus cared for by private initiative. In public institutions they are trained and made reasonably safe; without this care they are the most abject victims of their environment. The slow phlegmatic indolent type becomes a pauper; he cannot work because he does not know how to earn a living, he has not intelligence enough to keep even the simplest job; he accordingly would starve to death unless he were cared for by public charities.

On the other hand the nervous active defective takes the matter more or less into his own hands. Not being able to work intelligently and to earn a living he will steal it, and so he becomes a thief. In his association with other persons, not having intelligence enough to reason upon the situation he follows his blind impulses, and when impeded in his wishes or desires, not having intelligence enough to control himself, he may commit murder. If this defective is a girl she easily falls into a life of prostitution. Any or all of them, phlegmatic or nervous may become the dupes or victims of designing wicked persons who lead them to commit the crime and then place the punishment upon them.

It is from such a career and experience as hore outlined that care and training ought to save them; and yet it cannot be claimed that there is any universally accepted method of training defectives. Historically we have worked from the top down; that is to say we have modified our educational methods as used with normal children, first changing them but slightly but gradually as we have come to understand more of the character of the defective making ever larger and more extensive and more radical changes, until the tendency at the present time is to get far away from the methods used with normal children.

The first and most important thing is to recognize the mental defect and the level of intelligence; to decide this as early as possible and then to plan our training in accordance with those findings; that is, the lower the grade of intelligence the less can be done at once and the more useless it is to plan for the future. That is to say, it is useless to start a course of treatment, which while beginning with low intelligence will eventually require higher intelligence, if the individual to be trained is never going to attain to that higher intelligence. For example, a six year old child can

learn to read but it requires a ten or twelve year old child to read with sufficient intelligence to make it profitable; therefore, if we know that our six year old child is never going to attain to an eight or ten year intelligence it is not worth while to start him to learn to read because he can never finish it.

The first law for all training of such persons is to make them happy. As soon as any kind of training is clearly not adapted to them or is so difficult that they are not happy in the learning and the doing, then it must be changed to something simpler. As a rule the simple arts of living and of making a living in the most primitive way come the nearest to their capacity. It is common observation among those who have worked with defectives that they get back ultimately to the land, and so we find that farm work and simple housework are about the limit of their accomplishments as a rule. The very highest defectives can be trained to do some piece work and work at some regular industry provided they are understood by the employer of labor and their weaknesses somewhat catered to. It is not necessary that they be taught to read and write; indeed it is maintained by some that it is positively injurious for them to have this knowledge.

The farm colony with a few intelligent overseers to attend to the more complex details seems at the present time to be the best adapted to these defectives.

We have so far considered treatment from the standpoint of the individual, but there is a larger phase of considerable importance that is, treatment from the standpoint of society—what shall be done by society for the benefit of these defectives and for the protection of society itself?

In considering the question, what shall be society's treatment for the mental defective, we are confronted with the problem of their number. How many are there? What proportion of the population is so mentally defective that they are not able to take care of themselves, "to manage their own affairs with ordinary prudence" as the definition has it.

In 1890 the United States government attempted to determine through the census takers the number of mental defectives. The method was simply that of inquring at each house when the other statistics were secured, "how many imbeciles or idiots are there in your house?" On the basis of the answer to that question it was found that there were two in every thousand of the population. When we realize the reluctance of people to tell of the imbeciles or idiots in their family, and when we realize further that only the lowest grade of imbecile would be recognized as an imbecile, that the entire group of high grades or morons would be entirely lost in such enumeration, we see that it is not to be expected that this census secured even half the number of real mental defectives. It seems, therefore, entirely reasonable when we find that recent studies seem to indicate that the number of defectives may be as high as one in every two hundred of the population.

A careful census in certain places, for instance in one county in the State of Michigan, has given as high as one to every 171 of the population. Careful studies have indicated that two per cent. of school children are mentally defective. These two ways of counting mental defectives agree remarkably when we realize that the school population is about one-fifth of that of the total population, and again that the far greatest number of defectives are among school children, because they are as a rule short-lived they are not found in the same proportion in the older members of a community. On the basis of these estimates there are somewhere from 200,000 to 300,000 mental defectives in the United States.

What Shall be Done with Them?—There are two procedures much talked about at the present time. One is sterilization; the other is segregation, or colonization.

The advocates of sterilization say that since feeblemindedness is hereditary in at least two-thirds of the cases, we have only to stop the propagation of defectives to eradicate a large part of the trouble in the course of a generation or two; they therefore advocate laws requiring sterilization of defectives. Such laws have been passed in more than a dozen states, but in none of these states has the law ever been adequately applied, and most of them have made no effort whatever to apply it.

The provisions of the law apply only to the inmates of Institutions, and hence cannot reach the large numbers of persons outside of such Institutions. It can easily be shown that sterilization cannot be looked upon as a solution of the problem of mental deficiency.

Segregation or colonization looks at first more hopeful, but in reality it has also inherent difficulties which are practically insurmountable. We are at present caring for approximately one-tenth of the estimated number of defectives, and groaning under the pressure of that. What is the prospect of our caring for the other nine-tenths in a similar manner? Approximately half of the states have no Institutions whatever for mental defectives. Granting for the sake of argument that we could sometime provide the necessary colonies, will we be able to get all the defectives into these colonies? It is more than doubtful. Many of these persons are so high grade and present such a good appearance that only the expert can see that they are defective. The problem would be somewhat like that of trying to get into an insane asylum every person who "is not quite right" mentally.

We have the difficulty of diagnosis and we have the difficulty of persuading parents or others to place these persons in colonies when they are found.

We may conclude therefore that without doubt it will never be possible to get all the mental defectives housed in Institutions or Colonies. Must we then put up with this burden upon humanity, with this menace—for as we have shown, every feebleminded person is a menace to society? Another plan has been proposed which may yet prove to be of some value in the solution of the problem. The plan contemplates the discovery or recognition of these cases through the instrumentality of the Public Schools. Our compulsory education laws may easily be so modified that every child at the age of five or six comes to the attention of the school authorities; they then decide on his mentality on whether they can train him or whether he is too low grade to be trained. Even if they decide that they can train him they may still recognize him as a mental defective, and after giving him such training as he can take from the public schools, he is turned out to the farm or the shop or the home to do the best he can, but now under careful supervision and direction, by some sort of probationary or after-care system, so that everyone knows that he is an individual who is not responsible to the highest degree and who must not be placed in positions of high responsibility.

This kind of beneficient social ostracism may perhaps be the solution of the problem. Once let the public generally know that these persons are children in mind, though men and women in years and in physical stature, and the problem is largely solved. For then everyone will have a kindly interest and care if for no other reason at least from the standpoint of self-defense, realizing that these child-minds are always in danger of menacing the public, the public will in turn take care to protect themselves against them by not allowing them to get into positions where they can do damage.

If we can go a little farther and prevent their marrying or procreating, then we will have gone a long way toward solving the problem.

In the meantime, the care of the low-grade idiot and

the middle-grade imbecile, those who cannot be thus allowed to go about by themselves even under close supervision, is so important that it will require all our energies and all our revenues to build Institutions and equip them for the care of such as these.

It is now believed that from fifty to seventy-five per cent. of criminals are feeble-minded; that perhaps an equal proportion of drunkards are mentally defective. "The Massachusetts Commission for the investigation of the So-called White Slave Traffic" found fifty-three per cent. of the women they examined, the prostitutes, mentally defective. Probably an equal proportion of paupers are mentally defective, while the vagabonds and ne'er-do-wells would also come in for its large share of defectiveness.

We are fast coming to the view that mental deficiency underlies to a large extent our most troublesome social problems. Hence the study of the problem of mental deficiency has much to commend itself to society at large.

The reader who would go further into the matter will find two books of great value: "Mental Deficiency (Amentia)" by A. F. Tredgold—and "Feeble-mindedness: Its Causes and Consequences" by H. H. Goddard.

HENRY HERBERT GODDARD.

Mental Diseases, Classification of.—A classification is meant to be a short summary of a current state of knowledge concerning the subject under discussion. It seeks to group under one heading a number of clinical pictures and attempts to unite them into a harmonious group by means of some common factor or factors.

When mental diseases were considered as diseases of an organ, *i.e.*, the brain, it was quite comprehensible that such an attempt would be made, but since the development of the idea that after all the brain is nothing more or less than a central meeting point of a large number of connections which come from all parts of the body, it is quite evident that the brain is not one organ but many, and that any scheme which attempts to combine all mental symptoms, that is, adjustments of the individual to his social environment, is destined to be illusory. Hence it has come about that within the last fifty or sixty years, the classification of mental diseases has developed along very different lines from those of former times, and also that the remodellings of the ideas underlying the classifications have come to express widely different points of view.

The early attitudes of mind, as seen in the Hippocratic writings were very systematic. Diagnostic and pragmatic observations were found in these writings and we have from the time of Hippocrates a large number of the diagnostic symbols, which are in use to-day, although the meaning lying behind the symbols has been modified beyond recognition. Thus, for instance, *mania*, according to Hippocrates, was usually nothing more than a high degree of feverish irrational talk and sometimes mixed with great fear and depression. *Melancholia* was used by him to indicate certain bodily disturbances, such as those who had dark eyes and dark skins, and were so-called bilious. It also indicated a morbid predisposition of the body; sometimes it was synonymous with madness as a whole. Out of the Hippocratic writings, however, one can find that even then a distinction was made between those mental disorders which were due to infections and those which were not, because they separated a group which were called "phrenitis" from all others. *Phrenitis* was a type of delirium with irrational talk, accompanied by fever. The great group which is separated to-day under the head of somatic delirium, and recognized to be due to infections such as typhoid, pneumonia, influenza, pus, etc., etc., would, in Hippocrate's day, have been called phrenitis. In fact the description of most of the classic authors shows that phrenitis was mostly typhoid delirium. If one would wish to know what different things Hippocrates thought were different diseases, and given more or less descriptive details, one can turn to the dissertation of Nasse and obtain the following:

Dispositio ad insaniam:

1. ad maniam; duo gradus
   - *a.* homines adhuc sani (de diaeta 1, p. 352) (1)
   - *b.* iracundi, excitati (*ib*)
2. ad mentiam et melancholism; duo gradus
   - *a.* homines fere sani (*ibid.*, p. 351)
   - *b.* stolidi (*ib*)

I. Amentia
   1. Amnesia cum tristi animo. (lib. de morb. sacr. p. 309, tract de insan. p. 1286).
   2. Imbecillitas (de diaet. 1, p. 351).

II. 1. Conditio subfuriosorum (mania proxima, nisi morbus ipse) C 1, p. 352.
   2. Mania cum austero et tristi animo (lib. de morb. sacr. extract, de insan. II, c.c.).
   3. Mania ebrioso, vinosa (de diaet. I, p. 347).

III. Melancholia
   1. Melancholia cum tristi animo, amentiæ proxima (lib. de morb. s. et. tract de ins. II c.c. eadem abdominalis (de morb. II, 486).
   2. Melancholia cum vitæ satietate intermittens (epid. VII, 1234, 16 V. 1160—cum nisu ad autocheiriam (de virg. 1, 562; de loc in hom, p. 420).
   3. Melancholia hysterica (de morb. mul. I, 594).
   4. Melancholia dæmonomaniaca (de virg. I, c.).
   5. Melancholia panica (epid. V, p. 1159; epid VII, 1233).
   6. Melancholia cum fixa idea (*ib*).

Later writers were hardly any more definite than Hippocrates, although Celsus living in the reign of the Augustus in the first or second century of the Christian era, devoted a large part of his work to mental disturbances. As a matter of fact, he was one of the first to have written a special work on mental diseases, although Asclepiades may be said to have been the Father of Psychiatry, and to have given the first systematic account of mental disturbances. The works of Asclepiades, however, are lost to us and with the exception of the brief notes we find of him in Celsus and other contemporary writers we know little definite about him.*

Celsus distinguished, as did Hippocrates, phrenitis as fever delirium, and melancholia and mania, but his descriptions are solely clinical and non-systematic.

Galen's work on mental disturbances is not yet fully available to us. Mania and melancholia had remained all throughout these early periods—400 B.C. to 1500 A.D. as the two general terms for all mental disorders, and little by little the influence of contrasting pictures had served to give to *mania* the connotation of *excitement*, while all *depressions* had a tendency to be grouped as *melancholia*. We can see, therefore that these terms were simply broad diagnostic terms and had no application whatever to the mania or melancholia or similar words used later. Felix Plater (fifteenth century) was the first to enter the new order of things.

Plater's scheme was as follows:

1. *Mentis imbecillitas:* Hebetudo, immodicus, livio, imprudentia.

2. *Mentis consternatio:* Somnus, immodicus, carus, lethargus, apoplexia, epilepsia, convulsio, catalepsis ecstasis.

3. *Mentis alienatio:* Stultitus, temulentia, amor, melancholia, hypochondriacus, morbus, mania, hydrophobia, phrenitis, saltus viti.

4. *Mentis defatigatio:* Vigiles, insomnia.

Here we can commence to see the picking apart of

* Psychiatrists of the Augustan Era, Jelliffe. (Johns Hopkins Bulletin, 1908.) Also Notes on the History of Psychiatry, 1 to 10, Alienist & Neurologist, 1909 to 1915.

a number of things; thus the mental excitement attendant on apoplexy, on epilepsy, on convulsive states such as are seen in uremia, etc., are being separated. The insomnia of extreme exhaustion, with their attendant mental symptoms, are being set apart. Also the various forms of feeble-mindedness.

Closely following on Plater the next two or three hundred years brought about the widening of the descriptive terms used in psychiatry. Botany and zoology began to be studied at this time and the naming of species spread from plants and animals to diseases, with the result that throughout this whole eighteenth century, following the work of Linnæus in 1753, the classification of mental disorders ran riot. One can get an idea of the hundreds of species of mental disturbances on consulting the works of Sauvages, Plocquet, Valenzi, and the Englishman, Cullen. (Jelliffe, S. E.: Summary of the Origins, Transformations, and Present-day Trends of the Paranoia Concept, *Medical Record*, April 5, 1913.)

Thus in those days an acute excited patient might be called a maniac, but if in the course of his excitement he would have a tendency to tear *papers* it would be one kind of mania; if a tendency to tear *napk,ins* another kind; if to tear his *hair* another kind etc., etc. In other words all varieties of species and subspecies were made of the particular delusionary or hallucinatory trend of the individual, with the result that a single patient might suddenly change his disease every five minutes or every day or two, according to the changeability of the hallucinatory or delusionary trend. It was, therefore, to be expected that the whole business would be swept away, and this is what took place, and what really constituted the great reformation of Pinel in the early part of the nineteenth century. Pinel cut the hundreds of forms right back again into three. Although he used the words, mania, melancholia, and dementia, his mania and melancholia were different from those of the early Latin writers, nevertheless they still thrust the chief picture of excitement and depression into the foreground as a basis for classification. The dementia group was a large one made up of the majority of all cases, because it meant practically all of the chronic invalids, which resulted from the other disorders. Pinel's idea of dementia still persists in the so-called secondary dementias of our English pyschiatry, and is still frequently used in the law where much nonsense is talked about under the heading, dementia.

From Pinel's time there has been a steady reconstruction. The most important idea that entered into the situation, however, came from Heinroth in 1808, who, utilizing the concepts of the Kantian philosophy, was really the precursor of the present-day trend toward more pragmatic conceptions. From Heinroth's day, chiefly through the influence of Bayle, Falret, Kahlbaum and Hecker we see gradually built up the concept of separate diseases, *i.e.* that there is no such thing as *insanity*, as a whole, but that there are different mental disturbances. In the mental field one can trace a process going on which was precisely similar to that which was going on at the same time in the neurological sciences. Thus in the beginning of the nineteenth century *myelitis* meant practically all diseases of the spinal cord. When the celebrated French School, headed by Charcot, dismembered this group, there were separated from the myelitis trash basket a large number of different disorders, tabes, multiple sclerosis, syringomyelia, progressive muscular atrophy, poliomyelitis and a number of other forms. Myelitis practically had disappeared. So in the mental sphere, as a result of a similar type of analysis, the old terms, mania, melancholia, dementia have gone. When we come to the work of Griesinger, Krafft-Ebing, and finally to that of Kraeplin, we find the names have all disappeared, melancholia has been split up, the paranoias distributed, manias are gone to be replaced by disease entities, for the most part valid and sound. Acute excitement in a mental disorder no longer means mania; it may mean an acute delirium due to alcohol, an acute delirium in a course of patient with syphilis, an acute delirium as a result of abscess of the brain, or as a result of an epileptic convulsion, a tuberculous meningitis, etc., etc.

Classifications have become to be expressed in terms of etiology now rather than in terms of clinical picture; the whole trend has been to get causes into the scheme rather than the description of what one sees, and the tendency has been to increase the importance of looking at the disease picture as a whole in its origin, cause and evolution rather than at any transitory and passing phase of the disturbance. All this has produced an enormous amount of variation in the descriptive terms used by various psychiatrists at various times. One may rest assured that where there are rapid changes in descriptive terms there is rapid progress in the evolution of knowledge, which these descriptive terms endeavor to handle.

The chief problem that the student of the history of mental disease has to grasp is to see the reasons that lie behind the change in the symbols, and to see the varying attempts to amalgamate the new medical knowledge in the psychical or symbolic sphere. All mechanistic hypotheses stop short at the physicochemical level, and since mental disturbances are for the most part at the psychical level, it becomes increasingly difficult to grasp the significance of what symbolisms mean, especially in term of mechanistic concepts.

Thus the latest reaching out for comprehension of psychical processes has come about through the researches of the psychoanalytic school and their study of psychical mechanisms promises to introduce a very great change in the ways of looking at mental processes. These new studies will not change the solid foundations laid by the workers during the last century; for all those mental disorders, which may be said to rest upon definite organic changes in the brain, such as fever delirium, intoxication-delirium, the various forms of inferiority, the various mental diseases associated with organic diseases, diseases due to syphilis, etc., will mostly remain. The psychoanalytic school is devoted to the comprehension of those benign forms of mental disturbance termed psychoneuroses and the so-called functional psychoses, particularly those belonging in the dementia precox and the manic depressive group. It is here that the chief evolutions in systematization will take place and new classifications will be needed.

The chief representative of the present-day classification of mental diseases is best found in the last edition of Kraeplin's Text-book. This will undergo change, since after all any classification is solely a crystallization at a certain stage in the progress of science. Science is in a constant state of flux and therefore no classification can ever represent the attitude of mind of all of the students of that science. The chief point to be borne in mind is that the intellect makes diseases, they do not exist *per se*, therefore, any disease is solely the name and definition of the result of a method of looking at it; and that method of looking at it, which best comprehends and best handles it for the purpose of bringing about its overcoming and elimination, is that description which is going to persist the longest.

Smith Ely Jelliffe.

Mental Diseases, Examination and Diagnosis of.—The question of the diagnosis of mental disease may be approached from any one of a number of

directions depending largely upon what, in the mind of the examiner, a diagnosis consists. In the old days, speaking arbitrarily before Kraepelin, a diagnosis consisted solely of seeing the elements in a cross-section of the psychosis at the particular time that the patient was examined, and parenthetically it may be said, seeing these elements very superficially at that. Thus, for example, if a patient was excited the diagnosis was mania, if depressed, melancholia, etc. Such a method of approach to the problem involved the frequent necessity of changing the diagnosis, so that a patient who to-day was a maniac might to-morrow be a melancholiac, implying that one disease had fled to give place to another. Kraepelin emphasized the necessity of a longitudinal section of the psychosis and dwelt on the importance of defining its course and its outcome, and so by studying his patients over long periods of years and seeing the fluctuations from a point of view that gave him a proper perspective on the whole situation he was enabled to define those two mental diseases—the manic-depressive psychosis and dementia precox, which extend usually over many years if not throughout the entire life of the individual after their incidence. This method of approach to the problem of diagnosis was a very great advance upon the old one, but it was soon seen that it required still further elaboration, and while course and outcome carried the matter well along into the future it was necessary to investigate more in detail the past and study the make-up of the individual in whom the psychosis occurred. And so the question of diagnosis was now approached from the standpoint of the whole life of the individual, but when the life of the individual came to be appreciated as more than a personal thing and as being dependent upon what he came into the world with, namely, upon the hereditary factors with which he started, then for the first time we got a true and natural history rounding out of the whole situation, and came to look upon a mental disease, not after the medieval fashion as if it were some entity, which, in the dark ages they represented to themselves as being a devil, which came out of the nowhere and settled upon the individual, but as being a type of reaction expressing the individual and being the necessary outgrowth of his particular and peculiar personality, not only so far as it had been acquired during his growth and development, but also so far as it had been grounded in the hereditary elements with which he started.

Having, so to speak, brought the question down to the consideration of the individual as a biological unit, it is now essential to get the proper attitude toward the way in which this individual's mind as such is to be considered. When we realize that the mind is the final word in the course of evolution, and further realize that in the building up of the organism the mind, or at least the central nervous system, of which the final expression is mind, contains, so to speak, epitomized, the whole body in all its parts and in its entirety, and realize further that mental reactions are no longer reactions of parts of the individual as a reaction of an organ like the pancreas is a reaction of a part of the individual, but are reactions of the individual as a whole, then we are in a position to see the importance of envisaging our approach to the examination of the mental reactions by the widest sort of information regarding the bodily condition. While the relationship of a problem like aphasia to the mental problem as such is quite self-evident, it is not so self-evident that a problem of nutrition or of motility should be so related. We must continually bear in mind that conduct, which represents the reactions of the individual as a whole, must of necessity be built up out of material which includes the reactions of all the several parts of the individual, a concept which we can use when we see the representations of all the special organs in the body, not only in the nervous system, but even, as so far worked out at present, relatively high up in the nervous system.

We can now approach the problem of diagnosis from the standpoint of the individual reacting as a whole and such reactions being the outgrowth of the necessary elements which go to make up that individual's personality, whether they be acquired or inherited and whether they are primarily and directly mental in character, or whether they are reverberations from far distant organs.

And finally, in approaching the problem of the psychoses as exhibited in conduct, types of reaction, we must realize that the intelligence, or to be more accurate the aspect of consciousness, which we term intellect, is after all of much less importance than has heretofore been considered, and that the affects, the feelings, the emotions represent a much larger and much more important side of mental life and have much more to do than has heretofore been supposed with activating conduct. Taking this into consideration and the fact already mentioned, that conduct must be built up out of elements, some of which contain the reverberations of the functions of distant organs, we can correlate the two concepts on the basis of the recent work that has been done in connection with the sympathetic and autonomic nervous systems and the ductless glands. Here we realize that we have the nervous system at its lowest level closely related to important biochemical functions, which functions have to do with higher nervous levels, particularly with the emotions. Through the sympathetic and autonomic nervous systems the secretions of the endocrinous glands are regulated, and these secretions have an intimate relation at least to the sensitivity of certain portions of the central nervous system in their response on the affective side.

Bearing all these considerations in mind we then must approach the question of diagnosis and examination from the point of view of considering the individual as a biological unit reacting under conditions limited by his hereditary tendencies and his environmental situation. We therefore can consider his reactions from the point of view of their efficacy in dealing with all these conditions, or rather from the point of view of their expression of all these conditions.

As an example of the necessity for this broad method of approach let us consider a patient who has had a syphilitic thrombosis of a cerebral vessel with resulting paralysis and a psychosis. Such a complex of symptoms can be considered from three viewpoints. It can be considered solely from the point of view of an infection, syphilis, and so treated, it can be considered solely from the point of view of an organic lesion of the brain as evidenced by the paralyses and so dealt with, or the psychosis may be considered and its mechanisms worked out. While a consideration from the point of view of an infection or as an organic cerebral disease with disturbances on the motor side could either one be quite complete and the patient might be treated at these levels irrespective of what in particular were the psychic mechanisms that he showed, as soon as we get into the region of the mind it is no longer possible to consider the psychic mechanisms without considering the whole individual and these other matters of infection, thrombosis, and paralysis as parts thereof. The biochemical and neuromuscular levels, being on the way, so to speak, to the psychic, must be taken into consideration if we are to have a complete understanding of the psychic, although the opposite does not so necessarily hold true.

The object then of a complete diagnosis of a mental condition is to reduce the terms of the patient's conduct to elements that show the mechanisms involved and their meaning. It is no longer sufficient simply to give a name to certain outward manifestations, but

these manifestations must be analyzed sufficiently to understand what they mean, what they are an expression of, and in the realm of mental disease as nowhere else this understanding involves an understanding of the individual as a whole.

To the ends as above outlined, I will now proceed to give certain more concrete suggestions as to method of approach and ground to be covered in the actual examination of a patient, and a short account of the different groups of reactions into which mental diseases from our present knowledge seem to fall, with the caution, however, that the important thing is after all not to give a name to the disease, but to understand the individual.

Family History.—In collecting the family history it is desirable to include information as far as possible of all of the members of the patient's immediate family, that is, his own children, his parents and his four grand-parents, making such information complete enough if possible to construct a famiiy chart. Such information should of course contain as far as possible the characteristic traits of each individual, the diseases from which they suffered, the causes of their death, the dates of their birth, and their ages.

History of the Patient.—This should include as full an account as possible, on both the mental and physical sides, the childhood diseases, the age at which the patient learned to walk and talk, especially such diseases as are manifested by convulsions, and delirium, evidence and history of head injury, and infections. It should also include a history of any previous attacks, if there be any; the marital situation: if a female an inquiry into the menstrual functions, and in any case the sexual life.

Of great importance here is the question of make-up, which includes an inquiry into school life, the ability shown in acquiring knowledge, the practical capacity to use such acquired knowledge, and the ability of the individual to fit into difficult situations, and to adapt himself to his environment. This latter matter can be approached most practically by dealing with the consecutive statement, for example, of the different positions which the patient has occupied, what caused him to take up the work in each instance, what the wages were that were paid him, whether he was advanced or remained at a relatively low wage for a considerable length of time, how long he remained employed in each position, and how he came to leave it. Such a record is not infrequently illuminating as showing, for example, marked lack of continuity, an inability to stick to any given line of conduct, with incapacity for attaining any considerable efficiency in his work. It may show also, in the reasons which are elicited for changes in occupation, the controlling character traits which make for relative inefficiency, whether he is aggressive or passive, whether he is creative and has initiative, or merely follows, or whether he is controlled by impulse. Such a history should also take account of any special character traits, particularly dominant moods, feelings of inefficiency, or attitudes of excessive optimism. It should show also the capacity for making friends, in other words, for coming into efficient contact with his fellows. As bearing upon these character traits the sexual life is often illuminating as showing perhaps tendencies to seclusiveness, to being shut-in, masturbation, autoerotic phantasies, and the like which interfere with an efficient relation to reality.

It is important here to inquire into the feeling attitude of the individual toward the various members of the family, particularly the father, the mother, and the brothers and sisters, or those who stand as surrogates for these individuals, as for example, if the patient has been brought up by an older sister or an aunt or a grandmother. Recent psychological studies have indicated that the tendencies which show themselves very early in life in relation to the immediate members of the family, are often the controlling ones in shaping the future course of the feelings in the individual, and it is not uncommon to find the patient reproducing in his psychosis events in the life of some member of his family, for example developing a psychogenic paralysis which is similar in its outward manifestations to the paralysis from which his father suffered. Such signs should be carefully looked into for their meaning in the emotional orientation of the patient. The question of make-up of the individual is of great importance as showing the kind of person in whom the reaction under investigation took place and if sufficient facts are available this make-up will fit intimately into the history of the onset and expression of the psychosis, showing how the latter logically grew out of the former.

Present Illness.—This should be gone into in great detail. All of the circumstances surrounding the date of onset should be inquired into carefully, whether these circumstances be primarily physical or mental in nature. No circumstance at this period should be considered unimportant. The presence of disorders of the sensorium and of delusions of course should be observed, but the examination should not stop with merely recording them, but an effort should be made to understand their meaning in the whole picture. What do the voices say to the patient? Who are they that are talking? What are the delusional beliefs? These very often show clearly the nature of the particular conflict which the psychosis is expressing. Suicidal and homicidal tendencies are important to work out for the practical handling of the case, and the degree of insight is also important as indicating the degree to which the patient may be influenced by practical considerations. If no history is available from other sources than the patient he should be asked frankly what the matter is with him from his point of view. If he has been committed he should be asked why, what it is that he has done that has made other people think that he was suffering from mental disease, and if he thinks people have been persecuting him or making disagreeable remarks about him he should be asked for a frank statement as to who these people are and why he thinks they are interested in doing him an injury. A simple and straightforward approach of this sort will place the patient in an attitude of confidence toward the examiner which will help to make him accessible.

General Observations.—General observation of the patient is of course important. One should not be limited in the examination merely to what the patient says, but should observe carefully how he acts and appears, whether he appears silly, resentful, or indifferent, whether he has mannerisms, etc., the general expression of his face, and the attitude of the body and the way in which he reacts to questions and to emotional situations, such for example, as might be presumed to produce sadness or laughter. These outward evidences of what is going on within are of course relatively most important with patients who are not very accessible.

General Physical Examination.—This should include a full and complete examination, recording the height and weight, general condition of nutrition, presence of scars, condition of the respiratory, circulatory, genitourinary, gastrointestinal, and glandular systems. This may of course involve the necessity of the analysis of varions secretions, particularly the urine and perhaps also of the stomach contents, with an examination of the blood (Wassermann reaction, if indicated) and of the sputum (if indicated).

Neurological Examination.—This should include a general description of any hypertrophies and atrophies, the condition of the voluntary move-

ments as to freedom, accuracy, limitations, and of involuntary movements such as rigidity, tremor, spasms, convulsions, etc. The reflexes should be recorded, the presence of nerve trunk sensitiveness noted, as also tender areas, especially along the vertebræ and in the region of the breasts or the ovaries. Ordinary tests for coordination should be carried out, such as the approximation of the fingers, finger to the nose, knee to the heel, and station with eyes open and closed, and gait. An examination of the sensorium should be conducted sufficient to note the presence of any abnormalities, such as anesthesias, hyperesthesias, and disturbances of the sense of position or feeling of reality, for the presence of pain or disorder of the organic senses, paresthesia, etc. The cranial nerves should receive sufficient attention seriatim to discover any pathological conditions. Disturbances of smell, hemiopia, eye palsies, pupillary irregularities, disturbance of pupillary reflexes, facial asymmetries, taste, disturbances of hearing, swallowing, etc.

Mental Examination.—The mental examination should include an examination of the *orientation* as to time, place and persons; of the *general memory*, tested with reference to such matters as the memory regarding the different members of the family, school knowledge, occupations, marriage, children, diseases; *emotions*, presence of depressions, exaltations, indifference, insight; the *sensorium*, including the presence of abnormal sensations, paresthesiæ, hallucinations, illusions; *speech*, voluntary speech, naming objects, and writing. The patient may be asked to write his name and the date and such words as the United States of America, the Commonwealth of Massachusetts; auditory and visual language perception may be examined for as a part of the examination for aphasia; test words and phrases, particularly useful in examining patients for paresis may be given, such as statistical, perturbation, third Riding Artillery Brigade.

Stories.—These stories may be either told to the patient, read to the patient, or the patient permitted to read them. Then he is asked to repeat them from memory. This shows in a rough way the quality of attention and points of interest, the tendency to forget, to elaborate forgotten details, to decorate the story with inventive additions, to lay stress upon the emotional elements, the ability or failure to see the point, and the like.

Cowboy Story.—A cowboy from Arizona went to San Francisco with his dog, which he left at a dealer's while he purchased a new suit of clothes. Dressed finely, he went to the dog, whistled to him, called him by name and patted him. But the dog would have nothing to do with him in his new hat and coat but gave a mournful howl. Coaxing was of no effect, so the cowboy went away and donned his old garments, whereupon the dog immediately showed his wild joy on seeing his master as he thought he ought to be.

Gilded Boy Story.—It is related that at the coronation of one of the popes about 300 years ago a little boy was chosen to act the part of an angel; and in order that his appearance might be as gorgeous as possible he was covered from head to foot with a coating of gold foil. He was soon taken sick and although every known means was employed for his recovery, except the removal of his fatal golden covering, he died in a few hours.

Polar Bear Story.—A female polar bear with two cubs was pursued by sailors over an ice field. She urged her cubs forward by running before them, and as it were, begging them to come on, At last in dread of their capture she pushed, then carried and pitched each before her, until they actually escaped. The polar bear is a wonderful swimmer and diver. In the capture of seals lying on the ice, it dives some distance off and swimming underneath the water, suddenly comes up close to the seals, cutting off their retreat to the sea.

Good Girl Story.—Once upon a time there was a girl, whose father and mother were dead, and who was so poor that finally she had nothing but the clothes on her back and a little piece of bread in her hand. She was deserted by everybody, but since she was good and honest she went into the world with confidence in God. As she went along she was met by a poor old man who said "Give me something to eat, I am hungry." The girl gave him the piece of bread and went on farther. Soon afterward she encountered a little girl freezing and almost naked, who begged for clothes. The good girl gave the poor child the warmest of her garments. Night came on, the good girl was tired, cold, and hungry. She traveled into the woods, and, wandering off the road, she knelt and prayed to God. As she knelt she saw the stars falling all about her, and when she looked she found they were many bright gold dollars. (Adapted from Ziehen.)

Shark Story.—The son of a governor of Indiana was first officer on an Oriental steamer. When in the Indian Ocean the boat was overtaken by a typhoon and was violently tossed about. The officer was suddenly thrown overboard. A life preserver was thrown to him, but, on account of the heavy sea, difficulty was encountered in launching a boat. The crew, however, rushed to the side of the vessel to keep him in sight, but before their shuddering eyes the unlucky young man was grasped by one of the sharks encircling the steamer and was drawn under the water, leaving only a dark streak of blood. (Adapted from Ziehen.)

Special Memory.—Such questions may be asked as the date of the Civil War; name of two generals; three European countries; capital of native State; President; to recall the following numbers repeated singly, 45319628; 35984271; 487631; 955217; 7368; 9826; 487; 352; 375 Oxford Street (after three or five minutes).

Masselon Test.—Patient is asked to form sentences containing the following groups of words: hunter, dog, gun, forest, rabbit; man, wood, coal, stove, dinner; needle, thread, button, vest; pipe, match, smoke; pen, ink, letter.

Ziehen Test.—The patient is asked to explain the differences between the following contrasted objects: horse and ox; dwarf and child; lie and mistake; water and ice.

Mathematical Tests.—The following mathematical problems may be given to show the ability of the patient to keep his mind fixed a sufficient length of time upon simple matters: 7×6; $56 - 18$; $23 - 14$; $81 - 9$; $X - 5 = 17$; $X - 8 = 13$; have fifty cents; buy cherries twelve cents, butter seven cents, bread ten cents, how much change?

Forward and Backward Association.—Month; days of week; 752186, 35729, 6418, 265, 497.

General Information.—Cost of postage; color of stamps; holidays and meaning. (Christmas, Easter, Fourth of July).

Finchk Test.—Patient is asked to explain the following: "The early bird catches the worm;" "Lies have short legs;" "Set a thief to catch a thief;" "Burn a candle at both ends."

Ebbinghaus Test.—This consists of having the patient complete a sentence in which certain words have been left out such as: I got up in the . . . ., and after washing my . . . went to . . . Or better often is Ziehen's modification of this test. The patient is asked to complete such a sentence as this: If it rains . . . . because . . . . in spite of . . .

Bourdon Test.—This is very valuable as a measure of attention. It consists of getting the patient to strike out certain recurring letters or numbers in a standard page and timing the result. A similar test

is the tapping test—timing the number of taps that can be made in a given time, say thirty seconds.

Ethical questions may be asked such as, What would you do if you saw a man drop a ten dollar bill on the sidewalk?

The above tests of course are more or less arbitrary, and necessarily might have to be very largely modified to suit various conditions of education and the several nationalities.

Psychoanalysis.—Most of the above tests are intelligence tests and deal with the individual at a relatively high level. Recent psychological investigations indicate that we must go much deeper in order to find the real motives for conduct, and these may be approached by the methods af psychoanalysis. The reader is referred elsewhere for a description of these methods, suffice it to say at this point that it is always well to ask the patient for an account of one or two recent *dreams*, for even without very much knowledge of psychoanalytic technique it may often be quite possible to see meanings in the dreams which may throw light upon the situation.

Malingering.—An extensive and detailed account of methods of examination to detect malingerers is not in place here. It is desirable, however, to caution against hasty generalizations. Because a patient may lie is no reason there is nothing the matter with him. Some of the psychoses, particularly such an one as paraphrenia confabulans, is marked by a tendency which might well be called lying, while pseudologia phantastica is a term given to describe chronic liars who are a little more fantastic than the average. The study of the mechanism of lying indicates that it is an ineffectual attempt at squaring with the facts of reality and is an attempt which indicates an underlying weakness. The consideration of a patient, therefore, should never be dismissed with the diagnosis that he is lying as soon as that fact is discovered. It is merely giving a name to something without going any further and it would have no more significance for the understanding of the phenomena than saying that a patient is crazy has significance for the understanding of his symptoms. An attempt should be made to understand what the meaning of the lie is and why it is used. It is an abnormal method of reaction and must have some adequate explanation. The importance of taking this viewpoint is seen when we realize that some people go so far as to say that every patient who malingers is necessarily suffering from a mental disease. While this seems to be extreme, it is practically true in my experience. The mere presence, therefore, of a tendency to lie is *prima facie* evidence of an abnormal mentality.

Examination of Stuporous Cases. *General Attitude.*—Position of body: sitting, lying—on back, side, face; disposition of limbs; evidence of paralysis—hemiplegia, facial, ocular; voluntary musculature—flaccid, contractured; evidence of catatonic rigidity tremors. *Face:* expression—changeable or fixed, mask-like pained; grimacing—Schnauzkrampf; position of eye balls—rolled up under lid. *Reflexes:* Superficial and deep. Compare two sides. Pupillary; winking; tickling. *Reactions:* Can the patient be brought to maintain a position requiring volitional control? Does the patient voluntarily correct uncomfortable positions? Does the patient show any emotional (expressive, vasomotor, circulatory, respiratory) response to bad news, jokes? Do patient's eyes follow examiner? Does patient take food? Are his actions the same when apparently not observed as when under observation? Does patient respond to calls of nature? Does he retain saliva? Drooling? Are there any spontaneous acts? Why?

Such an examination as indicatedabove ought to enable one to, so to speak, reconstruct the psychosis, that is enable one to see how each step in the formation of the diseased reaction led logically from what preceded.

Having determined the pathological manifestations in the individual case it becomes desirable to group them under some designating caption. It must be understood, however, that the name of a so-called mental disease means nothing further than a signification of the general group in which it belongs, because of the particular type of reaction which it more especially displays. The names are only matters of convenience for designation and should never be permitted to obsess as they sometimes do. The following is a classification of the groups of reaction types which are deemed sufficiently well defined to warrant inclusion in a classification of mental diseases.

I. Infection-exhaustion Psychosis.—Owing to the difficulty of determining in many cases at what point the abnormal mental symptoms due to the infective process cease, and those due secondarily to the exhaustion resultant upon the infection begin, it seems desirable to use the broader term infection-exhaustion. In many instances it will be difficult or even impossible, to be more specific, yet certain quite definite clinical types are recognizable. Likewise it is difficult to separate in every instance the psychosis as associated etiologically with the fever or the infection itself and its consequent secondary exhaustion. We may, however, recognize clinically some fairly well defined forms:

1. *Febrile Psychosis.*—In certain instances the mental symptoms develop quite clearly in connection with the fever. Such is often the case in typhoid fever, erysipelas, acute articular rheumatism, scarlet fever, smallpox, malaria, cholera and septic diseases. The psychosis may develop at the onset of the fever, when it has reached the fastigium, or during the period of defervescence.

2. *Infection Psychosis.*—Here the mental symptoms may develop more closely in association with the infective process during a comparatively non-febrile period. They may be manifested clinically in epileptiform excitements, twilight states, hallucinatory and catatonic conditions, etc. Here too should be included the acute infections having a specific localization in the central nervous system, such as suppurative and tuberculous meningitis, hydrophobia, chorea minor, etc.

3. *Acute Confusional Psychosis.*—The so-called amentia of Meynert. This term is used to designate fairly definite symptom complexes, while the terms acute confusion, confusional state, etc., are reserved to characterize less definite conditions dependent possibly upon various etiologic moments, usually but vaguely determinable and therefore included in a subgroup under the general heading "Undifferentiated Psychosis" (see XVI).

4. *Symptomatic Psychosis.*—The foregoing subgroups are in a sense symptomatic psychoses but it is desirable to retain this term to characterize those mental disorders manifested as episodes of excitement, depression, delirium, etc., which develop more closely in relation with general or constitutional disorders and diseases of the internal organs. Here we have the cachectic and anemic conditions due to carcinoma, etc., and psychoses symptomatic of cardiac disease, uremia, diabetes, gastrointestinal disease, etc.

II. Toxic Psychosis.—Including such as are not due to agencies of the nature of those already included under the above. It is here to be borne in mind that the toxemia often leads to a condition of exhaustion. This, though it may modify the symptomatology, is really but secondary. To employ an additional term to cover this factor, *e.g.* toxic-exhaustive, is undesirable.

1. *Thyreogenic Psychosis.*—(*a*) Myxedematous. (*b*) Exophthalmic.

2. *Alcoholic Psychosis.*—A general term for such cases where though recognized that alcohol is the etiological agent in the production of the psychosis,

yet for various reasons its type cannot be stated. An attempt should be made in every instance to indicate the clinical type.

Among the alcoholic psychoses the more definite clinically recognizable types are: (*a*) Pathologic drunkenness. Psychotic states appearing in close association with acute intoxication and of very short duration. (*b*) Delirium tremens. (*c*) Acute alcoholic hallucinosis. (*d*) Chronic alcoholic hallucinosis. (*e*) Korsakow's psychosis. (*f*) Alcoholic deterioration. The term deterioration is here used to express an acquired defect not necessarily predominantly involving the intellectual sphere. (*g*) Alcoholic pseudoparesis. (*h*) Alcoholic paranoid states. The acute delusional paranoid state as well as Eifersuchswahn are included within the meaning of this term.

3. (*Other*) *Toxic Psychoses.* (Not included in the foregoing.)—Under this general heading, toxic psychosis are included psychoses due to drugs, as morphine, cocaine, bromine, etc., lead, gas, (carbon monoxide, etc.) and foods (ptomaine, pellagra, etc.).

III. Psychoses Associated with Organic Brain Disease.—1. *Chronic progressive chorea* (Huntington). 2. *Sclerosis, multiple.* 3. *Arteriasclerosis, cerebral.*—The psychoses associated with cerebral vascular changes present themselves in several clinical forms which often may be diagnosticated *intra vitam* with a fair degree of certainty. Among these the better recognized may be included under the following subheadings.

(*a*) Deterioration.—A more or less generalized vascular disease of the cerebral arteries associated with a lacunar demential process. As an especial type of "a" we find the group of postapoplectic deteriorations. These may be associated with various paralyses and other neurologic disturbances. (*b*) Paranoid state. (*c*) Excitement. (*d*) Depression.

4. *Brain Syphilis.*—The mental symptoms associated with syphilitic lesions of the brain are varied but possibly clinically there are symptomatologic groupings which may be well differentiated as follows: (*a*) Neurasthenic type. (*b*) Manic or depressed type. (*c*) Paranoid type. (*d*) Deteriorating type. (*e*) Pseudo-paretic type.

5. *Neoplasm.*—(Benign or malignant.)

IV. Traumatic Psychosis.—The term should not be employed to characterize such mental states as are produced by injury other than to the head or where this head trauma has merely been an etiologic factor in the precipitation of another definite psychosis, such as paresis, dementia precox, etc.

Clinically we recognize: a 1. *Past traumatic delirium.* 2. *Past traumatic constitutian.*—An acquired generalized defect of psychopathic character. 3. *Post traumatic deterioration.*—Often accompanied by many evidences of focal lesion such as aphasia, epilepsy, etc.

V. Paresis.—1. *Adult form.* 2. *Juvenile form.* 3. *Tabetic form* (*i.e.* taboparesis).

VI. Presenile and Senile Psychosis.—These are often associated with a physiologic senility, possibly somewhat premature. They need especially to be differentiated from those mentally abnormal conditions associated with arteriosclerosis. Age alone is not to be taken as the sole criterion, some senile psychoses, *e.g.* Alzheimer's Disease, may have their onset in the fourth decade, while certain of Kraepelin's presenile psychoses may not appear until the sixth. Although probably always associated in some degree with a demential process, all senile psychoses are not necessarily senile dementias. The predominance in some cases of certain symptom-complexes makes it advisable to differentiate where possible, certain clinical types of which the following are more common: 1. *Simple deteriorating type, or senile dementia.* 2. *Presbyophrenic type.*—Presenting a symptom complex similar to Korsakoff's psychosis. 3. *Confusional type.* 4. *Depressive type.* 5. *Paranoid type.* 6. *Excited type.*

VII. Dementia Precox.—1. *Hebephrenic form.* 2. *Catatonic form.* 3. *Paranoid form.* 4. *Simple form.* This term will include abortive, heboidoform, forme fruste, etc.

VIII. Paraphrenia.—This is a term that has recently been given new life by Kraepelin in the eighth edition of his work. Under it he provisionally includes certain cases for purposes of more accurate delimitation.

1. *Systematica.*—This practically includes Magnan's delire chronique, except that well defined precox deteriorations are not included.

2. *Expansiva.*—This form is found only in women and is marked especially by the development of ideas of grandeur, with mild exaltation.

3. *Confabulans.*—Here the delusional system, presenting both persecutory and grandiose components, has its foundation in memory falsifications.

4. *Phantastica.*—In this group the patient shows a moderate degree of exaltation and a tendency to the recounting of remarkable adventures.

IX. Paranoia.

X. Manic-depressive Psychosis.—1. *Manic phase.* 2. *Depressive phase* 3. *Mixed type.* 4. *Circular and Alternating types.* 5. *Cyclothymia.*

XI. Involutional Melancholia.—Many of these cases are manic-depressive psychosis; others should be included in the presenile group.

XII. Depression.—Other than that of manic-depressive psychosis, other depressive states, *e.g.* those occurring in senile psychosis, etc., or depressions not otherwise accounted for. 1. *Simple.* 2. *Psychogenic.* 3. *Hallucinatary.*—Depression, generally of acute onset, with hallucinations (usually auditory) prominent, without clouding of consciousness, the emotional state being one of anxiety or fear. Toxic, infective, or exhaustive features are not demonstrable as etiological factors.

XIII. Neurosis and Psychoneurosis.—This term to include the psychasthenia of Janet and more specifically—1. *Neurasthenia.* 2. *Anxiety neurosis.* 3. *Compulsion neurasis.* 4. *Hysteria.* 5. *Anxiety hysteria.*

XIV. Psychosis Associated with Epilepsy.—Epilepsy is not invariably associated with the occurrence of abnormal mental symptoms and should not be made a mental diagnosis. Associated with epilepsy the more common clinically observed mental abnormalities may be grouped as follows: 1. *Deterioration.* 2. *Excitement* (with or without hallucinations). 3. *Delirium.* 4. *Twilight states* (Dämmerzustände), dream or dazed states.

The other epilepsies such as hysteroid, senile, alcoholic, arteriosclerotic, should be classed under the psychosis of which they are only an especial symptom.

XV. Defective States.—Under this general heading are included a number of inborn defective conditions differing essentially in degree only, therefore merging one into the other in such a way that separation is often a matter of great uncertainty. However along general lines some degree of differentiation is possible and of practical value.

1. *Constitutional Psychopathy.*—More or less ill-balanced individuals usually intellectually bright but with twists or perversions in their mental make-up, commonly referred to as psychopathic personalities, or as exhibiting a constitutional psychopathic state. We have here to especially recognize that we are dealing with persons whose mental organization appears asymmetrical because of excess or diminution of development in one or another direction.

2. *Constitutional Inferiority.*—In comparison with the above we have a more general and uniform deficit in mental endowment and a noticeable restriction of the intellectual capacity. Developing upon the soil of mental instability, more frequently in the constitutionally psychopathic than the constitutionally inferior, we have episodic excitements, depressions, paranoid states, hallucinatory attacks, etc., which are advisedly recognized as a psychosis of degeneracy.

3. *Psychosis of Degeneracy. (a) Prison Psychosis.*—A psychotic state developing in a degenerative individual, which is to be looked upon merely as an abnormal mental reaction to an especial situation and its attendant environmental conditions.

4. *Imbecility and Idiocy.*—The transition is gradual from the constitutionally inferior to the feeble-minded, moron, imbecile and idiot. The latter two include the coarser grades of defect which render the person dependent because of unfitness for any occupation excepting possibly the simplest kind of labor under direction. The grosser defects may be clasified under the following types: 1. *Amaurotic family idiocy;* 2. *Thyroigenous;* 3. *Hydrocephalic;* 4. *Microcephalic;* 5. *Paralytic;* 6. *Epileptic;* 7. *Traumatic;* 8. *Sensorial;* 9. *Inflammatory;* 10. *Sclerotic;* 11. *Syphilitic;* 12. *Mongolism.*

XVI. Undifferentiated Psychosis.—This term may be employed where the amount of data obtained by customarily complete routine examination is still insufficient to permit of a classification under any of the above types. However, in many of these cases, it will be possible to make a symptomatological diagnosis, although such symptoms are not enough to clearly establish the disease entity of which they are a part. Thus while the psychosis cannot be further differentiated, we may yet recognize: 1. *Dementia:* 2. *Excitement;* 3. *Depression;* 4. *Confusional state;* 5. *Paranoid state.*

XVII. Unclassified Psychosis.—In many cases the information available is entirely inadequate and no definite conclusion can be reached. These cases comprise a class which, because of the incomplete records, are of little psychiatric value and may be disposed of under this heading.

XVIII. Miscellaneous.—Those mental disturbances which for various reasons cannot conveniently be grouped under any of the types mentioned but which do not belong in the unclassified or undifferentiated groups, for example postoperative, etc., may be included here.

William A. White.

Mental Diseases, Etiology.—In considering the etiology of a given case of insanity, only too often do we mingle cause and effect, thereby confusing ourselves and spreading false impressions among the laity. It is a daily occurrence to hear both the physician and the family speaking of the cessation of the menses as the actual cause of the alienation of some young woman, whereas in reality such cessation is only one of many somatic symptoms that may accompany the mental affection, the psychical and bodily manifestations proceeding *pari passu* under a general storm-cloud, that involves every cell and fiber of the body in varying degree. Surely then we should look deeper before ascribing to a single minor physical symptom the dignity of the entire upheaval. It might be approaching a little nearer to the truth to attribute such disturbances to the hemic depravity which is so frequently present in such instances, but how much better to explore more fully the, now hidden, pathogenic fields that induce the anemia itself.

The etiology of mental affections in very numerous instances is obscure, reaching back through the protoplasm of the fetus and the tissues of the mother and father, to those of preceding generations unto the third and fourth degree—and even beyond. Such predisposing causes do not, however, exist in each and every instance of alienation. An individual starting with a healthy mind in a healthy body may also become the victim of a mental disturbance should he violate the laws of nature to such a degree as to overset the nervous equilibrium, or should he have the misfortune to meet with a cerebral trauma, or to admit into his system a toxin, be it of syphilis or of some acute disease, in sufficient quantity to overcome the normal tissue resistance.

Again, in another series of cases, persons who have inherited only a moderate degree of stability, but who, owing to favorable environment and education, have been able to pass successfully through the minor trials of the struggle for existence which are common to all mankind, may nevertheless fall victims to mental disturbances when some unusual stress is laid upon them, either in the way of intense and prolonged intellectual strain, a shock, corporeal or psychical, or as a result of tissue changes induced by acute toxemia or prolonged cachexia.

Briefly, then, it may be said that the main causes of insanity are twofold—direct and indirect. In many instances these may be and frequently are commingled, rendering a clean-cut differential etiology difficult and sometimes impossible to determine.

Inasmuch as the far-reaching effects of neuropathic ancestry in its widest sense are of greater importance then the direct causes of vesaniæ, we will first consider the former, remembering always that the two are very frequently blended in the same individual.

Predisposing Causes.—*Heredity.*—The carrying-over from an ascendant to a descendant of the marks of a corporeal degeneration, such as webbed fingers or a deformed hard palate, is recognized and termed a stigma of degeneration. Were the marks of mental infirmity as clearly defined, much difficulty would be spared the alienist in the comprehension of mental deficiencies. Unfortunately such is not the case. For although the grosser defects of the mind, as they exist in the idiot and the lower grades of imbecility, are as unmistakable as those we are apt to regard as more strictly corporeal, the gradations between the mental level of the hopeless imbecile up to that of normal man are innumerable and varying for each individual, and when these deficiencies appear, for example, merely in a lowered standard of ethical conduct, in a passionate disposition, or in an inability to reason quite as logically as the majority of mankind upon an abstruse subject, one can readily see how extremely difficult it is for the physician to pronounce definitely upon the mental condition of a person who shows such slight departures from normal mentalization.

Statistics of *heredity* among the insane differ according to the locality from which they are taken—varying from ten to ninety per cent. Much depends upon the nationality and consanguinity of a community, as well as certain local conditions, as, for instance, the prevalence of drunkenness, of an insufficient or improper quality of the food supply, of syphilis, of extremes of heat and cold, and other changing factors.

Except in rare instances there is no direct inheritance of insanity—that is to say, the children are not born insane; it is only that the protoplasm is tainted with seeds that, under favorable circumstances, may at some future time grow and bear blighted fruit in the form of a psychosis. Under proper precautions in the way of education and environment such a development may not occur at all, and the man or woman may pass through life with his or her mental faculties performing their functions in an average normal manner.

In fact, in mental disorders we have an heredity analogous to that of tuberculosis. The child of consumptive parents does not necessarily develop

the disease, but if exposed to injurious surroundings which lower the general vitality, as insufficient breathing space tainted with the effluvia of human lung exhalations, it falls a victim to the disease more readily than one who has inherited more resistant tissues. In the psychoneurotic, as generation succeeds generation and there is no admixture of sounder strains, the tendency toward imperfect mental development becomes more and more accentuated, psychical maladies in the family become ever more frequent, until the lowest forms of mental infirmity appear and the house becomes extinct. An admixture of purer blood always has the tendency to correct both mental and psychical deficiencies and to induce a return to the standard level. When both mother and father are defective mentally, especially when there is consanguinity, the prospects for a perfect mentality in the children are ominous. When one parent is sound mentally, while the other is defective, a fixed proportion of the offspring is always feeble minded.

There is a curious law of inheritance, the passing over by a mental disorder of the second generation and its reappearance in the third—the so-called *atavismus*. Again, we frequently see insanity in a collateral progenitor—an aunt or uncle for example—reappear in the nephew or niece, though the father or mother may have shown no tendency thereto. Only rarely, however, does the same form of psychosis reappear in the children as existed in the forebears direct or indirect. As a rule transmutations take place, and a state of pathological depression in an ascendant may develop as a morbid excitement or early dementia in the offspring of the house.

Exceptions to this alteration of the character of the alienation are now and then noted. I have met with a paranoia which had developed through three successive generations, and among the frequent periodic insanities the identical form of malady may appear for generation after generation. In these instances it is always probable that the psychosis will come on at an earlier and earlier age until some of the grave forms of pubescent or adolescent insanity appear—in other words, the vital protoplasm becomes lower and lower and less capable of standing the strains of education as well as the duties and cares of daily life.

Suicide.—A suicidal tendency may appear in neuropathic families as the equivalent of a psychosis or replace it. Usually, however, there will have been some previous indication of mental perversion preceding the event, and most often this has taken the form of a more or less pronounced melancholia. Not long ago I treated a neurotic individual whose three aunts, an uncle, and father had all committed suicide at about the same age, and in the generations back were histories of neuroses, deaf-mutism, and individual peculiarities, with tendencies to melancholia. The descendants of hysterical, epileptic, neurasthenic, and eccentric parents always show a larger proportion of examples of insanity than those with a good family history. The former start in life with a defective cytoplasm, and when the environment is suitable the soil produces a crop of poisonous weeds. Such nervously deficient parents are apt to have children who are degenerates in the matter of moral tone, eccentric beings standing apart from the mass of their fellows, who at a later age show sexual perversions, criminal propensities, and are in constant conflict with the existing order of things, and under any unusual strain become victims of a psychosis.

Alcohol and Heredity.—Perhaps the most frequent cause of mental degeneration in the descendant is alcoholism on the part of one or both parents. The abuse of alcohol induces definite and pronounced tissue alterations, not confined to but most noticeable in the nervous and vascular systems. As a result the children of such progenitors are ever prone to epilepsy, hysteria, and grave mental maladies, and should the tendency increase in succeeding generations to a pronounced degree, the family soon dies out. Drunkenness on the part of both parents at the moment of copulation is one of the most certain causes of idiocy.

In the family of a drunkard, where there are a number of children, it is often observed that the first ones are mentally sound, while the later arrivals, after the drink habit has been confirmed, are less and less apt, and if the abuse becomes aggravated the youngest members of the family are not merely deficient in mental and physical capacity, but are actually imbeciles or idiots.

There are many notable exceptions to this rule. Owing to especial or exceptional circumstances, one child may stand forth prominently in the family by reason of his mental endowments, while all the others may be defective. As Griesinger long ago observed, genius and idiocy go hand-in-hand, and after all genius is but a one-sided psychical development, as is notably illustrated in the family history of the poet Byron, with his insane and suicidal ancestry, and his own tendency toward psychopathy.

The cheapening and accessibility of spirituous liquors in recent times are undoubtedly largely responsible for a certain proportion of the recent increase in insanity, and should their sale remain unrestricted by suitable legislation, mainly by increasing the price, by taxation, to such a degree as to render the abuse impossible by the average man, we may in the future expect to see a still more alarming augmentation of the lunacy evil. Unfortunately, also, other tissue-degrading drugs that act practically in the same way as the alcohols have in recent times been brought into extensive use. Degrade the vitality of the cell protoplasm of the ancestor, and as a logical sequence that of the descendant must also suffer—a dictum that applies not only to the effects of drugs, but also to those of syphilis, tuberculosis, severe febrile affections, sexual, corporeal, as well as psychical excesses, and a whole host of other debilitating influences.

In the psychiatrical clinic, one quickly learns to recognize the hereditary degenerative forms of insanity by the presence of certain characteristics. Thus we note the frequent onset at the time of adolescence, the periodical return of the psychosis, the tendency to impulsive acts or to stupor, the outbreaks of active insanity when any unusual strain, as in childbirth, is laid upon the person, or even when the system is deranged by a minor physiological function, such as the menses. These factors in the hereditarily burdened only too often suffice to bring about abnormal depression, hallucinatory excitement, profound stupor, or alternations of the one with the other.

Education.—This term as used here in its broader sense refers not alone to book-learning or technical training but to all the multitudinous and varied influences that surround the child *ab incunabulis*. Almost from birth the infant begins to receive and acquire impressions of various kinds, their complexity increasing as time goes on. In the earlier years of childhood the growing mind and body are susceptible to influences that later on would make no impression upon the organism. The judgment is not formed, reasoning is carried on in an imperfect manner; yet the soil is fertile and easily cultivated, and the impressions received are much more vivid than at a later date. According to the tilling it receives the ground may bear either weeds or precious grain.

Except in rare instances, in which hereditary tendencies are too strong to be successfully combated, if the young child is ruled with a systematic, firm, though gentle hand; if natural tendencies to evil are repressed by wise correction and proper reward, while at the same time suitable attention is paid to diet and hygiene, there can be no doubt that by the indrilling of correct principles a great

deal may be done to overcome hereditary neuropathic tendencies. But that education may have a lasting effect, these children must be taken from the time that the earliest permanent impressions are recorded on their brain cells, and such surveillance must not cease until adolescence is attained.

On the other hand, if a child, the offspring of insane or neurotic parents, be submitted to the usual course of training; if, as not infrequently happens, especially among the poorer classes, he be allowed to grow up with little or no moral or home teaching; if he be subjected to the brutalities of an intemperate father or to the perpetual irritation arising from a fretful, ill-tempered, or neurotic mother, the results can readily be prophesied; the force of constant surrounding and example must inevitably obtain. To these perverting influences upon the mind are often added an unsuitable diet, a total lack of hygiene, ill-ventilated rooms, and insufficient clothing.

In the case of those of better social standing other factors have to be considered. Many hereditarily unstable children are precocious, impulsive, irritable, and difficult to control. Too often the weak mother either neglects them or humors and pampers them in every way, and yields even when the exercise of a firm hand is of the utmost importance. As a natural result the children become wayward, emotional, without will power, and as they advance in years give way to license and self-indulgence. After a course of excesses in social pleasures, or in *venere et baccho*, which their undeveloped nervous systems are unable to withstand, many of these unstable minds fall by the wayside during adolescence.

Furthermore, even although the neuropathic children may have received a good home training and have been taught to control their passions and instincts, when they arrive at the school age a new danger awaits them. One of the crimes of our American system of public school education, which still obtains, is the grouping of large classes of children together with but little or no recognition of their natural individual mental capacity, physical vigor or infirmities, and ancestral tendencies. The bright ones are incited to continuous effort by varied stimuli, the dullards are goaded to exertions beyond their capacity. Many of the children of highly neurotic parents are intelligent, but have little reserve force, and when this premature forcing of their intellectual powers is laid upon them, they respond for a time with all their ability, but at the cost of their physical health. Should the danger signals, such as listlessness, irritability, and emotional outbursts be overlooked or misinterpreted, for a time the victims may still answer to additional stimuli, supplied by the vanity of parents and teachers, but sooner or later they collapse and become mental and physical wrecks. Recuperation in such instances is most difficult, and no amount of care on the part of physician or parents can fully overcome the lost freshness of psychic vigor. In later life they become neurasthenics, weak and deficient in nerve force, or fall a ready prey to some of the many forms of psychosis upon a constitutional basis.

Give the children plenty of open-air amusements with playmates of their own age, under suitable supervision; let them have plenty of food, not too stimulating; give them few hours of confinement in close school-rooms, and psychoneurotic ailments will much decrease in frequency. On the other hand, the running wild on the streets, the companionship of vicious children of older age, the forcing of the sexual proclivities in unnatural ways, by bad example, all tend to the evolution of a morbid nervous system.

The close crowding into cities, replete with all forms of vice, in recent years has also had much to do with the more frequent development of asthenic nerves and criminality.

Masturbation about the age of puberty is frequent among the hereditarily weak; if habitually practised for any length of time it tends to induce anemic and neurasthenic conditions. Although rarely the sole direct cause of alienation, its effects upon the undeveloped nervous system are always debilitating. Again, in addition to the physical harm there is the bad moral influence, the feeling of guilt, the constant fear of discovery, the tendency to avoid the society of others, to brooding, and to the neglect of wholesome exercise.

Civilization.—It is an undoubted fact that insanity is far more frequent and shows a steadier increase in civilized than in uncivilized countries. In England one individual in every two hundred and eighty is insane, and in the more densely populated States of the Union, as in New York, very similar figures are reached. The life of the savage is free from the cares that weigh upon the educated man; he takes no thought for the morrow, his necessities are not complex, and he is free from the multitudinous petty worries that besiege the civilization of the present era. Unless in contact with the white man he is not syphilized, alcoholized, or subject to the ravages of tuberculosis; he lives a life of freedom in the open air, his actual wants are few; he has no intellectual excesses. That civilized man is provided with better clothing, that he has more constant supplies of food, and in the cold seasons enjoys better hygienic surroundings can only to a small extent make up for the increased mental strain and the various detrimental physical conditions to which he is exposed.

Three main factors contribute to the increase in insanity among civilized nations—the constant struggle for a competence, which is daily growing more severe, the increasing frequency of the abuse of alcohol, the spread of syphilis, all of which act with especial violence upon the brain of such individuals as are hereditary weaklings.

Nationality.—It is somewhat doubtful if under similar conditions individuals of one nationality are more susceptible to insanity than those of another, and in this connection statistics are often misleading. Thus, for example, we find that the association of cretinism and goiter with mental incapacity is very common in certain of the Swiss and Tyrolean valleys. But although in a general count of the entire population of these districts alienation would thereby be considerably augmented, in other portions of the same country, not influenced by similar telluric conditions, there would be only the average number of insane. Under conditions in which the burden of life is brought to bear with unaccustomed violence upon the members of any race, as for instance the Irish who have emigrated to this country, or the Russian Jews who have been driven from their homes and obliged to start afresh in the world under unaccustomed conditions, the proportion of insane individuals is extremely high, though in their own land it may not be above the average.

In both of these races we may note an exception to the above general statement that the disposition to psychoses is about the same for the several races, in so far that with these there is a certain instability of the nerve elements that render them ready victims when the stress of life falls too heavily upon them. Again, our American negroes afford a striking example of the baneful results of altered conditions. Before the Civil War there were few or no psychoses among them, and such organic degenerative diseases as syphilitic insanity and dementia paralytica were practically unknown. To-day in communities where many are collected, as in Washington or Baltimore, the percentage of insane negroes, not to mention idiots and imbeciles, is already fully up to that of the Caucasian races with whom they are associated, and bids fair to surpass it. This is largely owing to the spread of alcoholism and syphilis among the colored people, to the deleterious effects of bad hygiene and

inferior food, and to an irregular mode of living, which has taken the place of the wholesome diet, the enforced regular habits, and the freedom from anxiety that belonged to slave life.

Climate and Seasons.—These are factors of very minor importance in the evolution of insanity. The harmful effects of heat in the South are more than counterbalanced by the more prevalent abuse of alcohol in colder regions. In a general insane asylum where the middle and lower classes of the population are received, a study of the records will show that a larger number of admissions in one year may occur during the winter, whereas in other years the same holds good for the spring, summer, or autumn. Hence one is obliged to conclude that the seasons have little to do with the evolution of insanity.

Gender.—In 48,587 admissions into the New York State hospitals there were 1,043, or two per cent., more insane men than women. Nor need the smallness of the difference surprise us much when we consider that the greater inclination in men toward the abuse of alcohol and the mental stress that falls upon the bread-winner are to some extent counterbalanced by the trying incidents of the puerperium, the climacteric, and the weight of family cares in the case of harassed housewives, whereas in single women the lack of natural sexual intercourse often predisposes to morbid psychical conditions. Hence in general it may be stated that the disposition toward insanity is about equal for the two sexes.

Religion.—While it is frequently true that certain sects, notably the Hebrew communities, show a higher percentage of alienated than others, it is probable that the faith of the insane person is not so often responsible as the repeated consanguineous intermarriages, particularly of neurotic strains, and to the fact that in past generations these people have been herded together in close and squalid habitations in crowded cities.

The duty, piety, abnegation of self to the needs of others, the raising of the moral and social tone, the trust in a hereafter taught by true religion, supply a strong prophylactic against, rather than a cause of alienation. It is a matter, however, of daily note that many unstable persons, when insanity is beginning, take a new and violent interest in prayer-meetings and missions, and that the mystic, erratic, evolutional paranoiacs seize upon the outward semblance of religion, not for its true intent, but as a stepping-stone in their perverted imaginings.

Civil State—Experience has shown conclusively that among the unmarried the percentage of insane individuals is far larger than among the married. A partial explanation of this preponderance, however, may be found in the fact that many persons do not enter into the bonds of matrimony because they recognize their strong proclivities to the psychoses, and do not wish to continue a degenerate race.

The greater regularity of the sexual relations, the influence of home life, the better sanitation and better food that belong to the home are undoubted factors in lessening the frequency of mental troubles among the married. To counterbalance these to some extent are the increased duties and obligations in providing for the progeny, nor can it be doubted that the irritation of constant strife and vexation incident to unhappy marriages tends to disturb mental equilibrium.

Age.—It has been generally thought that three periods of life are particularly liable to outbreaks of nerve storms of variable violence: the time of the evolution of the sexual functions at puberty, the time of their retrocession (especially in women), and the years of senility. In the first two, besides the evolution and involution of the sexual apparatus, the growth and recession of certain tracts of the central nervous system no doubt play an important part. In the last period imperfections of the vascular apparatus are of especial moment. On the other hand, statistics of a large number of insane of all ages show that from puberty to the forty-fifth year there is a gradual increase in the number of the alienated, and that the wave crest of the psychoses is not at an early or late age, but in the later years of middle life; also that afterward there is a recession. Accordingly the three periods mentioned above are notable only by the character of the physical disturbances that originate at these times.

About the seventeenth to the eighteenth year the intracortical association fibers reach their maximum development; nerve cells before inactive now come into function, the new adjustments of the neuron terminals affording paths of conduction that before this period were unavailable. As a result the mental development is now at its height, and the period of best attainment in both the intellectual and physical spheres is now beginning.

Should the brain organization be unstable, this rapid development may result in serious disturbances of the functional equilibrium, not alone of the nervous system but of the entire body, and a precocious senility may set in, accompanied by nerve storms of greater or lesser severity (excitement or depression), which end only with the death of the psyche, the person becoming relegated to an intellectual plane lower than that of the beasts of the field. The depths of the psychic tumult may be increased and the subsequent dementia greatly augmented by the presence of constitutional or acquired vascular insufficiencies or degenerations. This oversetting of the intellectual equipoise may be promoted or greatly assisted by excesses, especially in alcohol, onanism, and venery, as well as by over-study without sufficient outdoor relaxation, to keep the body healthy.

Insanity in childhood is a rare phenomenon. It is true that there is such a thing as an insane baby, but the disturbance represents merely an impulsive rage. Later, as mental development proceeds, the forms of the psychoses become more diversified, and we may encounter impellent acts, mania, as well as melancholia, and in rare instances, in families with a luetic taint, even a form of dementia paralytica.

For the reasons above given the age of puberty is perhaps the most hazardous in life for the mental stability of man or woman. While actual outbreaks of insanity are not nearly so frequent at this period as at some subsequent epochs, the groundwork is often laid for the later collapse. A sound education—using the term as meaning an efficient hygienic and moral training—begun in early childhood would go far to bring about the avoidance of the many factors (sexual, alcoholic, social excesses) that later lead to serious consequences.

It is somewhat difficult to determine the relative incidence of insanity in the sexes at the age of puberty. Krafft-Ebing states that females are more disposed than males on the ground that inheritance plays a greater rôle in the case of the former. Maclachlin, on the other hand, holds a diametrically opposite view, and his assertions are borne out by statistics from the immense material accumulated in the New York State asylums. In any case, however, the disproportion is not great.

Besides inheritance and excesses, especially onanism, other factors come into play as immediate evokers of alienation in youth. Of these the frequent anemias and chlorosis, the confinement in close rooms at school, mental over-exertion, insufficient sleep, and lack of open-air exercise in cities, all claim their victims.

Insanity in both sexes is much more frequent from the eighteenth to the twentieth years than in earlier life. Indeed as adolescence approaches the tendency toward insanity increases and the maximum is reached only some years after its attainment.

As nearly all the pubescent and adolescent insane are the victims of inherited predisposition, the majority

of the cases may be classified among the psychoses of the degenerate. They afford to the clinician certain characteristic stigmata, the principal of which are the frequent recurrences, automatism, and tendency to early dementia. Forms of depression (melancholia) are more frequent than those of exaltation. The former are chiefly of the periodic kind, sometimes simple, sometimes complex and alternating. It is not rare to find at this age the first phases of a circular insanity, or the germination of the seeds of a paranoia which is destined to come to maturity at a later period of life. The moral insanity of Pritchard is only a form of imbecility, the subjects in their one-sided character being not distantly related to the paranoiacs. Perhaps the most distinctive of the insanities of this period may be recognized in the hebephrenias (states of excitement) and catatonias (states of depression) of Kahlbaum, with the dementia paranoides of which so much has lately been written by Kraepelin and others. Epileptic insanity and hysterical insanity are also common at this age.

Age of Maturity.—From the twentieth up to the fiftieth year there is a steady increase in the numbers of the insane, male and female, the acme being reached about the forty-fifth year.

All varieties of insanity are now prevalent, one only being distinctive—general paralysis of the insane. In the earlier periods of full manhood and womanhood the less complicated forms obtain, the melancholias predominating, the acute manias being next in frequency. Toward the end of the third decennary alcoholic and syphilitic psychoses outnumber the insanities connected with a constitutional basis, though it is reasonable to presume that inherited tendencies still play a principal part; besides, one can but suppose that the toxins of syphilis, as well as of alcohol, act with greater potency upon the man who has inherited psychocorporeal infirmities than upon the individual whose nervous matter and blood-vessels are constitutionally sound. The dread disease of modern times, dementia paralytica, is ever growing in frequency, and though our home statistics (six to eight per cent.) do not show the enormous increase of the German and Austrian asylums (about thirty per cent. of the total admissions) the figures afford food for reflection. The *Trepanoma pallidum* has been found in the cerebral tissues of paretic dements, but whether it is an hereditary predisposition to this peculiar form of mental malady, or a secondary infection with another organism, supplemental to the syphilis, as is supposed by Ford Robinson, that renders dementia paralytica different in its symptomatology and course from brain syphilis, is as yet undetermined. Many other more common causes belonging to the prime of life and to our present civilization —the cares of the bread-winner, poverty, the burdens of a family, debilitating occupations, failures in business, mental over-strain in the great struggle for existence—all tend to overturn an already invalid brain.

Climacteric.—Whether we can speak of a true climacteric for the male is doubtful, but in any event this period does not come on until much later than in women, and is not accompanied by the same severe types of nervous and psychic disturbance. Between the fortieth and the fiftieth year a woman would appear to pass through the critical period of her mental life, not less than 19.8 per cent. out of 23,772 insane women falling victims within this period. Nor should such a result be unexpected. The fifth decade not only brings with it the gradual involution of the sexual functions with its concomitant emotional and nutritional disturbances, but also marks the beginning of senescence in the entire organism, the cerebrum included, and changes in the blood-vascular system, which from this time onward become more and more pronounced. As a natural consequence fatty alterations take place in the brain tissue, as is evidenced by the accumulation of metaplastic granules in the pyramidal cells. The evolution of productive creations of the intellect in some measure now comes to a standstill, though it does not cease altogether. The creative faculty is never so noticeable after the menopause as before that period.

The immediate factors in the causation of an insanity after the climacteric are often profuse menorrhagias or leucorrheas which tend to induce anemias and general depravity of the system. The sudden cessation of the menses not infrequently brings about a severe derangement of the entire system which may spend its force upon the nervous tissues, aggravating any psychical defect which may previously have been latent. Organic uterine disorders (myoma, carcinoma) do not seem to exert the same bad influence that follows the exhausting drain of a profuse, continued leucorrhea or metrorrhagia.

Inherited predisposition still plays an important part in the psychoses of the climacteric, as is proved by the forms of mental disorder (periodic melancholias, paranoia).

The majority of women at this period of life suffer from more or less severe disturbances of various kinds. All physicians are familiar with the frequent "flushings," the feeling of fulness in the head, the roaring in the ears, the headaches, the disturbances of digestion and neuralgic pains, accompanied by a more or less marked loss of the intellectual stability, and a greater or lesser degree of thought inhibition. Many of these cases afford the clinical picture of various types of neurasthenia and psychasthenia.

The graver disturbances of the psychic well-being are manifold, but do not attain to the dignity of any peculiar form of psychosis, unless the delirium of suspicion, which is quite common, may be classed as such. Many of these cases are so pronounced as to warrant the diagnosis of a paranoia. The patients show a hesitancy in both their thought and action; they are suspicious of every one and everything, although they may not reach the stage of actual delusions, and are usually able, if tactfully reasoned with, to correct their false impressions. Many of them stand on the border-line of sanity and insanity, and if carefully attended to and watched fully recover their mental stability. Of evil augury are hallucinations of smell and hearing which usually mark the beginning of a chronic form of insanity.

Among the true psychoses the melancholias are the most frequent, and are ordinarily of the delusional resistive type. Some forms of periodic insanity, especially the depressive type, may begin at this epoch of life; circular psychoses also are occasionally encountered. What has just been said with regard to the suspicions which characterize some of the milder mental disturbances at the climacteric is equally true for the large number of cases of paranoia that reach a stage at this age that places the patients beyond the pale of society and necessitates confinement in an institution. Among sixty cases of menopause alienation Krafft-Ebing diagnosed forty-two as belonging to one or the other of the various forms of paranoia, and although this proportion is not conceded by other observers, experience nevertheless shows a high percentage of persecutory systematized psychoses occurring at the climacteric. Cases of dementia paralytica, as well as those that run the course of a precocious senility, are now and then encountered.

The Insanities of Old Age.—For a man to have reached the age of sixty years and upward without the occurrence of an alienation of any kind is a distinct compliment to his ancestral protoplasm, and to a lesser extent to his own moral and hygienic habits. In advancing age the insanities of the psycho-degenerate have been left behind, except those that continue to recur periodically, and of which the habit is retained. As a matter of fact, however, these are comparatively few in number, the most frequent being the circular

vesaniæ, a disorder that belongs not only to early but also to late life.

In the senium other factors arise. Comparatively few human beings wholly escape, in advanced life, some form of that involutive change in the cardiovascular apparatus that we designate as arteriosclerosis.

These degenerative states of the arteries (which are also met with in the veins though in a less marked degree) affect mainly the intima and muscular layer of the vessel, and with the exception of one form bring about a certain diminution of caliber in the blood channels, while in all the proper transudation of the nutrient portions of the blood stream is seriously interfered with. These circulatory disturbances are often increased by the formation in the inner arterial sheaths of localized, circular, or nodular thickenings composed of fibrous knots or calcareous plaques embedded in dense fibrous masses, or deposits of fatty cholesterin matter covered by a thin fibrocalcareous layer that during life protrudes into the lumen of the artery, cutting off one-third or one-half of its blood-carrying capacity. The favorite seat of these nodules is in the internal carotids just as they pass into the skull through the foramina. In the small arteries and arterioles changes are met with which, although differing somewhat in character, produce the same effect—namely, the shutting off of a sufficient supply of nutrient fluid from the brain tissues. Moreover, there occurs a retardation of the outward lymph flow both in the cerebral substance and in the pia mater, caused in part by the accumulation of débris of all kinds in the extravascular lymph spaces, and in part by thickening of the trabeculæ of the pia with accumulation of leucocytes, hematoidin crystals, and débris in the lymphatic channels. As a consequence the brain as a whole becomes ill-nourished; there is a degeneration of the white fibers both in the cortex and in the gray layers, with accumulation of a metaplastic material within the cells of the cortex and basal ganglia which may reach a degree sufficient to bring about destruction of the function and vitality of the entire neuron.

The psychoses of old age are, therefore, with few exceptions, essentially of an organic-degenerative nature, and possess especial brand marks, which distinguish them from the forms that occur in youth.

In all, the most striking feature is the loss of memory for recent events, while incidents in earlier life, temporarily at least, are retained. At the same time there can be noted an emotional childish tendency, accompanied by disturbances of the sensory, trophic, and vasomotor nerves, followed in due course by apoplectiform and epileptiform attacks, which further increase the mental weakness, even though no actual paralysis is left behind. These insults are more frequently caused by the closure of an artery of medium or small caliber than by the rupture of its coats with consequent extravasation of blood and tissue necrosis.

Excluding senile dementia, which has been described as the "physiological death of the brain cell," and from which no man can escape should he live sufficiently long, we have, relatively as well as actually, fewer true psychoses among the aged than in middle life. Among 5,542 insane patients of all classes less than fourteen per cent. (772) had become insane in the twenty years between sixty and eighty. The women outnumber the men to some extent, 416 females to 356 males.

The melancholias are far more frequent than the manias, and are characterized by an anxious, distressed, agitated, errabund state of mind. As hallucinations and delusions have not the same relative frequency as at an earlier age, the agitation may be regarded as an exposition of the malnutrition of the brain centers, and the tendency is ever toward a terminal dementia. Suicide is extremely common.

The manias are characterized by their blind violence, approaching in intensity that of the paralytic dement; the erotic excitement is often intense; the delusions assume an expansive form, the imagery is senseless, and the periods of remission are infrequent. Many of the sufferers from agitated melancholia or senile mania absolutely refuse food, rendering treatment more difficult, as artificial feeding may become dangerous to life itself.

Confusional insanities are now and then seen in the aged. Ordinarily these are referable to the accumulation within the system of toxic products that the senile renal apparatus is unable to carry away, to intestinal autotoxis, occasionally to the absorption of putrescent substances from a chronic cystitis, or an extension of a bladder inflammation to the pelvis of the kidney.

In aged persons who have retained a moderately good vascular condition one may encounter benign forms of insanity, which may result in a complete recovery. A careful examination of the condition of the peripheral blood-vessels may give the necessary diagnostic clinch, although, unfortunately, the cerebral arteries are often more diseased than those accessible to the finger.

Occupation.—Certain callings appear to be more frequently followed by insanity than others. Poets and artists are especially prone to the psychoses, not so much by reason of their occupation as from the possession of genius, which generally means inherited nervous lability, and from the fact that the nature of their work allows of much time for introspection. Among the working classes, certain employments from their debilitating nature are more prone to occasion insanity than others. Among persons so exposed may be mentioned the employees of railroads, especially engineers who live a life of constant nervous tension, workers in lead, in mercury, in caoutchouc, or in aniline products, iron-workers, and others who are almost continuously exposed to the effects of artificial heat.

The same holds good, although to a greater degree, for brokers, bankers, domestic servants, governesses, students, and day-laborers. Pro rata, the lower the social class the more frequent are the psychoses.

Accessory Causes.—These may be roughly divided into psychical and physical. It is often impossible to separate accessory factors from the underlying inherited taints, and for the most part careful inquiry will elicit a history of constitutional weakness serving as a background to the immediate cause.

Psychical.—*Anxiety.*—In a large proportion of cases of melancholia the immediate etiological factor is ascribed to the death of a near relative (mother, father, son, or daughter). Many are also directly caused by domestic worries, inability to meet liabilities, or to provide properly for the family, and the dread of poverty. In the same category come business cares, loss of property, unsuccessful speculations, and similar reverses. It is hardly possible that these agents, in the total absence of constitutional predisposition, would be sufficient to interfere materially with the smooth running of the mental gearing, and though in rare instances such may be the case, for the majority an additional underlying cause must be sought.

Exceptions of greater frequency may be noted in the instances of alienation closely following some business or domestic calamity occurring in old people, who though they may not have derived neuropathic tendencies from their ancestors are themselves standing on the verge of a declivity, owing to advancing senile degeneration of the tissues.

Fear.—Numerous instances are recorded in which the witnessing of the commission of a murder, or an attempt at assassination, the shock of coming into contact unexpectedly with burglars, an attempted rape, and other experiences calculated to produce a vivid mental impression, have been followed almost

immediately by an insanity, the person within a few hours becoming stuporous or violently excited.

Examples of this kind are met with principally in individuals of weak mental organization, incapable of prolonged psychical effort and the disturbance for the most part must be attributed to the constitutional predisposition.

In the same class must be included a certain number of the psychoses of *childbirth*. The sudden lighting up of an acute insanity, occurring within a few hours of the parturition, can be brought about only by nervous instability. Not a few of the sudden manias coming on during the puerperium are merely instances of periodic insanity, the mental and physical strain incident to labor upsetting the hair-fine equilibrium and producing what may be termed a precocious return of the mental disturbance. Women who are always insane at the hour of parturition, and return shortly afterward to a more normal state, belong to the degenerate class.

Physical.—*Poverty.*—Anything that depletes the bodily strength, if it is far-reaching enough, may become a factor in the production of an alienation. With indigence are associated bad and insufficient food, close crowding in foul air, and lack of hygiene in the widest meaning of the word. Hence it happens that the rank and file of the insane come from the poorest classes, and the crowding from country districts into towns, in recent years, has been very instrumental in increasing their numbers. Poverty also brings with it a host of attendant evils of which not the least is the tendency to make up for the lack of food by taking alcoholic stimulants which are cheaper and more satisfying for the moment. Actual starvation induces a delirium of the hallucinatory-confusional type, and may be a direct cause of alienation, which, however, is usually temporary, if the case be treated early enough to save the victim's life.

Overexertion.—The overexertion of the college gymnast, of the soldier during campaigns, or the strain incident to particularly arduous occupations, in which heavy weights are carried, as in the case of stevedores, favors the occurrence of changes in the vascular apparatus, that may lead, when youth has passed and early middle age is reached, to early senescence, and to organic-degenerative alterations in the central nervous system which eventually produce an insanity.

Constitutional Diseases.—*Anemia.*—A dyscrasia, finding one expression in a form of anemia, is present in all cases of the severer forms of melancholia, as well as in neurasthenic and other types of insanity. This habit of body is so common as to make one question whether the impoverishment of the blood is not the direct underlying cause. In the sense that it heightens any inherent tendency to irritability of the central organ of the mind it is undoubtedly an excitant, but deeper lies the instability of the protoplasm itself. Even when there is no actual psychosis, anemic individuals often show a certain degree of mental incapacity with thought inhibition and irritability, and any strain, physical or mental, superadded to the dyscrasia, may cause the balance beam to oscillate violently.

Syphilis.—Next to alcoholism this is the most frequent direct cause of insanity. In addition, it may also have an influence indirectly by lowering the resistance of the organism and producing a secondary mental indisposition. As a direct agent it acts by inducing widespread changes in the intima (less severe in the fenestrata and muscularis) of the arteries, the cellular proliferation being often so extensive as partly or fully to obliterate the lumina of the vessels. Under such circumstances there may be necrosis of the tissue areas supplied by the most damaged vessels, not confined to the brain but equally apparent in the extremities.

Intense vascular changes are not confined to the early stage of lues; on the other hand, they are more common with the secondary and tertiary manifestations of the disease. In a vast majority of paretics, particularly in those who have a clear history of specific infection, there is found, on examination, a soft thickening of the walls of the vessels, a change for the most part due to periarteritis of a peculiar type.

Luetic neoplastic endarteritis has been encountered as early as four weeks after the occurrence of the initial lesion (G. de la Tourette, Alelakoff, Berkley), or as late as twenty years after the infection.

Besides the specific arterial degenerations, syphilomata and gummata may also occur within the cranial cavity, disturbing the return venous and lymphatic circulations and producing congestions and edemas.

When the syphilitic process is acute the form of mental disturbance assumes a furibund, excited character followed by stupor; with the more chronic changes the excitement, though less intense, is usually more prolonged, and may be followed by pareses, paralyses, or epilepsy, the final stage being a terminal dementia. The greatly increased frequency of the cerebral complications of syphilis in recent years, together with their protean character, is exceedingly striking, and is a comment upon the civilization of the present era.

In strong contrast with the records in this country of a multitude of mental troubles following syphilitic infection is the report of Holzinger of the Russian Red Cross Commission to Abyssinia during the Italian war. In a country where, according to his statement, eighty per cent. of the inhabitants are syphilitic, only twelve true psychoses occurred among 13,000 patients seen in a general dispensary, and none of these appeared to be directly due to the taint. In the same land tabes dorsalis (six in thirteen thousand) and dementia paralytica (none) are extremely infrequent. Either the luetic virus of the East is different from that of the West, or the constitutional proclivities to mental maladies vary very much.

Tubercuiosis.—This is an infrequent cause of insanity, and when it is present it usually succeeds instead of preceding the alienation.

Heart Diseases.—Cardiac lesions do not appear to be more frequent among the insane than among the sane. Those that lead to embolism are responsible for a larger proportion of the alienated than simple insufficiencies.

Kidney Diseases.—Mental disturbances are relatively frequent in the chronic forms of nephritis, especially with the contracting kidney, and with diabetes mellitus. In chronic uremia there is often alteration of the character, delusions generally of an expansive nature, or stupor, even when the urine shows neither the presence of any considerable number of casts nor a trace of albumin.

The non-elimination of the effete products of bodily waste is responsible for the evolution of the insanity in these instances, just as the effects of other chemical or toxalbumic poisons manifest themselves as a psychosis, the mental disturbance assuming the form of an hallucinatory-confusional insanity.

Diseases of Women.—It it noticeable that organic diseases of the uterus and its appendages (carcinoma, fibroma, etc.) are seldom accompanied by profound nervous storms. On the other hand, the leucorrheas, amenorrheas, profuse menses, vaginismus, chronic uterine catarrh, and a host of other comparatively benign affections are now and then followed by mental disturbances.

It is probable that the latter act upon the system in two ways: first and foremost they deplete it and induce blood depravities; and secondly, they lead to the fear that some incurable disease is present. In highly neurotic individuals an ever-present dread is likely to be a factor of considerable moment. Although it may be said, in general, that the influence of the affections of the generative apparatus as a cause of insanity in women has been exaggerated, as an

accessory factor it is often worthy of consideration. Diseases of the generative organs in men seldom lead to alienation.

Direct Causes.—It is never possible absolutely to separate inherited predisposition from the direct effects of deleterious drugs, febrile disturbances, and traumatism, so far as regards the degradation of the cerebral substance. Certain suggestions are afforded by the clinical phenomena resulting from such agents that render it very apparent that an invalid brain is much more readily overthrown by them than a sound one. Mark, for instance, the difference of the effect exerted by a febrile disturbance in a child the offspring of neurotic parents, and in one who comes of sound ancestry. With only a very moderate degree of fever the first child may exhibit a wild delirium with the evolution of vivid sense phantasies, while the other may not be appreciably disturbed. Again, in cerebral traumatism, a slight commotion may set up a train of psychical symptoms in the neurotic, while in the other the mental capacity remains unimpaired.

1. *Chemical Poisons.*—As has already been said, although syphilis may be a direct agent in the production of an insanity, its poison acts not upon the brain cells immediately, but upon the blood-vascular tissues, the nerve and neuroglia elements never being primarily involved. Alcohol, on the other hand, exerts its noxious influence alike upon mesoblastic and epiblastic elements, with the result that both suffer in equal or diverse degrees. An overdose of alcoholic liquor acts by causing, first, congestion of the brain, and later paralysis of the walls of the vessels, inducing stasis and edema with profound unconsciousness. If the same effect is produced time after time, the vasomotor paralysis leads to the permanent widening of the blood-vessels, especially of the arterioles and capillaries, with lowering of the vascular tonus. At a sequence we have lymph stasis with exudation of the white elements into the sheaths, and clouding with thickening of the pia-arachnoid. At length the alteration of the arteries becomes chronic, the sheaths undergo fatty-atheromatous changes, and there is established an arteriosclerosis with some narrowing of the lumen from thickening of the intima, which is in part compensatory. At a later stage fatty degeneration of the heart muscle may ensue with increasing defects in the circulation.

With the alcoholic arteriosclerosis come changes in organs of the body other than the brain, cirrhosis of the kidney and liver being the most frequent.

The effects of ardent spirits upon the human brain vary with each person. Upon certain individuals large quantities seem to have no immediate bad influence, beyond the slight immediate flushing and depression of the circulation; while in the case of others a few glasses of wine or liquor will entirely overthrow the mental equipoise and render the drinker temporarily insane. In a very few, an equally small dose, perhaps the first and only one of their lives, will permanently disturb mentalization, so that the unfortunates retrograde to the plane of dements.

From a psychical standpoint the evil effects of alcohol are usually shown in two ways. If a large quantity be taken at one time the result may be an immediate breaking down of the mental powers, so that there is produced an effect similar to that of various other irritant poisons—an acute hallucinatory excitement with thought inhibition. In the case of the alcoholic the condition is known as delirium tremens.

On the other hand, if the doses of liquor be small in amount but frequently repeated the same result is finally attained, the duration of resistance depending upon the individual, the frequency of the drinking, and to some extent upon the quality of the liquor partaken of. Since physiological experiments have shown that it takes about two days for the organism to completely eliminate alcohol, it is clear that if dose follows dose in rapid succession and an insufficient time is allowed for the expulsion of what is present in the body, an accumulation of the poison within the tissues must take place, which in the ordinary course of events will ultimately produce a nervous explosion —the so-called trembling delirium.

If, on the other hand, the ingestion of the drug is slower, but is constantly continued, and fatty degenerative changes are set up in the tissues, particularly in the arteries and nerve cells, the result is an insanity of a more chronic type—persecutory psychoses, manias and melancholias of especial character, a pseudodementia paralytica, as well as amnesic and epileptic states. Characteristic of all forms of alcoholism is the peculiar mental clouding known as amnesia, and an unreasoning irritability and suspiciousness. (See also above in the section on Heredity.)

Intemperance is directly the cause of about ten per cent. of all cases of insanity encountered in asylums. Indirectly the figures assume colossal proportions when we include the psychoses and psychoneuroses of the descendants of alcoholic parents that are attributable to the ancestral vice. Women afford only about one-third as many examples of alcoholic insanity as men, but in the lower classes this disproportion is much decreased.

Besides the alcohols there are a large number of poisons and chemical substances that produce a direct alienation, usually of the hallucinatory type. Among these may be mentioned cocaine, atropine, morphine, salicylic acid, iodoform, antipyrin, nicotine, chloroform, ether, chloral, illuminating gas, carbon disulphide, and numerous others.

The metals, lead and quicksilver, act upon the organism somewhat differently. They are essentially of the nature of chronic poisons, and while they may occasion an hallucinatory delirium with much motor agitation of a transitory type, the peculiar nature of their action is to evoke a permanent insanity with hallucinations and delusions approaching the character of a dementia paralytica and ending in mental annihilation.

Autointoxications.—A profound obstipation, with absorption into the circulation of certain products resulting from the splitting up of albuminous substances within the intestinal canal, as shown by the presence of indican and skatol, or of other less readily recognized substances in excessive amounts in the urine, may be the cause of an acute insanity, and as an etiological factor is too frequently overlooked.

Cases of this nature are by no means uncommon, and should the inducing agent be recognized and the proper remedies applied to correct the faulty digestion, they are usually readily curable. According to the degree of mental instability we may find conditions varying from simple obtundity to actual stupor; or a true psychosis, commonly of the melancholic type, may develop. On the other hand, the case may assume an alternating character, melancholia changing into mania, to be succeeded by stupor. Uremic and diabetogenous insanities have been already mentioned in another paragraph.

Among the autochthonic insanities the occurrence of an alienation following the disturbance of the secretion of the thyroid gland in the adult should be remembered. Examples are now and then met after disease of the gland, after childbirth, and occasionally without any ascertainable reason, in which the skin becomes doughy and foul, the face assumes a half-moon appearance, and soon an insanity manifests itself. The psychical torpor steadily increases, and eventually there may be melancholic depression, or excitement with hallucinatory delirium, followed by stupor. The majority of these conditions are curable if proper measures be instituted.

Other glandular structures belonging to the internal secretory system are at times implicated in either deficiencies of the intellectual growth, or in later

acquired defects in the mental equilibrium. Among them may be mentioned tumors of the pituitary gland causing acromegalia with sequent dementia; also changes in the thymus resulting in deficiencies in mental growth. Diseases of the thyroid occasioning either hyper- or hypo-activity of its functions are by far the most common as is evidenced by the frequency of trivial or serious disturbance of the mental functions in exophthalmic goiter.

Acute Febrile Disturbances.—The occurrence of an insanity during or after an acute febrile disease is by no means rare, but inasmuch as these cases are for the most part treated in private or general hospitals statistics as to the actual frequency are lacking. Wille gives 0.81 per cent. of typhoid fever cases as having postfebrile alienation, a not inconsiderable number in the aggregate when the frequency of this disease is considered.

Febrile psychoses may occur in either predisposed or non-neurotic persons, in the latter case intensity of the disease process overwhelming the natural tissue resistance.

The common mental disturbance that occurs during the acme of the fever is termed *delirium*. It is characterized by illusions, hallucinations, temporary facility of thought with confusion and interference with the ordinary association of ideas. Such departures from normal mentalization are produced by three agents: the rise of bodily temperature, the increase of the respiratory and circulatory activities, and lastly, but not least in importance, the impression made upon the vitality of the tissues by the toxin of a microorganism circulating in the blood and bathing the cells in a vitiated serum.

True psychoses do not accompany but follow the febrile disturbance: the acme of the fever is past, the excessive action of the heart has subsided and its contractions have fallen below the normal in force, while the toxin of the specific bacterium has been to a great extent overcome by the natural tissue resistance, though there may still remain within the organism sufficient to vitiate the nutrient plasma.

The condition is now one of profound nutritional perversion with blood depravity, and irregularity or actual disturbance of the circulation from cardiac weakness. At the same time there may also be venous congestions and edemas of the cerebrum, arising in some instances from actual damage to the arterial sheaths from the immediate effects and deleterious after-results of toxalbumins engendered in the course of the acute disease. The mental disturbance induced by these several factors is therefore in the nature of an exhaustion or collapse delirium. It is apt to be stormy in its onset, confusion being the predominating characteristic, accompanied by visual and auditory hallucinations, rapidity in the change of thought from one subject to another, and increasing mental obtundity. In addition there is generally active motor excitement and entire sleeplessness. The bodily temperature is now subnormal, the heart's action is feeble, and the reflexes are slightly elevated. The condition may last only a few days or may continue for several weeks.

Typhoid fever, influenza, polyneuritis, pneumonia, scarlet fever, measles, erysipelas of the head, and variola, in the order named, are the most frequent of the exanthemata to be followed by psychoses. Before the introduction of quinine malarial fevers added a considerable quota to the ranks of the insane. Probably the blood-letting then in vogue often aggravated the nervous phenomena. Even to-day in countries where the severer forms are encountered, about two per cent. (Pasmanik in Bulgaria) of those affected have some mental complication, usually stupor. The debilitating effects of a marked paludal intoxication would often account for these disturbances of the mental equipoise, though plugging of the capillaries with aggregations of the parasites, as is known to occur in the intestines, may play a not unimportant part. A number of the psychoses accompanying *parturition* must be classed among the febrile insanities, as they are the result of infection by cocci that have entered through the uterine passages, notably the placental site. The organism most constantly found is the *Streptococcus pyogenes*.

Brain Lesions.—Meningitis of a severe character is not uncommonly followed by a form of insanity approaching mania. The inflammation of the brain coverings, the disturbance of the circulation in the cerebrum, the obstruction of the pathways for the returning lymph along the vessel sheaths passing finally into the pia mater, together with the increase in the intracranial pressure are sufficient to account for the perversion.

In tumor or abscess of the brain, in primary internal hydrocephalus of the adult, in disseminated sclerosis, after apoplexies and embolisms as well as other local abnormal conditions, insanities are now and then encountered. They usually assume the form of a progressive dementia, the patients only occasionally exhibiting depression or exaltation, though rarely after a hemorrhage or embolism of one of the larger arteries of the brain, conditions of frenzy are seen.

All degrees of injury to the skull and brain tissues may be followed by an insanity, sometimes coming on immediately after the reception of the lesion, while at other times it may be postponed and remain latent for months. A trivial local traumatism, especially in the case of persons suffering from some constitutional disease, as syphilis, may start up an inflammation of the tables of the skull and the meninges beneath that eventually may implicate the brain, either by direct extension of the process or by pressure upon it. At other times, again, the neoplasm following the injury may interfere with some of the exits of the venous blood and the lymph fluids from the brain cavity and evoke an alienation. Active motor excitement is less common than a dull apathy with loss of memory and weakening of the faculties. An apparently trivial injury may also be the match that lights up the flame of a periodic insanity, circular or maniacal in type.

Insolation.—The form of alienation that follows insolation is also ordinarily a dementia of passive type, though now and then a series of mixed motor-psychical phenomena, strongly suggestive of the demented form of paresis, is seen. The condition results from the degenerative effects of the thermic fever upon the cortical gray matter, inducing changes in the vascular lymph apparatus and degradation of the cellular elements.

Operations.—Instances of insanity following surgical operations are somewhat rare. In this connection the mechanical shock to the nervous system, especially in the case of an unstable subject, and the effects of the ether or chloroform are elements to be considered. Operations that involve an extensive loss of blood are, perhaps, more commonly succeeded by an acute alienation than minor surgical procedures.

Operations upon the eye and castration are said to be especially dangerous. Simple *anesthesia* from chloroform or ether has occasionally been followed by a psychosis of short duration. The mental impression induced by the dread of the procedure and the fear that death would occur during the narcosis, together with the systemic effect of the drug, all play their part in the overwhelming of the faculties. The precocious advent of a periodic insanity must also be borne in mind. HENRY J. BERKLEY.

Mental Diseases, Pathology.—To bring the data observed in the cases of insanity in line with the data of pathology generally is a very difficult task on account of the heterogeneous character of the material. It is safe to say that for a general

pathology there must be sound material of special pathology. The literature of special psychiatry is, however, unfortunately, more conspicuous by quantity than by broad scientific points of view, and only here and there we can discern successful efforts to bring the observations on the level of standards which hold for pathology generally: the reduction of events to chains of cause and effect. The following sketch is an attempt to show the principles with which we proceed to-day, and for examples we must refer to the articles on special pathology.

The Data of Psychiatry.—The phenomena which we get for the formation of a scientific picture of a case of mental disease are, *First*, the general data concerning the family type and the occurrence of special diseases in other members of the family. *Second*, the data concerning the condition in which the patient entered the causal constellation which we designate as the disease. *Third*, the string of phenomenology or symptomatology of the entire disease; (*a*) the deviations of the course of reactions in which the mental phenomena are essential features, the mental symptoms proper (including as much as we actually know of the objective or physical signs of "mental" reactions); (*b*) the disorders of the organic mechanisms (circulation, digestion, respiration, secretion, reproductive organs, and nervous system); (*c*) the findings in autopsies, the anatomical evidence of the deviation from the normal processes of life, naturally obtainable in only a portion of the cases, because few die of the "mental" disease. This group of data is often given an exclusive position as "the pathology" of a disease. For practical reasons and on account of the character of the method of investigation it becomes the field of workers of special training; but so far it has been but little productive in the general frame of a pathology of insanity. Only in a few types of disorders, the essentially organic diseases of the cerebral cortex, have the findings more distinctive features than the functional finding observed during life; and even where they do, the lesion may be fully as puzzling for a truly experimental explanation, as many other features of the disease.

To reduce these heterogeneous data to some sort of useful and practical order and especially into strings of causal connection is the task of a general and special pathology of insanity.

The distribution of the work in this Handbook has decentralized the analysis of the various topics mentioned above. It will be necessary, however, to encroach upon the fields of other contributors at least to the extent of showing some of the principles which guide us in the utilization of the various facts for reasoning in pathology.

There are two ways of entering upon the study of mental aberrations. First, the consideration of *disorders* which *can be produced experimentally* and under definitely known conditions. Second, the study of the *phenomena* of insanity as they present themselves *in a large practical experience*. These two lines of inquiry must cooperate and tend toward the ideal that we should be able to understand all the happenings in mental pathology with principles of thought which come up to the accuracy of those of an experiment. The extent to which this can be obtained marks the extent of accurate knowledge of the pathology of insanity.

Considering the large number of varying types of deviation from the normal and the small number of experimental products in these lines, we find ourselves forced to lay the emphasis on the purely empirical material of the physician, and we shall investigate how we can hope to bring some order into the immense material. It is rather striking that most of the serious study has been devoted to the things which are most difficult to establish and interpret properly, viz., to the problems of heredity and to the problems of pathological anatomy. Either of these lines is not usually accessible to actual observation; the one represents hearsay facts and the other seldom facts which can be directly related with the actual psychosis; and it must be our attempt to work for a more satisfactory utilization of the variations of life processes in the general scheme for studies. That is to say, we must learn to use for diagnosis, prognosis, and therapeutic possibilities that which we actually meet in our practical work, the symptom complexes and their causal connections, and the evolution of the symptoms, as far as possible in terms of dynamic factors which determine nature's experiment, and which may or may not be modifiable.

The Data of Heredity.—In order to make up for the usually meager digestion of the data concerning the foundation of insanity in the individual, the alienist has attached great value to the finding that in a great number of cases the patient is not the only member of the family that shows abnormalities. The family history of any moderately large group of cases of insanity shows a relatively frequent occurrence of mental disorders, nervous disorders or of various "diatheses," and the conclusion is drawn from it that where there is a "history of gout, rheumatism, diabetes, gravel, phthisis, migraine, epilepsy, asthma," or of peculiarity of character, criminal record, or nervous or mental disorders in one or more persons of the family, a "morbid taint is fully established." Under the influence of the general views of evolution and dissolution the concept of the *morbid taint* has moreover been closely associated with the concept of *degeneration*.

The data of heredity of mental disease have been brought into prominence chiefly by Morel and under the influence of Magnan and Lombroso and their associates. During the last decade the great advances in revival and further explanation of Mendelian principles have inspired extensive studies in our field as it has done in biology generally.

From the great amount of literature we select the following types of contributions. On a very favorable material in a Canton of Switzerland in which the movements of the population are not excessive, Jenny Koller (*Archiv f. Psychiatrie*, Bd. xxvii., S. 286) has studied the histories of 2,273 patients admitted between 1881 and 1892. Heredity was noted in 78.2 per cent. In 64.3 per cent. of these cases, or 50 per cent. of the whole, there was direct heredity—a disorder in the father or mother, or in both; in the rest, heredity was collateral, or atavistic. The heredity is somewhat greater in the women than in the men, 81.7 per cent. against 74.9 per cent. The material of comparison consists in the accurate family history of 370 mentally healthy individuals of the same layers of the population, and 370 consecutive admissions of the years 1885 and 1886 chosen for immediate comparison. The facts were classified in the following table:

	A—Normal series.		B—Insane series.	
1. Mental diseases	57	26.1 per cent.	39.8 per cent.	113
2. Nervous diseases	38	17.4 per cent.	10.2 per cent.	29
3. Alcoholism	55	25.2 per cent.	22.2 per cent.	63
4. Apoplexy	36	16.5 per cent.	5.6 per cent.	16
5. Senile dementia	10	4.6 per cent.	2.8 per cent.	8
6. Peculiar character	16	7.3 per cent.	18.0 per cent.	51
7. Suicide	6	2.8 per cent.	1.4 per cent.	4
	218			284

This table would assume that only one "inheritable" fact had been counted in each family.

The next table gives the relative percentage of direct, indirect (atavistic), and collateral heredity.

A comparison shows how very important the direct

heredity of mental diseases and peculiar character of the parents is among the insane, whereas nervous disorders and apoplexy and even suicide happen to be found in larger numbers in the families of the normal than in the families of the insane.

Similar studies have since been made by Diem and by Scholomowitsch on kindred material. Diem shows that in families of patients with mental disease there is 8 times as often insanity in a parent and 9 times as often insanity in a brother or sister and only 2.5 times as often insanity in a collateral branch as in the families of the average population. Heron has worked out the heredity coefficient according to Pearson's methods and finds it similar to that of tuberculosis.

Ball and Régis ("Les familles des aliénés," *l'Encéphale*, 1883) described a definite "cachet" of heredity in the descendency of various mental disorders. In normal families the causes of death are greatly varied and distributed in almost equal proportions among the various groups of disease; there is no special tendency

	Direct.		Indirect.		Collateral.	
	Normal. Per cent.	Insane. Per cent.	Normal. Per cent.	Insane. Per cent.	Normal. Per cent.	Insane. Per cent.
1. Meotal diseases	10.1	25.4	11.9	7.7	4.1	6.7
2. Nervous diseases	11.0	7.4	4.6	1.8	1.8	1.0
3. Alcoholism	14.2	19.0	10.5	2.2	0.5	1.0
4. Apoplexy	7.8	4.3	8.2	1.2	0.5	
5. Senile dementia	0.5	2.1	3.6	0.7	0.5	
6. Peculiar character	3.2	15.8	3.2	1.2	0.9	0.7
7. Suicide	0.9	0.7	1.9	1.1		
Sum of factors of heredity.	47.7	74.7	44.0	15.9	8.3	9.5

to repeated affections of the same apparatus. Ball and Régis showed that general paralysis is followed chiefly by brain affections; while mental disease and neuroses, alcoholism and consumption are not more frequent than in the normal. Non-organic insanity is followed by a diathesis of insanity, while brain disease, neuroses, alcoholism, and consumption are not abnormally frequent; epilepsy is followed chiefly by brain affections in childhood, while phthisis and alcoholism are prominent in the ascendency; epilepsy itself is rarely transmitted as such; hysterism is followed most frequently by nervousness; alcoholism by a disposition to phthisis and brain diseases in childhood. Morel points to a frequently quoted progressive type of familial degeneration in alcoholism which leads to decline and to idiocy, within four generations. Experience certainly favors the statement that the existence of cases of mental disorder opens greater statistical chances of developing mental disorders in other members, and where this fact is present in a family the disorders are apt to appear at an earlier age and to show a greater tendency to relapse. Mott has lately demonstrated the frequent validity of this "law of anticipation." On the other hand, hereditary attacks are often slighter and more curable and the danger for life is less. In a large number of individuals with insanity in the ascendency there are no psychopathic traits at all; moreover, in many patients with essentially "degenerative" phenomena the hereditary data are negative. The assertion that "the subject of ordinary insanity is not a normal individual, that there exists in his constitution a latent disposition which any accidental determining cause may at any moment transform into evident symptomatic manifestation" has its corrective in this last remark and in the experience that there are "thousands of predisposed persons who escape the graver risks of their faulty inheritance and pass through life untarnished by insanity (Macpherson, "Mental Disorders," p. 22). In order to make the occurrence of mental disorders intelligible in some people, we pass over a large percentage of humanity a verdict as gloomy as the dogma of infant damnation, unless we recognize the limitations of the statistical method and do not overdraw its positive and negative value. True to the fact, pathology should avoid this unnecessary evil prognostication, except where it is actually justified by the events. For the purposes of real individual pathology, we are obviously forced to search for more important data which would explain how it is that a certain proportion of members of families "with a morbid taint" tend to represent an abnormal variety. We are encouraged in this direction by almost all the data above mentioned, if at least we know how to read between the lines, especially such facts as: that educational influences from mere peculiarities of the parents or criminal surroundings are far more serious than the record of a decided attack of insanity of one of the parents, and that forms of insanity classified as particularly hereditary not infrequently occur without any evidence of "heredity" at all.

As principles of pathology we cannot admit statements about heredity as digested material except:

(1) Where they apply to large numbers, and mean to be of general bearing;

(2) Where we have sufficient certainty that the feature attributed to heredity cannot be explained more directly on grounds of influences during growth, education, and other determinants of the individual life; and

(3) Where the *corpus delicti*, the inherited feature, has a sufficient relation to the disturbance of health which brings the person under consideration.

These rules should especially be applied to the so-called "stigmata." They will exclude completely a considerable number, and place another large portion on the list of true *accidents of development* for which the pathology of growth is still to be worked out before they should be used as more than signs of mishaps of growth, the bearing of which should be stated in every instance and case. I should repeat concerning them a remark made in a review of the "Signs of Degeneration and of Methods of Registration" in the *American Journal of Insanity*, January, 1896, p. 345: "Probably for a long time to come the study of mental capacity and potentiality will be best carried out by studying the psychical manifestations rather than the physical forms of the person," inasmuch as the majority of the physical signs of degeneration are utterly uncorrelated facts, and of value only as remote collateral evidence of difficulties of development. The whole doctrine of stigmata has received a severe shock from Channing, who finds that the variations of the forms of the palate in defective children only slightly exceed the variations in normal children (*Amer. Jour. of Insanity*, vol. lxi., p. 695). A careful review of the facts claimed in favor of seeing in feeble-mindedness and insanity a Mendelian unit character shows more zeal in the use of attractive simplifications in a narrow domain of biology than sober analysis of the facts at hand. The studies of Rosanoff and Orr (*Amer. Jour. of Insanity*, vol. lxviii., pp. 221–261) claim insanity and the neuropathic constitution in general as "recessive to the normal constitution;" but the seventy-two families with 206 different matings and 1,097 offsprings are clearly open to far more divergent interpretations; and Rüdin's study reviewed by Cotton (*Amer. Jour. of Insanity*, vol. lxix., pp. 31–89) is admittedly only suggestive.

These critical remarks do not attack the facts of heredity but their looseness and hasty interpretations. There are indeed some types of mental disorders which we look upon as constitutional in the sense of familial, and some types of disease which might be called at least equivalents of one tendency (dissimilar heredity).

But it is of no small interest to see that in these heredity is not always the only possible or even probable explanation, and that we probably go too far in appealing to the dogma without enough analysis.

A fresh impetus was given by the very noteworthy study of Dr. Vorster, of Stephansfeld. Eleonor Fitschen had found that positive hereditary data were not more frequent in periodic (manic-depressive) insanity than in mental diseases generally, but that there was a greater number of real mental disorders mentioned. Vorster has shown that in families with manic-depressive insanity he found seven with exclusively manic-depressive insanity in the ascendency, and in none of them any cases of dementia precox; in eight families with several cases of dementia precox there was no case of manic-depressive insanity. This article (*Monatsschrift für Psychiatrie und Neurologie*, April and May, 1901) is worth quoting for the purpose of possibly dissipating a number of traditional illusions of the frequency of heredity and of the relative value of factors and as an instance of what precautions are needed for valuable studies in this field (see especially Rosanoff, Dissimilar Heredity in Mental Disease, *Amer. Jour. of Insanity*, vol. lxx., pp. 1–106).

The Data of Individual Etiology.—Looking over the determinants of make-up and of deviations of life implying mental disorders, we again meet with the problem of heredity in most writers. At the present stage of biological knowledge, especially in view of the facts collected by Weismann, we see in the liberal use of principles of heredity little more than the term for the unknown quantities in the concept of *constitution of the individual.* Constitution is the sum total of the make-up of an individual. Every good history of a case of mental disorder should give us accurate information concerning the make-up of the person before the complex constituting the disease or break of compensation was considered as complete. The types of make-up are approximately grouped as types of constitution, as far as possible without reference to the final event which is supposed to enter only under definite additional influences.

The concept of constitution has come into discredit because pathology has been more fortunate in detail work than in this general problem. Kraus and Martius have finally put it on truly pathological foundations, *i.e.* on principles which can be understood from what is accessible to study, and does not need the designation from a merely *possible* result (as, for instance, in the term apoplectic constitution; we should not speak of an apoplectic constitution, but of the presence or absence of arteriosclerosis). Kraus has pointed to the tests of fatigability as an index of the constitution of the heart; and Martius to similar types of function in the stomach, and more directly in our field we find the study of individual types of neuromuscular reactions taken up by the schools of Kraepelin, Sommer, etc. They are only fragments though but a no longer mystical attempt to bring a useful order into the descriptions of the make-up which the clinician already distinguishes as types of instability, etc. In ordinary language, we do well to look to the nature and extent of the development, the habits and the efficiency, as the chief features of the constitution of an organ or an entire person. The features of comparison must be chosen somewhat arbitrarily, but preferably among items which can be brought in line with other biological facts, constituting diseases. Thus, the pathologist will arrange people from points of view different from those of the moralist or the artist or the ordinary statistician.

Psychiatry has done little in the differentiation of types so far. It limits itself to the general classification as to whether a person is neurotic or not. We need further subdivisions. Even Kraepelin supposes that one developing paranoia must show from the start traits different from those of the hysterical or the manic-depressive. In a general way, our hope for clews lies in the direction of studies like Kraepelin's (mainly from the point of view of fundamental characteristics of neuromuscular and mental reactions studied under the influence of fatigue, practice, toxic interference, etc.); further, in the direction of studies concerning the influence of variations of habits and functions of other organs on the nervous system, the ease of reaction to toxic and autotoxic febrile influences, and the existence of types of abnormal metabolism, such as may perhaps lie behind the group of facts covered by the claims of the uric-acid theory. And for practical orientation we use characteristics like those of sociability or seclusiveness, efficient and systematic or desultory nature, determination or oscillation, social or antisocial instincts, normal or abnormal sexual life, the existence of definite psychic peculiarities and defects, etc. For practical purposes and for possible avenues of research all these features offer problems nearer those of fundamental individual pathology than the theories of heredity can offer, because they are present in the available subject of our study, the patient.

A remarkable increase of precision in the analysis of constitutional make-up has been gained during the last decade through the study of the characteristics of persons affected later by manic-depressive and schizophrenic psychoses (Hoch, Kirby, etc.); but the greatest advance came through the work of Freud, Jung, Adler, etc., in their efforts to explain the character out of the *factors of individual evolution.*

The other factors which are necessary to make complete the conditions for the development of mental disorders are in about the order of their frequency: direct and indirect toxic effects of alcohol and other poisons; direct or indirect consequences of infectious conditions; direct or indirect damage of the nervous system by senility, organic lesions, etc.; and effects of exhaustion, or the occurrence of excessively dominant preoccupations. However vague some of these general designations may appear, their usefulness in modern mental pathology makes them a worthier subject of investigation than are many high-sounding speculations. The article on etiology will enter more fully on this topic.

The Pathological Value of the Evolution of Symptom Complexes.—The data of this part of psychopathology are to be found in the fields of clinical investigation and postmortem manifestations.

In reality, most of the components which determine mental diseases belong already in the field of symptomatology, *i.e.* of manifestations of abnormal conditions. A further point for consideration, a very important one, is the form of termination which closes the working of the disease principle. From the sum total of the manifestations and their causal evolution we are accustomed to derive an abstract principle of the "disease type" or "disease process." To this is referred the whole string of events which we have reasons to designate as abnormal.

At first sight there seems to be a formidable chaos before us, especially when we find ourselves under the influence of a feeling of inadequacy produced by the older efforts of school psychiatry in these lines. Their abstract half-philosophical classifications do not fit into the ways of thought of the physician. Hence the traditional sigh: There is no pathology of insanity as yet. In reality the conditions are not at all hopeless. The experimental neatness of bacteriological pathology makes us too fastidious and perhaps also too lazy to develop standards and methods of other lines of pathology, such as are needed for the pathology of the skin, or of the kidneys, or of the liver, or of digestion, where more than bacteriology and also more than histology is needed to reach the standards of experiments. What we know of the pathology of the

various forms of Bright's disease, or of cirrhosis of the liver, or of diabetes, or even of the condition of development of some forms of pneumonia, is not a particle clearer than are the few facts which we possess for the appreciation of delirium tremens, or general paralysis, or even dementia precox, although we can boast that our inventory of distinctive manifestations is rich in palpable and also microscopically magnified post-mortem findings. The anatomical findings are as much in need of a "pathological" explanation as are all the other manifestations. Just as in many diseases in which mental reactions are not involved, the establishment of causal chains of so to say experimental strength is not far advanced in psychiatry; but there are valuable beginnings and there is much material for a natural and useful classification of the deviations from the normal and a good start for a "mental" pathology.

This is, of course, excluded if all the work is limited to grouping the features according to the scholastic division into mental symptoms, and functional (dynamic or physiological) and physical or morphological manifestations without due consideration of their evolution. Attempts are usually made on the "physical" side, and the data on the "mental" side are classified and arranged logically, but not sufficiently as part of the whole economy. As soon as we analyze mental facts we follow the path of least resistance and think more of logical justification than of their relation to the trend of individual biological adaptation. We get satisfied with the fact that a depression is not adequately founded; that voices are heard or things seen which are not there, that the patient is suicidal or dangerous, etc. In other words, we adapt ourselves to be satisfied with what the judge needs for the commitment. We see, however, no reason why we should not embody the reactions of the individual which happen to have the quality of mental reactions, in a general plan of human biology, with due recognition though that morphological facts and physiological facts and mental facts are recognized from different standpoints, overlap, and must be reduced to a common denominator of biology before they can be material of a harmonious pathology of experimental accuracy. Even without an ideal simplification, we can establish sufficiently valuable strings of facts which will make a decided improvement over mere resignation.

The analysis of a large number of faithful records of cases of insanity furnishes certain natural groups of almost identical conditions. The similarity may lie in the constitutional make-up, the etiological constellation, or in the temporary symptom complexes, or in the general course with reference to sequence of symptom complexes, or with reference to the outcome of the whole process and the events in the subsequent life of the patient. Where there is a coincidence of the main points in all the five directions we have every reason to surmise a definite law of development, especially if the type occurs often enough to free one of the impression of chance. Where three or only two of the directions coincide, we have at least reason to search for the value of the points of coincidence as compared to those of difference.

Our habit of seeing in the successful experiment the proof of an empirical claim leads us to give very strong prominence to the *etiological constellation*. The difficulty of establishing it is, however, not small. Not only do we often fail to get the necessary accurate information, but even where the conditions develop under our eyes we often fail to be able to foretell what the effect and the outcome will be, on account of the acknowledged personal differences which we are not able yet to estimate with more than approximate accuracy. The most common illustration met with in practice is that of alcoholic insanity. From the mere pathological forms of intoxication to the delirium tremens, and the subacute alcoholic hallucinosis, and finally the chronic alcoholic paranoia and the alcoholic polyneuritic psychosis and pseudo-paralysis and alcoholic senile affections, and recurrent "alcoholic" mania, or "alcoholic" dementia precox, we see the factor alcohol enter a number of sets of constellation with a rôle of variable importance, and we see clearly that the etiology cannot be exhausted by one factor. It is a complex function of one or more determining factors with definite types of make-up and temporary or lasting conditions (such as gastritis, or states such as are characteristic of epilepsy, periodic insanity, or dementia precox or senility), the coexistence of which makes the condition more complicated but in principle at least none the less as clearly accountable for the consequences as if only one factor were needed for an experimental test.

The value of *symptom complexes* as such has probably been overrated at various times. Some of them have caught the attention as typical because they seemed plausible and were easily described and communicated, from the point of view of the normal, such as depression, etc. Others are refractory and scarcely described in most text-books. As such, the value of symptom complexes for the estimation of pathological processes cannot be tested too carefully. Even short experience shows that apparently identical symptom complexes occur under so variable conditions that conclusions drawn from a temporary picture as to etiology and outcome and the general nature of the conditions are apt to be guesswork. The most valuable determining feature is, as a rule, the *form of evolution* of the complex, the time and duration and circumstances of its development, and the character of possible transformations of the picture. The great wealth of forms does not exclude the justification of the hope that at any given moment we may learn to find features characteristic for definite special types of evolution, such as we see in a certain kind of disorder of the sensorium, in certain acute delusional episodes, or in monotonous and strained productions in hebephrenic and catatonic excitement different from the excitement of simple or recurrent mania, etc. Distinctions will strike us only if they are suggested by definite *demands* for distinctions built on the experience concerning types of definitely known etiology and evolution. In the evolution of the symptomatic phenomena the *form of the outcome* is probably next in importance to the etiology, inasmuch as it furnishes an index to the amount and nature of damage done. Classical instances are general paralysis and Kraepelin's manic-depressive insanity and dementia precox. These three groups show moreover, that in each entity, the forms of the symptom complexes may appear variable, superficially at least, unless we consider their evolution, which is more likely to bring out the features characteristic of just one typical form of general course and outcome. General paralysis with its fairly established etiological constellation and its almost uniformly demonstrable dementia and neurological disorders and fatal termination offers a large variety of symptom complexes which we can grasp correctly only if we are familiar with specific traits that characterize the disease as a whole and especially the *form* of dementia and its combination with disturbances of the nervous apparatus proper, about which even remissions simulating recoveries cannot, as a rule, deceive a trained diagnostician. And manic-depressive insanity certainly shows us that a disorder strikingly characterized by its run in definite attacks with little tendency toward dementia offers many equivalent symptom complexes of greatly different appearance, but nevertheless must be recognized as at least an empirical entity, with fairly distinct fundamental symptoms. No form shows better how much more fundamental symptoms mean for pathology—*i.e.* an understanding of the bearing of a disorder—than

this one contrasted with the mere superficial divisions into "mania" and "melancholia," the "attendants' diagnoses" of most statistics.

On the other hand, it is questionable whether, in dementia precox, there are any psychobiological reactions or mental or behavior symptoms which would give us a definite indication of the localization and the amount of deterioration of the brain in each individual case. Not even in general paralysis has it become possible to predict antemortem the localization and depth of the lesions, except where they were of a type giving neurological signs of hemiplegia, hemianopsia, etc. It is by no means certain that we could infer from the distribution of the lesion whether the case was one of simple dementia or of polypractic megalomania, or of a circular or paranoic type. And it appears to be equally improbable that one should be able to say whether a case was in a state of remission or not, since Alzheimer found the same condition of lesions in cases of remission as in other cases dying from some incidental disease. Southard infers from his findings in dementia precox that cases with lesions in the parietal and cerebellar region are catatonias and those with prerolandic lesions paranoid (*Am. Jour. of Insanity*, vol. lxvii., pp. 119–176); and Bleuler assumes that in dementia precox he can contrast the fundamental symptoms (special disorders of association and of affectivity and autism) and the accessory symptoms (hallucinations, delusions, the catatonic features), with the result that his schizophrenia embraces a much larger field than Kraepelin's dementia precox.

There is no doubt that during the last decade, the gradual elimination of the term "insanity" from our fundamental consideration of mental disorders has diminished our faith in excessively sweeping units of nosology. The Kraepelinian emphasis on the outcome of the disease as its principal criterium was a wonderful relief from the Graeco-Roman psychiatry and the attendant's diagnoses in vogue up to the end of the last century. But we do not need a new dogma of disease entities, and we place much more confidence again in synthetic conceptions of abnormal function and of anatomical disease processes. What clinical psychiatry has created as disease entities can to-day be accepted for what it is worth: We do not assume that the "patient" or the "case" must necessarily be pigeon-holed in one of a limited number of dogmatic classes or "diseases," but in each experiment of nature, we can single out fundamental and more incidental factors at work along more or less well-defined lines of break of compensation; a large number of the cases fall into groups with distinctive contrasts, and if twenty-five per cent. of the cases are not as distinctive, we try to be more discriminative and analytical rather than more dogmatic and violent with efforts at classification.

As a move in the direction of greater accuracy and justice to the case in hand, I may briefly sketch the present program used in the study and disposal of each case:

1. The study of the family tendencies (heredity plus social factors).

2. The constitutional make-up of the patient and the specific etiological constellation.

3. The determination of the psychobiological reaction type (see the problem of mental reaction types, mental causes, and diseases; *Psychological Bulletin*, vol. v., p. 245) and of the non-mental somatic factors.

4. The determination of the special anatomical, physiological or psychopathological process and our opportunities of modifying nature's experiment for the better.

5. The classificatory and etiological and prognostic position of the case.

The principal weight is laid on the recognition of any definite *type* of organic or functional disorder and among the latter the psychobiological disorders or mental mechanisms (see William A. White, "Mental Mechanisms;" The Journal of Nervous and Mental Disease Publishing Company, 1911) present a line of study which promises to humanize the field of psychiatry. It recognizes special constitutional tendencies, special types of reaction for defense and compensation, special types of break of compensation (the hysterical, obsessive, schizophrenic, manic-depressive, and paranoic substitutions) and the existence of more or less specific situations and conflicts offering openings for more favorable readjustment.

The Somatic Components of the Mental Disorders.—Any organ improperly used, exposed to irregularities and interruptions or overstrain of function is liable to disorders of regulation and breaks of compensation, etc., of the maintenance of its anabolism and catabolism or even its structure.

Such disorders may be merely part of irregular psychobiological adaptation (habits not compatible with any regular working of the individual organ, as in the relation of dyspepsia to improper feeding habits, or under the influence of frequent emotional crises), or part of more profound psychobiological disturbances (such as the deeply rooted psychobiological reactions of hypnotism, of hysteria, of catatonia, of certain epileptic reactions, or of states of overactivity or underactivity). The same deviations of balance may hold for the regulation of the heart activity under the burden of emotional orgies, the regulation of the sex functions under abuse or excessive use, etc. Or the organ may be primarily deranged by pathological processes like intoxication or infectious or vascular disorders and its share in the psychobiological integrations may become difficult, deranged or perverted (certain cases of thyroid disease; premature atrophy or removal of the sex glands; disorders of emotional stability in heart disease; vascular and infectious disorders of the nervous system). An intermediate and, in a broader sense, more or less all-embracing position belongs to the disorders of metabolism.

Whether these conditions act directly or indirectly, they naturally affect the psychobiological adaptations mainly when they interfere with the proper functioning or metabolism of the brain.

The most popular concept of somatic pathology in psychoses is that of autointoxication. Of the most comprehensive program evolved by Van Gieson in 1897 very little has, however, stood the test of concrete experience. The principal types of autointoxication accessible to-day are those of acidosis (in diabetes and in states of dyspnea) and of uremia. Indicanuria as a measure of gastrointestinal autointoxication or as a measure of abnormal catabolism in states of putrefaction and, according to Bechterew and others, in manic-depressive states, has not stood the tests of thorough quantitative studies (Borden). The condition of fatigue and exhaustion would seem to be far less clearly analyzed; it undoubtedly involves also the direct balance of anabolism and catabolism of the tissues especially in question. The dietetic deficiency theory of beriberi has been applied to pellagra (Voegtlin) and may play a rôle in central neuritis (see below). Improper proportions of amino-acids have been made responsible, but so far with little light on the psychoses as seen empirically.

The studies of the weight of patients naturally have a roughly empirical value. The weight is apt to decrease during an acute psychosis. When it begins to increase together with an improvement of the mental symptoms, the prognosis concerning the mental adjustment seems to be favorable, and unfavorable when increase of weight occurs without such improvement.

Albuminuria accompanying certain acute deliria,

epileptic and paralytic fits, etc., has been assigned to a direct cerebrogenic influence in the kidney by Köppen. It is more likely referable to agents affecting brain and kidney alike. All the other urinary findings (glycosuria, peptonuria, albumosuria, or propeptonuria (Pilcz) and acetonuria) are most probably purely incidental and casual and not causal.

The mental effects of the internal secretions have been described succinctly by Frankl Hochwart ("On the Relations of Inner Secretion to Mental Condition"). The extent to which Ludlam has pushed this line of interpretations makes one most conscious of the difficulty of explaining one unknown quantity out of other unknown quantities. On the other hand, the studies of Cannon demonstrating the rôle of adrenalin in fear and anxiety states and Crile's suggestions as to the share of the thyroid in emotional disorders make one look forward to gains along this line.

Metabolism studies in various diseases such as the contrasting non-deteriorating and deteriorating psychoses have so far given very heterogeneous and contradictory results (see the surveys of Allers in the *Zeitschr. f. d. g. Neurologie u. Psychiatrie*).

All the more expectation has been attached to the serological studies. So far the complement fixation of blood serum and cerebrospinal fluid in various forms of lues has proved the one very helpful gain; while complement-fixation studies in other directions (methods of Lewis Bruce, etc.) are still very problematic.

Another great field has been opened by Abderhalden's claim that it is possible to demonstrate specific ferments evolved whenever abnormal decomposition products from special organs enter the circulation. Unfortunately, both the methods and the ferment character of the agent in the reaction are still undecisive and the decision should be made on much more clearly experimentally controlled ground before the rather contradictory results are applied too categorically to the vague field of psychopathology.

Whatever the results and the developments may be, it will always remain a most important task to determine to what extent a change is incidental to the psychobiological function and to what extent it can have a leading rôle. It is conceivable that thyroid disease can play an autonomous or leading rôle; but it also stands to reason that certain states of hyperthyroidism, like certain conditions of gastric hyperacidity, can be incidental to emotional strains.

The share of *neurology* in the explanation of mental disorder which reached its climax in Wernicke's school, had its culmination in Kleist's attempt to explain the catatonic disorders as a disturbance of the frontal lobe functions. Apart from the fact that they conflict with Southard's claims, Kleist's most ingenious speculations rest on a very slender basis of facts and casuistics. They make one very conscious of a remarkable lull in the progress of brain physiology following the critical analysis of our knowledge of localization of aphasia and apraxia at the hands of Pierre Marie and von Monakow. Neither our knowledge of the neurones nor our knowledge of the neurone complexes and brain centers can save us from the most urgent task of this century, viz., that of creating an unprejudiced science of those biological functions which we may properly call the psychobiological integrations. With the advent of this chapter of "human behavior and the conditions of its normal and abnormal working," the "pathology of insanity" will no doubt become much more simplified and fitted into an acceptable frame of biology and general pathology.

Pathological Anatomy.—The following review of the pathological anatomy of mental disorders will give the essentials of the available neuropathological data. It is the fact that just in this direction relatively little has been achieved and that the little is difficult to understand, a result that gives food to the idea that "there is no pathology of insanity as yet." Under the sign of the cell concept, pathology has become, to perhaps an undue extent, a science of what is met with in the dead. To be sure, ordinary pathology also occupies itself with the living; but chiefly along lines which lead to an understanding of definite pathological lesions which we see fully only in autopsies, while the insane reach in death a stage of existence in which they are but slightly if at all distinguishable from the remains of the sound. Apart from profound idiocy, general paralysis, senile and organic dementia, and a few conditions which entail peculiar attitudes and consecutive deformities, the majority of the bodies of the insane furnish at the present stage of knowledge no data which would answer satisfactorily the question: What distinguished the patient from a person with the same physical ailments but sound mind? or the question put to me once by the foreman of a jury after a medicolegal autopsy, And what did you find on the mind?

Pathological anatomy must have been a field in which the physician had a right to seek refuge from the bewildering flood of dogmatism concerning the mental symptoms. It has, however, become fully as speculative as that of the dynamic and psychobiological side of man, and the assumptions of histopathologists who compounded their theories out of "tangible" material and data derived from anatomy, have certainly been fully as great and bewildering as the ones compounded by those psychologically inspired.

Normal neurophysiology and neurohistology have gone through very interesting and instructive phases during the last century. The memory of the up-and-down movements of dogmata should cure us of exalted expectations as to their maturity as exclusive guides and starting-points. The senseless use made of hyperemia and anemia of the nervous system for the purpose of explanation of pathological states, the endless misinterpretation of artefacts in histology, the shifting of the actual function between nerve cells, nerve fibers, and even the neuroglia—all this should caution us. It is not within the scope of the topic allotted to me to say what can be considered the safe data which had best be taken over into the new century. A sketch of some of the fundamental concepts is given in my "Critical Review of the Data and Methods of Modern Neurology," *Jour. of Comp. Neurology*, vol. viii., 3 and 4, and in a summary of "Morbid Conditions of the Nerve Cells" in Robertson's "Pathology of Mental Diseases," and in *Brain*, vol. xxii., pp. 204–327.

For didactic purposes the make-up of the nervous system has been reduced to schematic diagrams the importance of which is apt to be overrated, and has probably been overrated in that unparalleled popularization of neurology which we have experienced during the last ten years. Neurology has been revolutionized by the neurone concept; but the new structure does not hold in its most popular form. Serious attacks call for a return to that which is actually established after the dissipations in neurone-retraction theories and the like. Developmental and pathological facts in connection with simple histology furnish laws of *growth* and *trophism* of the nervous system. With reference to growth and trophism, we know something like "neurones;" but the *dynamic* (physiological) and psychic series of data is not traced to individual neurones yet, and much more likely is referable to whole *sets* of histological "elements." Parts of the morphological series have been prematurely correlated with parts of the functional series of facts, and this has led to the fetichism of memory cells, perception cells, etc., and to rash correlations of appearances of nerve cells, etc., with functional states. We have not arrived at a stage yet when we may give a correct and exhaustive description of the nature and happenings of the apparatus of biological plasticity, the nerv-

ous system, in concise statements of the "neurone" and its life. A "psychiatry of the neurone" is probably a preposterous notion, and a pathology of the neurone apt to be one-sided, and missing very important facts of neuropathology which can be grasped only if we speak of the nervous system as a *tissue*. The recognition of this fact in more than one way keeps us above the contest for and against the neurone theory and we are less in danger of obstructing our way by preconceived dogmatic ideas. To go on without a realization of the poor foundation of mere dogma would probably add to the disappointments of the last four years.

The nervous tissues are constituted of the derivates of the epiblast (nerve elements, non-differentiated cells, and neuroglia), and the mesoblastic vascular outfit, sheaths (meninges), and membranes of support. Moreover, the various parts are exceedingly heterogeneous both in the general texture and in the structure of the constituent parts, far more so than holds for any other organ of the body. If there were not a remarkable constancy from individual to individual in the anatomical distribution of the tissue types and characteristic tissue elements, the very differentiation of the various parts would make it almost useless and even hopeless to try to enter into great details in a general pathology of the nervous system. It becomes almost of necessity a *special pathology* of the differentiated parts; and, indeed, this is what is furnished us by well-established neurology—the analysis of effects of special lesions in special parts with their immediate and remote consequences is the bulk of what is of value in pathological anatomy of the nervous system to-day.

In the first line we find the study of "secondary degeneration" of fibers; in some more studious investigators there is also a desire to know something about the fate of cell bodies belonging to the degenerating tracts. Further, we have good data on certain primary systemic degenerations. On inflammatory and other tissue changes beyond the minute local consequences of embolism and hemorrhage and injuries, and perhaps certain changes in myelitis and encephalitis, but little has become common property and safe knowledge of facts.

As soon as general problems arise, such as the pathological anatomy of paralysis agitans, we are led into a great deal of uncertainty, which is shown to exist because of the imperfect foundations for a general pathology; in this special case, because of an imperfect knowledge of the senile nervous system. And in the sphere of mental diseases we find ourselves even more at sea because changes are found and would seem to be of importance which have always been passed over by the neuropathology of the level of the Weigert-Pàl stain. Delicate newer methods have opened new paths and made great claims, and now it seems that they have not as yet been tried sufficiently in non-insane material to allow of a generally accepted discrimination of what conditions are normal or trivial, and what conditions are pathological and how they are produced. So much has been made of findings with the delicate recent methods that the "pathological anatomy" related to psychopathology would be forced to be to a great extent a critical review of the results of some special methods, principally those of the type of Nissl's stain, those of the type of the Marchi reaction, those of the neuroglia stains, and to some extent those of the metallic impregnations (Golgi, Cajal, etc.). They have proved very helpful in the study of neuropathology for the types of myelitis and of multiple sclerosis and other disorders of fairly definite standing; not to mention the consequences of embolism, thrombosis, and hemorrhage, and within the field of psychiatry general paralysis and senile dementia, topics which are to be treated in the articles on special pathology, and to which we shall refer only as far as the principles are involved. But where they dealt with conditions found in ordinary "non-organic" psychoses, the details lacked the large frame found in general paralysis, multiple sclerosis, etc., and the judgment of the investigators was frequently at sea on account of the absence of a suitable material for comparison.

After all, the data obtained by the inspection of the brain as a whole, especially its weight and the condition of the membranes, have not been altogether eclipsed by what the recent methods of staining reveal. Moreover, it might be of importance for a real "psychopathology" to add a study of the condition of the non-nervous organs which participate in the "mental diseases," if such material did really exist.

Several text-books of mental diseases attempt to give an anatomical and anatomo-pathological outline, but these chapters are only rarely helpful. They limit themselves frequently to the cortex, and to the things which appeal to the alienist, and often fail to show a good sense of proportion as to pathological concepts in general. It seems quite obvious that for a pathological anatomy of the nervous system all possible disorders, whether or not accompanied by mental diseases, must first be subjected to a sufficient study before the special cases which show mental disorders can be expected to furnish sufficient material for comparison. Such a general pathology and *general pathological anatomy of the nervous system* are growing but slowly. To-day, the best and most helpful books on mental disorders happen to be those which speak least in terms of anatomy and more in terms of function, and in this lies a very strong hint.

Averse to generalizations concerning the "neurone," we must leave the description of cell types and their reaction to the articles on nervous histology and general pathology of the nervous system. Since most of the data are in the stage of "uncorrelated facts," they must certainly be known to one working on the pathological anatomy of mental disorders, but are of no help yet in a general pathology of insanity. We give in the following summary a concise statement of what is likely to be a topic of discussion in *general pathological anatomy in connection with the insane.*

We do not know any disorders of nerve cells which could be considered specific for any special mental disorder, with perhaps the only exception of what may be seen in senility and idiocy. In idiocy, Hammarberg has demonstrated underdevelopment of cortical cells both in form and number; in senility we meet with usually pigmentary atrophy.

A great share of other disorders described in the literature are terminal affections, not directly connected with that which may represent the actual foundation of the psychosis *per se*. Clinically, too, we know that the dying insane patient is no longer merely "insane," but both physically and mentally his condition is different from the classical stage of the disease. What will be said here of cell changes and tissue changes is said without any reference to clinical correlations beyond what is explicitly stated.

With febrile agonal coma (as in pneumonia, etc.), we have learned to associate the "*acute alteration*" (of which Hoch gives a description in the *Journ. of Insanity*, vol. liv., p. 604), practically identical with what the experiment of overheating produces: reduction of the stainable lumps into dust and more or less complete dissolution, diffuse stainability of the cell plasma, so that the dendrites and the axone show for an unusually long distance, even in cells and cell parts which show almost no stainable substance normally; the nucleus is either not changed or is swollen slightly, or less frequently diminished in size. Among the chains of the linin net, especially along the nuclear membrane and near the nucleolus, there appears a greater number of deeply stainable and fairly large grains reaching the size of "accessory nucleoli," but more deeply stainable by hematoxylin than the nucleolus itself. In the nuclei in which a reduction in

size has occurred these grains are more numerous; the nuclei become darker and finally they assume a diffuse stain, and the nuclear membrane is apt to disappear. At the same time the nucleolus may grow larger and paler. In some of these cases the nuclei may show a fairly regular distribution of very sharp dots, while the membrane is hardly visible and the nuclear sap is delicately stained. These forms with darkening and diminution of size of the nucleus and usually crumbly decay of the cell body belong to the so-called *grave alteration*, which appears as a rule alone, *i.e.* distinct from acute alteration, and impresses one as a much more serious decay almost amounting to liquefaction. It resembles certain forms of post-mortem alteration, but must be upheld as an ante-mortem product, as it has been observed in fresh autopsies of general paralysis and tuberculous meningitis (Hoch). This and the acute alteration cannot demand more than general neurological interest, as they both seem to be terminal appearances not directly associated with what is usually included among mental diseases. Another incidental alteration is the rarefaction; a reduction of stainable substance without affection of the non-stainable plasma, visible, especially in some cases of senility and general paralysis, in the motor cells of the medulla and cord and in some cortical types, with or without pigmentary changes.

A further change of almost mechanical importance is that produced by edema, and described by Hoch (*Am. Journ. of Insanity*, vol. iv., p. 231) as "*shrinkage.*" It affects especially the smallest and medium-sized pyramids of the cortex and hardly ever the largest elements. The nucleus becomes homogeneous and dark and loses its membrane; the cell body gets a honeycomb or crumbly structure, the cell outline and nucleus are distorted and shrunken, whereas in some of the smallest pyramids the cell body becomes distended, vesicular. (See also Alzheimer: "Zur pathologischen Anatomie der Hirnrinde." *Monatsschrift für Psychiatrie und Neurologie*, Bd. ii., S. 96.)

A neurologically more fundamental alteration is the one which accompanies various types of myelin decay, analogous to what happens when a nerve fiber is cut near enough the cell body. This condition is extensively present in "*central neuritis,*" which is fully described in *Brain* (Part xciii., 1901). In the cases described there, the typical *axonal alteration* of all the largest cortical and other elements was present as a systemic parenchymatous affection and in fiber sets belonging to them the Marchi reaction showed decay of the myelin sheaths. As a terminal affection the condition deserves notice. It is summarized as follows:

1. Eight times in two hundred autopsies in which a microscopic inspection of the cortex took place a condition of bilateral changes of the nature of the axonal reaction in practically all the Betz cells was observed, accompanied by the same changes in other cell types and, where this was looked for, by decay of the medullary sheaths of some of the corresponding sets of fibers, whereas the characteristic disease of the tissue of general paralysis (gliosis, vascular infiltration, etc.), was absent. An extensive examination of large areas of the brain in three cases shows the existence of a partially systemic but widely distributed and strikingly symmetrical parenchymatous alteration of numerous nerve elements, chiefly of the cortico-thalamic connections of the motor area, the auditory radiation, the forceps, the pyramids, the fillet, the restiform body, and, to a lesser degree, the posterior columns of the cord, the intersegmental elements, and the segmental efferent motor elements. The change is that of axonal reaction in many of the large-cell types and decay of the myelin sheaths. Instead of the long descriptive term "partially systemic parenchymatous degeneration principally of the central nervous system," we propose the expression "central neuritis" in the sense of an equivalent of parenchymatous neuritis, but mainly of central distribution.

2. This alteration has been found to occur in peculiar forms of end stages of depressive disorders, near or after the climacteric period, alcoholico-senile and alcoholico-phthisical cachectic states, idiocy, and perhaps also general paralysis (Turner's case). Ordinary infectious and cachectic states do not, however, appear to form an important link in the causes.

3. Clinically, the symptoms are rather vague: after a course in which there is no suspicion of organic disorder there appear, more or less suddenly, difficulty of locomotion, increasing weakness for co-ordinated movements, rigidity and at times jactitation of the limbs, and disorders of the reflexes, often together with diarrhea and occasional febrile fluctuations; the mental condition in this terminal episode is either that of anxious perplexed agitation, delirium, or stupor, similar to a protracted delirium tremens. The nature of the disorder appears to be an equivalent of the general type of parenchymatous nerve-cell alterations, but, in distinction from the well-known infectious and toxic types of "polyneuritis," of pre-eminently central distribution.

It is by no means certain what the real connection is between the myelin decay and the cell alteration. There are in my collection a number of cases in which it would seem that there is a beginning decay of the stainable lumps between nucleus and axonal process, or all around the nucleus with an occasional full-fledged axonal alteration (this was the case in a patient who committed suicide in an attack of hypochondriacal melancholia), but without decay of myelin sheaths. The temptation is great to take these cases as initial forms and the "central neuritis" as the typical ones; but there are good reasons against such easy explanations.

The wide distribution of the change requires studies of most parts of the nervous system and warns us against a premature limitation of the attention of the alienist to the cerebral cortex only.

Intermediate between these chiefly parenchymatous alterations of nerve elements, and the prototype of real tissue disorders, such as constitute the classical picture of general paralysis, there are a few conditions, in which the *neuroglia* plays the important part. Alzheimer has described in melancholia the existence of fibril production in the neuroglia cells of the deeper cortical layers, where the average brain shows no fibrils. He has also shown that in the cases of acute insanity which pass by without defect, such as conditions of exhaustion and delirium of fever, the glia remains essentially passive, even in very grave cases. In psychoses of intoxication, the reaction of the neuroglia is more active; even in very acute cases this can be seen by numerous mitoses, rather than by formation of fibrils for which there may be no time. In the processes of deterioration there is a decided increase of glia with growth of fibrils but apparently limited to certain parts of the cortex only. The newer methods of Alzheimer have indeed furnished interesting findings of *ameboid glia* as characteristic findings in dementia precox, without, however, furnishing any clue as to the probable position of these effects in a well-defined general-pathological frame which would tell us whether the change is incidental to an essential deterioration of the brain or the result of an exogenic or somatogenic poison. In general paralysis the well-known overgrowth of neuroglia is general; in senile dementia it shows, moreover, a tendency toward appearance in foci depending on vascular distribution; in epilepsy it implicates chiefly the surface.

We can largely corroborate these data, but we must add that excessive proliferations of neuroglia (free nuclei or satellites) around nerve cells especially of the deeper layers of the cortex have been described frequently as effects of over-eating, starvation, as

phagocytosis, etc., and that it would be unwise to accept Alzheimer's first distinction before those matters have been subjected to experimental tests. In my description of this condition (*Journ. of Insanity*, vol. lii., pp. 246–249) I still shared the error that these free nuclei might be leucocytes. I cannot see more in it than a reaction to nutritive anomalies, as is especially shown by Lubimow's experiment on starving dogs.

This condition leads over to *reactions of the tissue as a whole* and finds its prototype in the alterations in general paralysis, to be treated elsewhere. Suffice it to say that it probably represents two types of pathological changes: (1) The more or less systemic degeneration, especially of terminations of fibers or at least their parts rather remote from the cell body; types of this are the frequent tabetiform degenerations of the posterior columns of the cord, and, in part, the degeneration of the lateral columns. The latter and the diffuse degenerations which Starlinger demonstrated with the Marchi method stand midway between this primary (toxic?) degeneration and (2) the degenerations which depend far more obviously on disorders of the tissues as a whole, with early changes in the vessels, the neuroglia, the intercellular substance and many cells, and a general disturbance of the normal orderly stratification and orientation of the elements. The demonstration of *Spirochæta pallida* by Noguchi in Moore's specimens does not clear up the problem altogether. Nor do the amplifications of our knowledge of the senile brain (Alzheimer's disease and Redlich's miliary sclerosis) furnish new explanatory principles.

All degenerative disorders, if they last long enough, lead to conditions which can be used as *macroscopic indices of lesions* in various parts of the nervous system: thickening of the membranous and vascular apparatus and of the envelopes of the brain generally, and reduction of the mass of brain substance in the shape of general or localized atrophy. E. E. Southard's findings of focal atrophies in a fairly large number of cases of dementia precox and also in eighteen per cent. of the cases diagnosed as manic-depressive psychoses are as yet unexplained. The conditions of the scalp, calvaria, dura, and pia are described in Robertson's "Pathology of Mental Diseases," with such detail and care that the reader can be referred to that treatise with the remark that the whole complex of data can at best be a fairly useful index in autopsies, but is not promising of fundamental clews from the point of view of true general pathology of insanity. It is too much of the nature of a side product, but as such a strikingly faithful reagent, which must not be taken too lightly. So far, however, next to nothing that would throw any definite light on the nature of mental derangements and of the actual degenerative processes that are at work in the nervous system, has been gleaned from the study of the minute anatomy of the *membranes*. It seems that where the disorders of the membranes occur, whether with or without mental derangement (as in simple chronic alcoholism), they are always of essentially the same type. The condition of *hemorrhagic membranes of the dura* also is not different from what is seen in chronic alcoholism, or ordinary senility, trauma, or cachexia, although it occurs more frequently in senile dementia, general paralysis, alcoholic insanity, and epilepsy, a product of retrogressive changes combined with reactive overgrowth of endothelia of the dura, involvement and new formation of blood-vessels and organization of extravasations, and perhaps oftener connected with trauma than is usually admitted.

The condition of the *skull* is very variable. The most frequent anomalies are senile dystrophies, especially irregular or strand-like hyperostoses of the frontal bones with increased adhesion of the dura. There are no sufficient statistics available concerning these findings in those not insane.

A topic usually included in the pathological anatomy of mental diseases is the *othematoma*. That cystic degeneration of the ear cartilage is more frequent in cachectic insane persons cannot be denied. But a careful observation of the cases under my observation has shown the hematoma to be invariably of traumatic origin, and I have not seen a case yet in which trauma was excluded. Consequently it has little bearing on the general pathology of insanity.

The work of Robertson and that of Berkley contain extensive discussions of the *vascular lesions* in insanity. This is a chapter of pathology of the vascular apparatus in general, and apart from special disorders such as atheromatosis and the syphilitic and metasyphilitic and traumatic alterations of but little correlated value. Here again we feel the great lack of material derived from non-insane individuals for comparison, which must form our foundation. A prolonged study of these matters has made me so strongly convinced that the problems must come from the study of the living and not from the dead, that I consider a discussion of these details a waste of space and time for all who do not work on them specially.

There remain the gleanings from the nervous system in the directions of *general conformation, weight, and chemistry*. The first shares the verdict of what has been said concerning the stigmata of abnormal development. The beginnings made by Mickle, meritorious as they are as collection of facts, will be of little comparative value until we know something of familial comparability of brains, and of the determining factors in the growth of specific varieties of fissures of the brain, or, at least, until the material for comparison supplies sufficient data concerning the constitutional value of the "normal" bearers. This is so difficult and laborious a task that it will probably not be attacked very soon.

A similar statement must be made concerning the weights of brains. From the largest series of brains (that of Boyd, who compares 2,086 brains from a London work-house with 725 brains of insane persons), Donaldson concludes that the insane are not a class with a characteristic brain weight. It is true that in senile dementia and in general paralysis a striking loss of weight is noted, and that the loss refers probably more to the frontal lobes than to other parts. But these are matters of special pathology of these two disorders. Personally I do not expect anything from the summary statements, especially those made concerning the whole promiscuous mass of "the other psychoses." Before generalization comes, even if made on such excellent observations as Forel's and Meynert's, there should be more discrimination among the mental disorders and the distribution of lesions, and some sort of a possibility of knowing what amount of brain matter is to be expected in an individual of definite size, age, and attainments. It is possible that Bolton's measurements of the layers of the cortex in the insane and an application of Hammarberg's cell counts will prove more fruitful.

Concerning specific gravity and even chemistry, little is available that is not much better expressed by easier methods of observation of abnormalities. There is one noteworthy series of studies on the presence of cholin in the cerebrospinal fluid, by Halliburton and Mott, which shows cholin to be in proportion to the amount of myelin decay and which may give valuable *intravitam* evidence in time—a claim which has, however, been withdrawn by its authors. More interesting results are promised through the researches of the late Waldemar Koch and his sister. The latter's investigation of pellagra brains strongly points to a nutritional deficit similar to that occurring in beriberi, and most probably also in the "central neuritis" mentioned above.

This general statement of what the anatomical symptomatology of insanity furnishes in the line of data for a general pathology of insanity must appear negative to the one who adheres to the common belief

that pathological *anatomy* is more than a possible help for pathology, or that it is even the "pathology" itself. To uproot this superstition will be one of the first tasks of this century. It is to be hoped that with better insight the idea will disappear that the temporary fruitlessness of mere pathological anatomy implies the verdict that there is no pathology of insanity as yet. What makes pathological anatomy so valuable in many other disease groups is that the field was ready to give a frame for distinctions; and these distinctions, already foreshadowed by the clinical evidence, happened to be more easily demonstrated anatomically. But where anatomy furnishes fewer distinctions than *intravitam* observation does, pathology must penetrate the most promising points with relative resignation concerning anatomy. This does not imply that anatomical research is hopeless. It certainly must be carried further on the ground of a general pathology of the nervous system, and with guidance from clinical psychiatry, as an essential part of psychiatric phenomenology.

The Malpighian question "ubi est morbus," *i.e.* where is the point of attack of the disease, urges us to look for greater clearness in the question of correlation of function with special mechanisms of the nervous system. In this direction the pathology of aphasia and of focal lesions will be of great help, and it is possible that Flechsig's data concerning the growth and maturation of the fore-brain will prove of use. On a material of forty-eight hemispheres of twenty-eight brains from the seventh month of gestation to the age of fifteen months, he has ascertained the time of medullation in various parts of the cortex (*Neurolog. Centralblatt*, November, 1898, vol. xvii., pp. 977–996) and found forty areas which can be distinguished by the phenomena of growth. It remains a task of the future to show how great the bearing of data of growth will prove to be for data of function.

For some time to come, psychiatry will have to work on the "special pathology" of the disorders that it meets. To show that this is possible is the purpose of this article; to bear it out, the task of the special articles. A more helpful general pathology depends on more accurate data of special pathology.

Adolf Meyer.

Mental Diseases, Prognosis of.—Thurnam's frequently quoted paragraph giving his conclusions from a generalization of the histories of the patients at the York Retreat, which has stood the test of time, will best introduce this subject. These histories possess especial value, as he was able to trace the after-history for the rest of his life of every patient who had been at the retreat. He wrote: "In round numbers, of ten persons attacked by insanity five recover and five die sooner or later during the attacks. Of the five who recover not more than two remain well the rest of their lives. The other three sustain subsequent attacks during which at least two of them die."

These statistics barely approximate the truth, and are open to several objections, the chief of which is that they represent hospital cases only, which are most likely to be of the severe, difficult, and chronic variety. They cover therefore but part of the ground, and a different idea of the prospect of cure would prevail if the undoubtedly large number of cases—chiefly of the melancholic type—which recover without going to a hospital or even (as Blandford believed) to a doctor, could be included. At the same time these results are instructive and sufficiently accurate to enable one to make a fair estimate of the termination of mental disease in general. They show plainly that a fairly large proportion of patients have incurable forms, characterized in the main by a succession of attacks which are followed by temporary returns to a degree of rationality sufficient to warrant the name of "recoveries."

Heredity.—The chief element in the prognosis of mental disease is faulty heredity. This is the most prominent factor in the causation of idiocy and imbecility and of the different forms which degenerative mental disease assumes. Those included under this head are: paranoia, manic-depressive insanity, circular insanity, the constitutional psychopathic states, including congenital neurasthenia, pronounced psychasthenia, contrary sexual instincts, and moral insanity; some authorities would add dementia precox. When any of these conditions are unmistakable the disease is sure to be of the chronic type, whether its progress is uniformly degenerative or manifested by periodical attacks.

It is not an uncommon belief among non-medical people and even general physicians that the inheritance of insanity means impossibility of recovery in any sense from an attack of mental disease. On the contrary, so far as the attack goes, certain strongly hereditary cases make, as has been shown, good recoveries, although they are more liable to relapse than are those in which the hereditary tendency to disease of the mind is absent. A bad family tendency to mental disease may be shown in actual and marked insanity of certain members, while the rest are sound and strong and appear to have the normal amount of resistive power to disease. This, however, is a better inheritance than less distinct mental disease and more unsoundness and a low state of mental and bodily health *in the family generally* in the forms, for example, of various neurotic disorders, convulsions in childhood, weak-mindedness, bad habits and propensities, and physical defects.

Importance of the Form of Mental Disease.—If we analyze the cases which are characterized by a succession of attacks with intervals of apparent "recovery," we shall find two classes of patients, one in which the attacks occur very irregularly and are of a variety of forms—excitement, depression, stupor, confusion, etc.—modified, it may be, by other conditions, such as katatonia or catalepsy. Moreover, the succeeding attacks are rarely of the same kind. In these patients the interval of so-called recovery is of the nature of a remission of varying length, and the mind, though sometimes clear and apparently sound, very rarely returns fully to its normal condition, and in the succeeding intervals becomes more and more impaired until, in the majority of cases, complete mental disorganization or dementia closes the scene in a few years. These are the cases of dementia precox.

In the other class the attacks are usually relatively short (from six to twelve months); they occur in the main at fairly regular, periodical intervals; the symptoms are seldom other than exhilaration, excitement, or depression, and the intervals are characterized by complete return to reason and normal health. These intervals are in some cases of long duration, lasting it may be for years, while in others the attacks may recur every month or even oftener. In many instances the combined duration of all the attacks represents but a small proportion of a patient's lifetime. It is safe to say that, excepting in the circular type, *i.e.* in cases in which the opposite states immediately succeed each other, it is only a minority of cases of this form in which the attacks occur within two years of each other, although they are likely to recur more frequently with advancing years. It is, however, impossible to predict the length of the intervals, as they are more or less irregular, although it may be approximated after several attacks have occurred. This is the form known as manic-depressive insanity.

It is obvious that the difference in the outcome of these two varieties, in typical cases, is a wide and important one. At the same time it is sometimes exceedingly difficult to distinguish between them before a second attack has occurred. Nothing can emphasize more strongly than these groups of cases the necessity of a correct diagnosis as a preliminary to

even a fairly accurate prognosis in mental disease. These indications are fully considered in the special articles on the manic-depressive psychosis and dementia præcox, where will also be found the prognostic indications relating to the subordinate states of mental disturbances, such as excitement, depression, stupor confusion, and the like, which distinguish these diseases.

General paralysis of the insane, also known as paretic dementia, general paresis, and popularly as "paresis," when once fully developed is, it can be safely said, invariably fatal. There are, to be sure, a few, very few, examples of recovery reported by competent observers; but they are not by any means incontestable, while the usual alleged cures are either due to faulty diagnosis or are the result of premature conclusions during some remission in its course. The disease has certain features alluded to in but few text-books, the proper interpretation of which is essential to a correct diagnosis. It is a frequent experience of the alienist to find that favorable prognoses have been made in cases of general paresis by general physicians who have mistaken for ordinary mental disease attacks of "mania" or "melancholia" that are really of paretic origin, and which, far from being idiopathic, functional psychoses, are simply symptomatic groups or syndromes occurring in the course of the grave structural disorder of the brain—general paresis. As the psychoses which are characterized by "manic" or depressive symptoms have similar manifestations, whether occurring independently or in the course of general paresis, it is not surprising that such errors occur where the opportunity for observation is necessarily so limited as is the case in general practice. It is also a common error to mistake the incipient stage of general paresis for neurasthenia or hypochondriasis, so closely does it simulate these disorders in many cases. The consequent prognosis may lead to serious results, for, as Berkley points out what slight hope there may be in the treatment of paresis can obtain only in those cases in which the therapeutic measures are undertaken in the earliest stage of the affection; added to this, its early recognition is necessary to protect the family of the patient from serious ethical and financial misadventures as well as from possible brutalities.

The duration of general paresis is often perplexing; and although we may rightly say in the majority of cases that the end may come at any time within three or four years at the furthest, from the onset of active symptoms, according to the kind of care the patient receives, the nature of the attack, or the severity of the intercurrent affections to which it predisposes its victims, there is considerable variation in the length of its different stages, whether of remission or of progress. We also meet occasionally with surprises in the way of temporary recuperative changes, both mental and physical, which are little short of startling, and which it would have seemed folly to predict. When convulsive seizures are frequent and are a marked feature from the first, there is danger that the patient will be cut off by a series of them in the form of the epileptic status.

But it is the stage of remission in general paresis which is responsible for most of the mistakes of diagnosis and prognosis that are made in this disorder, as only the trained observer can find evidences of mental failure in many of these patients, who at this stage may appear to their relatives to be entirely well. That, however, an exacerbation is sure to follow sooner or later, in spite of this apparent return to health, and that only by the most careful and quiet living can it be long delayed, is the only opinion to be given that is consistent with fact. It is often months, and occasionally years, before the signs of degeneration recommence and our prognosis is finally verified.

Alcoholic mental disease is usually of comparatively short duration, ending in complete recovery; but when persistent delusions of persecution develop, an unfavorable prognosis is indicated.

The time of life at which a psychosis occurs may tend to modify the prognosis. As in physical so in mental disease, the young, especially females, are far more likely to recover than the mature, especially the old. It has been estimated that sixty-three per cent. of the "recoveries" from mental disease take place before the age of twenty-five. At the same time the young are more subject to relapses, and it is at this time of life almost exclusively that dementia præcox appears.

The menopause is another period of life at which many cases of mental disease recover; but the disorder is usually of long duration, not ending until the cessation of the menstrual function is complete. It must be borne in mind, however, that genuine "climacteric insanity" is rare, as cases in which the menopause is unmistakably the sole or even the chief cause of the trouble are far less common than is usually supposed. Melancholia of involution is now thought to cover most of these cases. Predisposition to mental disease occurring at this time, is the rule, but the condition is also largely due to diminished vigor of body and mind generally and the failure of the system properly to readjust its powers to meet changed conditions rather than to any local change.

Old age, on the contrary, is obviously the most unfavorable time for an attack of mental disease; but here it is death from exhaustion that is to be feared rather than death of the mind alone. Even at this time of life, however, there is risk in predicting that recovery is impossible, as it is among the aged that the marvellous cases are occasionally met with of complete cure of acute melancholia in which exhaustion seemed inevitable from the extreme agitation, depression, refusal of food, and consequent emaciation. Such miracles have few counterparts in physical disease.

The physical condition before the trouble begins is, if good, a less favorable sign than might be supposed, as it is the mild, slowly developing case with gradual and permanent mental deterioration in which the bodily health is but little disturbed. On the other hand, the acute, severe, rapidly culminating, and for the most part presumably curable cases are often preceded by a season of reduced physical health and strength and loss of flesh, which continues throughout the acute stage. The immediate cause of an attack, when well limited and appreciable, which is not often the case, indicates a good chance of recovery; for example, sudden bereavement, shock, accident, money loss, lactation, etc. Psychoses occurring during the puerperal state usually end in recovery and are of short duration. In primiparæ, however, the attack is sometimes the initial manifestation of dementia præcox.

Treatment affects the prognosis in no small degree, especially the time of its adoption, the patient's chances growing fewer the longer it is delayed. It is needless to emphasize by statistics this well-established and well-known fact of the importance of early treatment (not necessarily that of a hospital) away from home. The kind of treatment also has a decided influence; and the greater prevalence, both within and outside of institutions for the insane, of care and treatment directed to the needs of the individual patient, is sure to be a most potent factor in increasing the number of cures, or at least in preventing relapses and relieving the chronic cases. The practice which is still largely unavoidable in public institutions for the insane, of placing acutely violent patients in a perhaps overcrowded ward for obnoxious and equally excited patients in different stages and forms of insanity, as well as of different classes of society it may be, can but retard, if it does not actually prevent, recovery in many cases.

The Minor Conditions of an Attack of Mental Disease and its individual symptoms often tempt us to predict the outcome; but it is a hazardous practice. There are many, however, which it is useful to know when properly estimated—like minor symptoms of physical disorders—as simply corroborative indications. Of this order is the important prognostic point that is furnished by the way in which an attack begins, as in general a quick onset is often followed by recovery, excepting of course cases of *delirium grave*, otherwise known as typhomania and as acute delirious mania or melancholia, a form which is extremely dangerous to life, especially in old people. *Per contra*, a long antecedent period of mild mental symptoms or peculiar conduct betokens chronicity.

Another indication that is quite reliable is the familiar one that when improved nutrition keeps pace with the mental gain, as evidenced by the patient's weight, the chances of recovery are good, while an improved physical condition unattended by mental improvement, or *vice versa*, is a bad omen. Marked and protracted hallucinations of hearing, especially when they develop late; the creation of new words; the adoption of a pathological language, of a peculiar costume; a tendency to self-decoration, special attitudes, hoarding, etc., mean, as a rule, incurability. Incoherence and persistent delusions without excitement are usually signs of confirmed mental weakness. This is frequent in hebephrenia. Absence of the feeling of satiety, eating or drinking nauseous articles, are usually found in unfavorable cases. In continued sexual excitement recovery is rare; but the practice of masturbation, if discontinued, may not interfere with recovery.

Among the surest indications of recovery is the recognition of former delusions as such.

The intervals of calm and rationality which suddenly and unexpectedly occur, especially in cases of melancholia and the infection-exhaustion psychoses are very deceptive, and often tempt one to make a prognosis of speedy recovery that is soon found to have been premature. It is only when these sudden recoveries of reason follow a period of decided gain in sleep and general health that they are permanent as a rule. Generally speaking, the mind is clouded over again in a day or two, and the disease runs its course with renewed intensity. It is safe, nevertheless, to predict that *ultimate* recovery is probable in cases that are characterized by such intervals of rationality.

When hypochondriacal delusions are a marked feature of a case, the outlook is bad, especially if the subject is advanced in years.

Persistent refusal of food, especially when due to hypochondriacal delusions and when prolonged, is an unfavorable sign. Recoveries may occur in such cases, as in other extreme conditions; but they are as rare as they are surprising.

"Mild" cases of melancholia, which are apt to be treated at home, are very deceptive in respect to the probability of suicide; and the more rational the patient the more crafty and deliberate he will often be in carrying out his plans. It not infrequently happens in such cases that a desperate attempt at self-destruction is the first warning given the family or the physician of the suicidal propensity. Careful and frequent examination of the patient's line of thought will usually reveal the desire for suicide, after which it is a grave risk to attempt to give such a patient proper supervision at home. The desperate and violently determined melancholiac, whose efforts are constant and unremitting owing to the strength of the suicidal impulse and in whom there is little sign of reason, is doomed to dementia unless there be an early turn in the disease.

The suicidal tendency is often looked upon by people in general as a particularly ominous feature as regards recovery, whereas it is a frequent and logical manifestation of a curable psychosis—melancholia. The chief danger is, of course, to life, before proper measures for the patient's protection have been taken, after which his chance for recovery is quite as good as that of any case of melancholia without such tendencies.

Finally, the best recoveries are seldom perfect, and a large proportion fail to recover their former mental condition in full. As it has been well put by Folsom: "There is left some change of character, no matter how slight, some moral perversion, irritability, impaired will, lessened power of self-control, diminished mental capacity—some lowering of the intellectual or moral standard, some deterioration of some kind." This is also true of the physical condition, which in many cases never fully returns, and the power of endurance especially proves to be much diminished.

Regarding prognosis as to life, it may be said that, excluding the suicidally inclined, in relatively few cases is death to be feared as a direct consequence of mental disease that is not organic, *i.e.* general paresis, senile cases, and those consequent on focal lesions. The others are largely from one group—the infection-exhaustion psychoses—the form of death being exhaustion from continuous, intense, and often febrile excitement. Death is much more likely to take place in the beginning of an attack, as that is the time of greatest violence and strain. It is then, too, that refusal of food and suicidal attempts are most common.

HENRY R. STEDMAN.

Mental Diseases, Symptomatology.—The symptomatology of insanity is as varied in its expression as mind itself. Definitions of insanity in court or elsewhere are unsatisfactory for the reason that conciseness and clearness are well-nigh impracticable. Insanity is not a specific entity; it is rather an ever-varying symptom complex corresponding to many diverse underlying disease processes. It is extremely difficult to frame a simple brief definition sufficiently comprehensive to include the great variety of mental and physical phenomena encountered in the various types of mental disease.

Briefly, insanity may be said to be a prolonged departure from the individual's normal method of thinking, feeling, and acting due to functional or organic disturbance of some portion of the encephalon. The most striking general symptom of insanity, evident to the very superficial observer, is *conduct* which varies from slight peculiarity to extremely erratic and irrational acts. The insane person is usually in poor adjustment with his environment, his reactions to his surroundings are not those of the ordinary individual and lead to unusual or extravagant conduct. In order that these irrationalities in conduct may be understood it becomes necessary to delve down deeply into the patient's mind and ascertain the psychogenetic processes that are influencing his reactions. Not only does the pathological process within the cerebrum induce well-marked psychic phenomena, but certain physical changes are quite constant accompaniments of the disease. The persistence or permanence of these physical changes again depends upon whether the psychosis follows functional or organic brain conditions. The symptomatology of insanity then may be classified into two large divisions: I. The psychical. II. The physical or somatic.

It is also necessary to bear in mind that there are two large divisions of mental unsoundness, viz., (*a*) Idiopathic insanity or the insanity of the non-degenerate, or, as Macpherson characterizes it, the insanity of the slightly degenerate, for in nearly every case of idiopathic insanity the presumption is strong that there must be an hereditary predisposition; and (*b*) the insanity of the pronouncedly degenerate. In the former class are found the periodic insanities such as acute mania and acute melancholia occurring

in adolescent and adult life. In the latter division are found the congenitally deficient, the imbeciles, the idiots, and those moral degenerates whose vices and crimes often startle society. The insanity of the non-degenerate rarely ever occurs until after puberty, and sometimes does not develop until the stress of adult life acts as an exciting cause. The insanity of the degenerate, on the other hand, appears in those whose minds were never normally developed owing to congenital structural brain defects. There are therefore insanities that are functional in their origin, and still other insanities whose underlying cause is some congenital or acquired structural brain defect.

The custom at one time prevailed of classifying insanity according to its etiology, at another time according to its symptomatology, especially when the symptoms represented a changed state of the feelings. Thus there was homicidal insanity, suicidal insanity, impulsive insanity, and so on ad infinitum. Morbid exaggeration of the feelings afforded a basis of classification and a nomenclature founded on the prevailing emotion resulted. Depression long continued was called melancholia, prolonged exhilaration mania. It is obvious that changes in the states of the feelings are too evanescent to be made the basis of a system of classification. Under such a method every new symptom or group of symptoms, every change in the condition of the emotions sufficed to establish a species of insanity.

Again, the etiological basis of classification is misleading because identical symptoms frequently follow causes that are entirely dissimilar, and because the symptoms of one supposed type of disease so encroach upon those of another variety that the clinical characters are not consistent and the result is confusing to the mind of the student. Moreover, in many instances the causation is so obscure and unascertainable as to render a nomenclature founded upon etiological factors alone impracticable.

Recent progress in psychopathology, in the histology of the central nervous system, has modified our conception of the psychoses and materially changed our classification. The tendency is toward simplification. A single species of insanity takes the place of several under the older classification. The acute psychoses, melancholia and mania, are considered to be one and the same disease. Kraepelin's proposition to make the tendency of the underlying disease process, whether toward recovery or dementia, a criterion of the character of the psychosis is certainly helpful. His masterful description and separation of *dementia precox* from the varieties of mania, melancholia, and katatonia under whose symptomatology it had so long been obscured, his demonstration of its natural history, thereby proving that its various phases are but stages of one underlying disease process, is a most valuable contribution to psychiatry. Finally, the *neuron theory*, though still a theory, is sufficiently well sustained to illumine much that was dark and uncertain.

In the following brief account of the symptomatology of insanity it is proposed *first* to outline the psychic phenomena that accompany disordered mentality, whether of functional or of organic origin, and *secondly* to portray as briefly as possible the physical changes associated with the disease, including not only those physical symptoms consequent upon disordered function but also those more permanent physical stigmata the result of transmitted long-continued structural defect.

Psychical Symptoms.—Dynamic disturbance, either psychical or physical or both, is a distinguishing feature of all the psychoses. This is manifested in four ways: 1. Excitement; 2. Depression; 3. Enfeeblement; 4. Confusion. These four symptoms represent a disturbance in the general activities of the nervous system and are witnessed in both the psychical and the physical spheres.

Excitement.—States of excitement are accompanied by a heightened activity of all the nervous elements. There occurs as a result of this stimulation a marked feeling of exaltation, excessive egoism, intellectual activity proceeding to incoherence of thought and speech. There is an increased motorial activity of which we shall speak later. There are also hyperesthesiæ of all the special senses. Oftentimes there is marked acuteness of hearing, sight, and touch, which tends to heighten the intellectual and motor activities, and render the perception remarkably acute. In states of excitement the degree of stimulation may be so slight as to be scarcely perceptible, showing itself possibly in a slightly increased egoism or in an unusual loquacity with a diminished capacity of holding the attention to individual subjects or to customary pursuits, or it may extend to complete incoherence and wild furious outbursts of psychical and physical excitement. Excitement receives its fullest illustration in the psychosis called mania, but maniacal symptoms may appear at any time in the course of other forms of mental disease, as in paresis, in dementia precox, and in the insanities of degeneration. In states of mild excitement, cerebral metabolism may be only slightly increased beyond normal limits. In such cases elimination of tissue waste proceeds normally, digestion and nutrition are good, and the patient may take on flesh.

The neuron theory offers a plausible explanation of the condition. Diminished resistance with increased irritability of the nervous elements permits a flooding of the sensorium with innumerable sensory impressions and a consequent unrestrained outflow of nervous activity over all the efferent routes. This pathological release of nervous energy differs from normal activity in that all mental and physical action is more or less purposeless. There is a manifest inability on the part of the patient to hold the attention to definite subjects; the power to inhibit irrelevant lines of thought is so weakened or lost that discursiveness is a result. It follows that the patient laboring under morbid nervous excitement is able to accomplish little. Although busy from morning to night and frequently far into the night such individuals produce no tangible results. In its milder forms the patient is so excessively loquacious, so officious, and so fussily active as to be exceedingly troublesome. In extreme states excited patients may become destructive, absolutely incapable of connected thought, and in advanced and oftentimes fatal stages consciousness becomes obscured and automatic, aimless muscular movements alone remain. These latter symptoms are usually an indication that the nervous elements within the higher cerebral levels are exhausted, their functions suspended, and uninhibited cell action within the lower levels has full sway.

Depression.—Depression is exactly the reverse of excitement. The two conditions cannot exist at the same time in the same person, although they may alternate with each other. Depression is attended with a diminished metabolism in the nervous elements. There is reduced excitability and increased resistance of the cerebral neurons. Intellectual and physical activity are both diminished. Sensory impressions are reduced in number and owing to the poorer conduction fewer sensory stimuli reach the higher brain. In states of depression the patient lives within a limited world of his own. He sees and hears less than the normal individual by reason of the high resistance to the transmission of nerve energy over either the afferent or the efferent routes. There is therefore morbid concentration upon a few impressions, an inability to escape from dominant lines of thought and to project the attention upon new or even habitual subjects. Moreover, intellectual action is painful. Psychalgia in states of depression is as characteristic as is exaltation in conditions of excitement. The

patient loses hope and courage. Molehills seem mountains. Abasement of the ego is pathognomonic. There is retardation of thought due to poor conduction along afferent and efferent routes to and from the brain, and also because of functional dissociation between cerebral cells. Such retardation easily merges into negativism. In extreme depression few stimuli come to the brain over the sensory routes, the field of conscious thought becomes narrowed, the external world is more or less excluded, and actual involuntary resistance to impressions follows. The will power is too feeble to initiate or determine any sort of intelligent mental activity and automatic negativism results. The patient automatically resists every suggestion presented. Negativism has been well defined by DeFursac as "the annulment of a voluntary normal reaction by a pathological antagonistic tendency."

In extreme stages of depression, as in excitement, the functions of the nervous elements within the higher cerebral levels may become partially suspended. In these conditions consciousness may be more or less obscured; automatic movements and even stupor may prevail. While excitability of the nervous elements is lowered in states of depression, perversions of special sensation and local neuralgias are of quite frequent occurrence and serve to intensify the psychalgia. In extreme depression the diminished cerebral metabolism prevents removal of tissue waste, induces imperfect digestion with secondary intestinal autoinfection, impaired nutrition, and emaciation.

In the evolution of the acute functional psychoses depression and excitement are not now considered to be specific disease entities but parts of one and the same disease process. In the natural history of these psychoses melancholia or depression is considered to precede excitement, and in those cases in which excitement is the prevailing feature a brief initial stage of depression is said to occur. As long ago as 1865 Sankey declared that "mania and melancholia are simply stages of one disease," and called attention to the fact that Griesinger, Guislain, and Neumann had all advanced the opinion that classification based on the expression of the emotions alone was unscientific.

It is a fact that the two conditions, excitement and depression, both representing dynamic disturbances of such wide diversity, do succeed each other with such ease and frequency in the same person that one is constrained to feel that the underlying pathological condition is the same, only attended with varying emotional expression. Identical causes may lead to depression or excitement, or to both states in succession. Whether depression will be brief and excitement long, or *vice versa*, will depend upon whether there are increased irritability and diminished resistance of the neurons or whether there are lowered irritability and heightened resistance. There is a psychical reason why depression should precede excitement in the acute psychoses. Before alienation is fairly established, prior to the actual development of delusion and other intellectual derangement, the patient himself realizes the fact that something is wrong. Consciousness, being neither clouded nor exalted, discloses to the patient the fact that he neither thinks with his accustomed vigor nor feels the same as in health. Discomfort, dissatisfaction, induces mental distress which, though transient in many instances, is nevertheless real and constitutes the preliminary psychalgia characteristic of all the acute functional psychoses.

Enfeeblement—mental weakness or dementia—is, as its name indicates, a reduction of all the mental faculties from their normal vigor. There is diminished metabolism in the nervous elements. Retarded conduction along the various neural paths is an early symptom. There is a blunting of sensation. Fewer sensory impressions reach the higher brain through the different afferent routes, and those sensations that are transmitted from the periphery are so delayed in their passage as to make the interval between the external impression and realization in consciousness noticeable to the observer. Oftentimes several seconds elapse before a stimulation at the periphery reaches the higher brain levels. In like manner the passage of nervous energy over the efferent routes is similarly delayed. The mandates of the will are slowly and feebly obeyed. Reflexes are retarded or obscured. The intellectual processes are slow. The attention, the will, and especially the reasoning power are all diminished.

Mental enfeeblement is usually secondary to some antecedent psychosis. Generally speaking, all forms of mental disease that do not recover terminate in varying degrees of dementia. Cases of acute primary dementia so called are usually preceded by antecedent psychical disturbance, or occur in individuals possessing an hereditarily neurotic constitution. Ordinarily mental enfeeblement either occurs as a result of congenital defect (imbecility, idiocy) or is the termination of an acute functional psychosis, or finally it may be secondary to structural brain change the result of traumatism, arteriosclerosis, embolism, apoplexy, and the like.

The diminished irritability and retarded conduction of the nervous elements in dementia differ from similar conditions met with in depression. In dementia there is an actual degeneration of the neural paths, while in melancholia there is merely a temporary suspension due to functional disturbance. In dementia the cell structure within the higher brain levels undergoes deterioration. Consequently the lower levels are left to act without direction. Automatic action and the more purely vegetative functions of the nervous system supplant intelligent purposive action. Marked trophic and peripheral motor symptoms occur; to these reference will be made later.

Mental enfeeblement may succeed acute functional insanity quite soon and progress very rapidly, or it may appear tardily after many attacks and progress only to a slight degree, there remaining stationary for many years. Its early appearance after an acute functional psychosis and its rapid progression to extreme mental reduction depend upon constitutional idiosyncrasy. In some individuals the nerve centers resist this tendency to secondary degeneration, while in others they succumb quickly.

There is a growing conviction that tissue durability is an individual endowment conferred by heredity. "Every individual born into the world has, if it could be determined, a definite potentiality for development" (White[1]). It is not at all improbable that involutional melancholia, presenile insanity, Alzheimer's disease, and senile insanity are all the pathological expressions of the same underlying condition, viz., tissue ageing. Each individual has his own inherited limitations. Those who are fortunate enough in their inherited power for resistance pass through the various crises of life, such as teething, puberty, adolescence, the stress of adult life, the involutional decline of advancing years, without succumbing to the strain. Others less fortunate suffer cerebropathies from teething, founder on the "rock of puberty" or adolescence, developing an early dementia, or, if safely passing these dangers they enter adult life, succumb finally to a presenile decline. Dr. Joseph Shaw Bolton,[2] advances the theory that all epochal and degenerative insanities have an organic basis, and classifies all such as *dementia* and *amentia*. By *dementia* he designates "in the widest sense the mental condition of patients who suffer from a permanent psychic disability due to neurone degeneration following insufficient durability;" and by *amentia* he means those cases "suffering from deficient or subnormally aberrant neurone development." According to this theory all human beings at birth come under one of two classes: (1), those who are well endowed and have normal resistance, and (2)

those who possess deficient durability of nerve tissue, or an actual defect, an incapacity in nerve structure to develop normally. In either case there is a pathological handicap which sooner or later results in a more or less permanent mental instability.

One characteristic of the mental reduction of dementia is that it does not affect the mental faculties equally. Quite frequently some faculties are intact while others are noticeably damaged. Mental reduction usually occurs in the inverse order of mental evolution. Those faculties that are the last to appear in the natural process of growth are very apt to be the first to deteriorate in the dementing psychoses; moral and volitional stability show evidence of weakening before there is marked change in consciousness and perception which represent an earlier stage in the process of mental evolution.

Confusion.—Prominent among the dynamic disturbances of the central nervous organism in insanity is confusion. In health the nervous system is a delicately adjusted mechanism composed of numerous individual elements functionally associated with each other in groups. These groups are still further associated with others even more remote, and all are in a state of equilibration. Excessive action in one area encounters resistance from adjacent or remoter tracts with which it has been associated, so that the entire mechanism works harmoniously toward a given end. In states of depression there is increased resistance with diminished irritability of these nervous elements; in states of excitement there are diminished resistance and increased irritability; in states of enfeeblement, diminished irritability and conduction due to general deterioration of cell structure. In confusional states there is a dissociation of the different nervous tracts. Limited areas are cut out as it were. Neural pathways that in health were intimately associated are no longer correlated. The result is the utmost confusion in thought. A certain degree of confusion characterizes every variety of insanity. In confusional insanity there is profounder disturbance.

There is not only an incapacity for what Berkley calls the "power of serial thought," but there is more complete interruption of the intelligence. There may be exaltation and depression alternating with unusual rapidity in the same case, transient hallucinations, delusions very imperfectly developed, obscuration of the personality and consciousness, and finally automatism.

It is now generally recognized that the confusional insanities are all of toxic origin. The toxins of alcohol, of puerperal and other fevers, of septicemia and those that are developed from autointoxication are supposed to have a special affinity for the nervous system. Macpherson contends that toxins may even have the power to "select certain physiological neuron groups for attack." One group may be stimulated, another depressed. He concludes: "In normal conditions excessive functionating of one group of neurons is physiologically interfered with by the inhibiting influence of opposing nerve currents, but where this, owing to the irregular pathological nature of the process, is impossible, there result confusion of thought, disturbance or loss of the idea of personality, uncertain and impulsive action, and many other anomalies depending upon the intensity of the poisoning of the cortical cells, and the area of the elements involved" (Macpherson[3]). Homicide and suicide are occasionally attempted by persons in the toxic confusional state following alcoholism. Amnesia, submergence of the normal personality, and automatism usually characterize such acts. An analogous condition is met with in the *epileptic state*.

In each one of the conditions just outlined the ideation is fundamentally different. In states of excitement there is exaltation of the ego—a feeling of expansion predominates. In states of depression there is abasement of the ego—painful ideation prevails. In states of enfeeblement there is deficiency of ideation varying from the slightest impairment to the profoundest dementia according to the extent of the central cell deterioration. In confusional states there is disconnection of thought, a blending of all the symptoms encountered in the three preceding conditions due to the toxic interruption of function in certain brain areas.

Among the early noticeable and most persistent symptoms of acute or chronic insanity are those special disorders of the intellect—delusions, hallucinations, and illusions.

Delusions are so universally prevalent in nearly every species of insanity, are so persistent and striking a feature in the majority of cases that they were in the past and occasionally are at present regarded as a proper legal test of the disease. In 1800, at the trial of Hadfield, Mr. Erskine proposed the substitution of delusion for Lord Hale's absurd wild-beast test of insanity. He said: "Delusion, where there is no frenzy or raving madness, is the true character of insanity." This, however, like many other legal tests, is fallacious, for many cases of alienation exist in which no delusions can be detected.

In the early stages of mania and melancholia and in incipient dementia there may appear marked disturbance of the feelings, failure of judgment, and inability to appreciate the proper relations of things, but no evidence whatever of delusion. Such patients are manifestly elated or depressed, they may be extremely active in business, undertaking too many schemes, making foolish purchases or sales contrary to their previous good judgment; they may in countless ways manifest an inability to adjust themselves to the conditions of their environment, and yet on the closest examination fail to disclose a single delusion. These cases are often puzzling to the general practitioner and the laity generally. They may be very troublesome and even dangerous and require the restraints of a hospital, but their coherence of thought and speech, the absence of delusion, and their general good appearance tend to obscure the real condition which is one of failure of the higher mental processes. Notwithstanding the untrustworthiness of delusions alone as a test of insanity and responsibility, they are still in the majority of cases a striking evidence of intellectual derangement. When proven in court they are always convincing to judge and jury.

Delusion may be said to be a belief in some person or something that is impossible in the nature of things or that is inconsistent with the circumstances of the person who believes it. A man believes his legs are made of glass, is afraid to walk, run, or jump for fear he will break them. This would be a belief in something impossible in the very nature of things. Or a poor, ignorant laborer believes himself to be president of the United States, which would be a belief entirely inconsistent with his circumstances and condition in life. The difference, if any, between an insane delusion and a sane erroneous belief is that the sane person can be convinced of the falsity of his perception, while no amount of argument can persuade the insane man of the error of his delusive conceptions. As well might you attempt to dispel the pain from an inflammatory joint by argument as to induce the insane patient to give up his delusions. Regis insists that "there is not, properly speaking, any essential difference" between delusive conceptions of the insane and the errors of the sane, and that the delusion is separated from mere error only by its causes and consequences, which give it a pathological character never possessed by the other" (E. Regis[5]).

Delusions are the direct product of insane reasoning. They are false conceptions arising within the disordered mind of the patient either as a result of incoordinated central cell activity or in obedience to perverted peripheral sensory impressions. The patient, as a result of his impaired reasoning and without the slightest evidence, believes that his dearest relative

is his worst enemy, or a sensation of numbness and prickling in the hand leads him to infer that some one is charging him with electricity from a battery.

Delusions always partake of the character of the prevailing emotion. In states of excitement expansiveness characterizes the delusions. There will be delusions of wealth, great power, and a general feeling of elation. In depression exactly the reverse occurs. The delusions will be of painful character; there will be belief in specific imaginary acts of wrongdoing that are to be followed by terrible temporal and future punishments. Delusions are of infinite variety and so numerous as almost to defy enumeration. They may be persistent or evanescent. The longer they last the less likely they are to disappear and the surer is the evidence of permanent mental derangement. The systematizing of delusions, the development of a few persistent false beliefs grouping themselves around one or more central dominating conceptions, are evidences of an underlying brain disturbance and consequent chronic incurable insanity. Thus a delusive belief in enemies who are making every effort to defeat personal success in life, this delusion crystallizing itself around a central conception of self-importance and worth entirely inconsistent with the facts, is symptomatic of paranoia.

Hallucinations.—Hallucinations are false perceptions projected outward and referred to some one of the peripheral organs of special sense. They correspond with delusions in that they originate within the person's mind and owe their origin to disturbed activities of the neurons and a consequent inability on the part of the patient to correct the wrong impressions. They differ from delusions in that they always concern some one of the special senses. The brief definition of Ball is sufficiently explanatory: "Hallucination is sensation without an object." A person sees smoke issuing from the register in the wall when there is nothing of the sort; he hears a voice addressing him when there is no voice to be heard. The accepted theory of the origin of hallucinations is that they are partly psychical and partly physical. They may entirely originate within the mind, or they may be initiated by morbid peripheral activity in some one of the special sense tracts. Dissociation of the cerebral nerve cells prevents erroneous impressions from being corrected, and the result is a false perception referred to the peripheral organ in which the stimulation originated. According to Tanzi[5] hallucinations have their primary origin in an idea or symbol "when the pathological action has affected the fibers of conduction." Reversed action along representational nerve paths occurs with such intensity as to make sensation seem real even though there is no actual sensation. Hallucinations like delusions are usually influenced by the character of the prevailing emotion. The exhilarated patient hears voices giving him information of pleasant import, or has beatific visions; the depressed patient hears words of ill omen or has visions of a painful, distressing character. The paranoiac who is convinced that enemies are conspiring against him to injure him and prevent his success in life usually hears the voice of his foes, can actually recognize what they say, or smell and taste the poisons they have placed in his path. Hallucinations serve to intensify delusions and contribute to the psychic pain or pleasure of the patient. In the evolution of insanity delusions appear first; hallucinations are a later symptom, which would seem to indicate that they are chiefly psychical in their origin and owe their existence to the dissociation of neural pathways.

Illusions.—There is little real difference between hallucination and illusion, both are deceptions of the special senses. Strictly speaking, an illusion is a wrongly interpreted sensation. A man sees a tree with its branches swaying in the wind, his disordered mind interprets the spectacle to be a many-armed giant waving its arms and hands. There is an actual sensation which is perverted by the imagination to mean something entirely different. Owing to the dissociated action of the cerebral areas impressions received in the higher brain through the channels of special sense cannot be corrected. They remain as persistent evidences of the dominant beliefs of the patient. As in delusion and hallucination the character of the illusion will be modified by the prevailing character of the disturbance, whether it is of exhilaration or depression.

The Will.—Impairment of volition is an early psychic symptom of insanity. The will is not a specific entity; it is rather a complex resultant of past experiences and idea associations modified, stimulated, and directed by education, environment, and hereditary predisposition. On the purely physical side the will is nothing more than the reflex motor realization of the strongest sensation. Owing to the intimate association of volitional selection with consciousness, by which we are made aware of a power within us to choose between one or more courses of action, we say that a sane man possesses a free will power. We say that he *can* decide between several courses of action submitted to him. By reason of this power he is said to be responsible for his acts. No matter how arbitrary the law of association of ideas may be nor how rigidly such associations may dominate the will we do feel that every sane man has the power within him of selection. This power is weakened in insanity, and is one of the very earliest symptoms of mental disease. The knowledge of right and wrong may exist, but "the power to choose the right and avoid the wrong" may be impaired or wholly lost. The status of the will power is, therefore, a most important question in all criminal cases in which insanity is suspected or urged as a defense for crime. In all such cases the real test of responsibility is not a knowledge of right and wrong, but the power to choose between two courses of action. If a person has not such power by reason of insanity, then his act is the product of his disease and he is not responsible. The general practitioner who ordinarily see cases of insanity in their inception before they come under the observation of the specialist, should be familiar with the importance of volitional impairment in the insane and its relation to knowledge of right and wrong.

The fact is, insanity and irresponsibility, or at least modified responsibility, are nearly if not quite synonymous. Certainly it is true that no form of insanity exists in which there is not modified responsibility. Not only does the insane man reason from wrong data, but the power to see things in their proper relationship is impaired. His mental perspective is distorted. The inability to make rational comparisons and to exercise the power of choice are the earliest symptoms of mental disease. The capacity to distinguish right from wrong, either in the abstract or in any particular case, is not lost until the insanity is far advanced. Such loss is one of the later manifestations of pronounced functional and organic brain disturbance. To state arbitrarily, therefore, that responsibility depends upon a knowledge of right and wrong is decidedly unscientific.

The theory that partial insanity necessarily or usually implies responsibility is based upon fallacious reasoning. One error, as has been so often stated by alienists, lies in the fact that partial insanity is not so limited in its effect on mental operations as the lay mind conceives it to be. Limited delusions and isolated morbid ideas may be only a small portion of the symptomatology. They are noticeable phenomena, but must not be considered to represent all that is morbid. Because the insane person manifests only one or two delusions, talks coherently and intelligently, and transacts business correctly, it does not follow that his mind is sound on all other relationships outside

the one or two prominent delusions that he may exhibit. Their unfortunate possessor is usually damaged in all the higher mental processes, such as the judgment and the moral perceptions, and, particularly in the exercise of the will power.

While apparently sane on all other topics and able to talk connectedly on everyday matters and transact his routine business, he may be so dominated by certain prevailing ideas as to be wholly unable to resist certain acts, because in his own disordered mind they are justified by the facts in his individual life. These are the insane people who are most dangerous. It is not the turbulent maniac, full of incoherence and noisy destructiveness, but the quiet secretive paranoiac, who moves around among people in his daily avocations, who may spread destruction in his path.

The man who is, as the lawyers say, "partially" insane may know that his act is wrong and a punishable offense, but in his disordered reasoning he will argue that the facts justify the deed and it will be impossible to convince him to the contrary. So distorted is his perception of the proper relations of things, so overwhelmingly exaggerated is his own morbid egoism, that he will feel impressed with the justice and absolute necessity of his act and will usually assert that, when others know all, his conduct will be sustained. The reasoning of the partially insane mind is nearly always utterly inconsistent. But the laity usually commit the blunder of expecting and insisting that the partially insane mind will reason exactly as does the sane mind.

In every case of suspected insanity especial effort should be made to ascertain whether the criminal act is the result of morbid reasoning or is the product of mental disease. If the act is the outgrowth of disordered reasoning, if the man's judgment is so enfeebled that he cannot properly estimate the natural relations of things, if his will power is so enfeebled that he cannot resist the powerful pressure from within that impels him to the deed, then the act may be said to be the product of his disease and is not criminal, no matter how clearly he may understand the nature and quality of the act, whether right or wrong in the eyes of the law, or how coherently and intelligently he may converse on ordinary topics, and plan and effect an ingenious escape from detection.

The ruling of Chief Justice Doe in the famous New Hampshire case of The State *vs.* Pike has acquired an international reputation because of its manifest conformity with clinical and pathological facts. Judge Doe decided that there is no legal test of insanity: each case must be decided on its own merits. The basic facts are that insanity is a mental disease; the product of mental disease cannot be a crime; tests of mental disease are matters of fact, and whether the defendant has a disease and whether his act is the product of that disease is a question of fact for the jury to consider.

In the dementia precox of Kraepelin there occurs a remarkable perversion or almost paralysis of the will which gives rise to catatonic positions of the muscles, negatavisms to which reference has already been made, strange and meaningless attitudes and automatisms. In his earlier descriptions of dementia precox catatonia and negatavism were regarded by Kraepelin as almost pathognomonic of this early dementia. Like countless other symptoms in mental diseases they cannot be identified with any special disease process. The catatonic syndrome is now recognized as occurring in functional and curable psychoses. Melancholia with stupor is very frequently characterized by both catatonia and negativism which may persist for months or even a year and yet be followed by complete recovery. These strange automatisms, resistive states and meaningless attitudes are dependent on a disordered affectivity, inability to react normally to external sensations or internal impressions, and on a suspension of the will. This retardation or absolute paralysis of reaction to environmental stimuli is called *blocking*. The usual reaction which instantly follows an external stimulation under normal conditions is inhibited by the pathological automatic negativism. Blocking is a common symptom in dementia precox, in profound functional melancholia, and in many psychopathic states involving suspension of the will. The persistent negativism of dementia precox has this characteristic—it is utterly senseless, fulfills no useful purpose, and oftentimes is contrary to the best interests of the patient.

Memory.—Memory like will is not an individual entity, a specific faculty existing by itself. There is organic memory and psychological memory. Organic memory is simply the organization of functional activities in certain neural pathways. Such memory is subconscious. Psychological memory is more complex. It is organic memory plus consciousness. Every activity within the lower centers that is associated with cell activity in the higher brain is undoubtedly accompanied by a registration in consciousness which will be fleeting or permanent according to the intensity and duration of the corresponding metabolism in the supreme centers.

In insanity psychological or conscious memory will be variously affected. In the acute psychoses the functionating of those higher centers that are identified with mentality and consciousness may be so intense that a rigid recollection of all that has transpired during the illness will be preserved after the attack is over. Or dissociation of cortical areas may be so marked that little or no recollection is preserved. In all those mental diseases in which the structural cell integrity of the higher brain is affected memory will be weakened according to the extent of the deterioration. In the different varieties of dementia, in paresis, in senile insanity, amnesia is a striking symptom and in its progressive increase marks the advancing steps of the disease process. In senile dementia particularly is the retrograde failure of memory noticeable. In this disease those events of later life which have received the briefest organized registration are the first to disappear from memory, and the occurrences and associations of early life which are represented by a longer and more complete organic registration are the last to disappear.

Amnesia characterizes all subconscious states. All disease conditions associated with automatism are invariably followed by an almost total amnesia. Post-epileptic automatism or the so-called *epileptic state* affords a good illustration. Many crimes have been committed by epileptics while in this condition. Undoubtedly such individuals at the time of committing these acts are subconscious, and as the higher brain centers have no participation whatever with the lower levels from which they are temporarily dissociated no registration in consciousness occurs and there is no psychological memory of the act.

In acute melancholia cerebral dissociation occasionally is so complete, functional activity is so rigidly restricted to limited cortical areas, that consciousness, if it exists at all, exists in such a weak form that amnesia results. The writer recollects one case of ineffectual suicide in which the patient made a good recovery but could never recall the act. In another case of melancholia the mother drowned her only daughter, a little girl to whom she was passionately devoted, told some one of the act shortly after its performance, and then sank into a partially stuporose state. After recovery she could not recall the occurrence. Such cases are especially interesting, as they seem to indicate that there may be a retroactive amnesia. Events are feebly registered in consciousness, partially recalled, and then completely obliterated from the mind. These cases also demonstrate how purposive acts may still be attended with amnesia.

As Ribot[6] says: "There is no contradiction in admitting that a nervous state, sufficient to determine certain acts, may be insufficient to awaken consciousness."

Much has been said in recent years about partial responsibility. Because many insane are not entirely bereft of reason it is contended that their responsibility should be measured by the degree of their mental impairment. In 1907 Joseph Grasset[7] protested against the prevalent lay and legal impression that a man is either wholly insane and wholly irresponsible or wholly sane and entirely responsible. He argued that this matter of responsibility among the semi-insane is oftentimes a psychical problem that ought to demand the ablest special talent for determining its degree. The alienist in examining these cases of partial insanity should extend his research to the "discovery of the psychic stigmata, and it is not sufficient for him to confine his duties merely to making a list of symptoms which he has noted: he ought to group them, interpret them, and draw a diagnosis from them. This diagnosis practically comes down to the question of responsibility, irresponsibility, or attenuated responsibility." Every medicolegal expert has frequent occasion to realize the force of Grasset's argument. There are many cases in which absolute fairness to the prisoner on trial, as well as justice to society, seems to demand the recognition of a modified responsibility. In such cases the indeterminate sentence with possibly later care in a special institution is particularly applicable.

The Emotions.—The emotions or feelings seem to be almost a part of ourselves so readily are they elicited by the slightest provocation. When analyzed the feelings are found to arrange themselves in two large classes: those that are expansive and those that are depressing. The former are the basis of pleasure; the latter underlie sadness, pain. Among the sane the feelings are under the control of the individual to a greater or lesser extent. The extent of the control depends largely on personal idiosyncrasy. Among normal individuals we notice the greatest diversity in the expression of the feelings. Some are always quiet and undemonstrative, others excitable, bounding from one extreme to the other. The former are called phlegmatic, the latter emotional. There is a happy mean difficult of definition, yet readily recognizable. Excessive emotionalism implies lack of equipoise and such persons are said to be *hysterical*, implying by that term feeble self-control.

Insanity is characterized by weakened inhibition. The emotions are emphasized, and the patient makes few and ineffectual attempts toward restraining their expression. All those feelings that are the outgrowth of the two great classes of emotion, pleasure and pain, receive constant expression in insanity. Affection, hate, jealousy, envy, revenge, and innumerable feelings are exhibited by the insane, and attempts at suppression and concealment are the exception. All these varying emotions are intimately identified with action. The acts of the insane are often instigated by the overwhelming and uninhibited stress of the emotions.

Whatever opposes individual desire is painful, and whatever assists the accomplishment of our ultimate purposes is pleasurable. In the various phases of insanity the ego is depressed or exalted by the character of the ideation. The maniacal person has confidence in his own superiority, he is sure of success, schemes cannot arise too rapidly for his competent disposal. He is elated and hopeful. On the other hand the melancholiac has lost all hope. His cherished plans are not realized, the failure in physical health and strength incapacitates him for sustained mental and manual work and confirms his belief in his own incompetency. In the maniacal patient, in the early stages of paresis there is exaltation of the ego; in the melancholiac there is abasement of the ego. In the paranoiac there may be feelings of depression, but for a somewhat different reason than in the melancholiac. The paranoiac has primarily unbounded egoism. He feels that his real merit is not recognized and that his plans do not meet with success because of the determined and malignant opposition of those who are jealous of his fancied ability.

This imagined opposition, coupled with the fact of non-success and non-recognition by the world, awakens feelings of intense displeasure and pain. By constant brooding over his failure in life, which is really the result of incompetency and not of unrecognized merit, his first feelings of depression are, by virtue of his primary all-overpowering egoism, transferred into feelings of suspicion, then of hate, fear, and desire for revenge. So the paranoiac, who begins with a state of overweening egoism, merges into depression, passes from that to feelings of suspicion, then to fear, and finally to the bitterest sort of hatred. In this latter state of the feelings he is ready for revenge. Nothing short of homicide can satisfy the overwhelming sense of injustice with which he feels he has been treated. Could the innermost feelings of such men as Guiteau and Prendergast be dissected and spread before us for observation the network of mingled emotions of pride, egoism, hatred, jealousy, and the like would be a revelation and go far toward convincing us that such unfortunate creatures are in a maelstrom of emotion impelling them on with resistless violence. Undoubtedly the emotions play a most prominent part not only in the symptomatology but in the etiology of insanity. Emotional reaction to environment is a fundamental physiological endowment, and is closely identified with what we call *temperament* or in modern parlance, "constitutional make-up." The ancient physicians were not so very far from the truth when they formulated the four temperaments which represented different phases of emotional reaction. Eliminating their idea of a fog or an invisible humor that rose from the viscera and acted variously on the brain, and substituting for it a reflex relationship, over definite nerve tracts, between brain and abdominal viscera we arrive at practically the same conclusions expressed in a different and more scientific phraseology. And when we admit that nerve conductibility varies in individuals, that potential reactions depend largely on the transmitted cell character of the nervous system we recognize how fundamental a part the emotions play in the development of insanity. In health normal emotional variation occurs in everyone. There are those who are volatile and mercurial in make-up, others who are calm and deliberate and never ruffled or disturbed by environmental occurrences, still others who are easily depressed and discouraged, looking on the dark side of life. When these normal emotional reactions become so extreme that the individual cannot adjust himself to his environment, and his conduct becomes inconsistent with that of the ordinary man under identical conditions then we realize the psychogenetic relationship between the emotions and various mental diseases. Persistent elation expands the ego, leads to a feeling of unlimited power and in extreme conditions to grandiose delusions, that the individual is a mighty general or even deity itself. Many of the strange impulses acts and beliefs of the dementia precox case are the outgrowth of a perverted and distorted emotional reaction.

Impulsions (*Imperative Conceptions, Fixed and Insistent Ideas, Obsessions*).—Disturbances of the will and the emotions are closely related to the not uncommon symptom of impulsions known also by the other synonyms above mentioned. Ideas obtrude themselves in consciousness, meet with feeble or absolutely no resistance, and are then realized in acts

which are varied as the ideas they represent. Impulsiveness characterizes all the acts of the insane, may even be a striking idiosyncrasy of some sane individuals. Many persons of ability and mental integrity are impelled by a certain inherent quality of mind to act hastily on the spur of the moment and without the thought, delay, and reflection that are associated with a mature judgment. Children are notoriously impulsive. They seek instantaneous gratification of their desires, not always with due regard to their own best ultimate interests. Arrived at maturer years, however, the child who develops normally exercises reflection and judgment and the impulsive action of an earlier period yields to the deliberative and conservative conduct of adult life.

The forms of insanity in which dementia is not far advanced are characterized by an impulsiveness and a weakness of inhibition that is as striking a feature as are the similar conditions in childhood. Feeble inhibition, imperfect exercise of the will are prominent symptoms of insanity, and play an important part in the genesis of imperative conceptions. Macpherson's explanation of the pathology of obsessions is certainly plausible. Dissociated action of the neurons is the underlying pathological condition. Certain neuron groups, he argues, for some reason become highly resistive, then the discharge of currents modified by these particular groups seeks an outlet through other, though limited, channels. For this very reason the discharge is all the more intense, and the oftener it is repeated through the newer routes the more easy and persistent does its manifestation become. If this mechanical explanation is correct, it is easy to understand how ideas representing the limited and dissociated action of certain cortical areas are projected with great violence into the individual consciousness. The will power which depends upon the normal associative action of all the neuron groups is limited or so reduced as to be ineffectual, and the ideas acquire an intensity and persistency that seek immediate gratification in approximate action. Imperative ideas are accompanied by marked emotional disturbance which intensifies their persistency. The startling abruptness, the utter irrelevancy, the entire absence of any rational cause for the existence of these insistent ideas are clinical evidence of their mechanical origin in neuron dissociation.

However we may explain the mechanical origin of imperative conceptions it is a fact that they are of very frequent occurrence among the chronic insane, especially in the hereditary and degenerative types. In nearly every instance they are associated with a weakening of the will power. However much the patient may desire to banish these ideas from his mind he is utterly unable to do so, and usually is compelled against his will to yield to the appropriate action which they so insistently demand. Such impulsive acts are innumerable, and as varied as thought itself.

At one time it was the fashion to classify insanity into groups according to the character of the imperative conception. There were misophobia, folie du doute, cleptomania, pyromania, and many other species. Such a classification by symptoms is extremely confusing. Every new obsession becomes a new species of insanity, and when occurring in the same person necessitates a change of diagnosis, while in reality the underlying disease process in all such cases is the same. While impulsiveness, emotionalism, weakening of the will power are all prominent features in the symptomatology of insanity, obsessions undoubtedly represent a specific pathological process. They arise subconsciously, have no associative relationship with other ideas, enter the domain of consciousness unbidden, awaken the most positive emotions, and finally by their very persistency compel their realization in conduct against every possible effort of the will. Individuals with a vicious heredity, those who possess a neurotic constitution as the result of either direct heredity or some degenerative process, the hysterical and the neurasthenic, are favorable subjects for the development of obsessions. Such individuals oftentimes realize the absurdity and even the moral obliquity of the impulsion, but seem powerless to resist a certain word or phrase, again to touch certain objects with the hand or foot, or it may even be an overwhelming impulse to homicide or suicide, The patient may be startled and frightened at the unexpected suddenness of a conception which seems thrust upon his consciousness without reason and without this bidding; it may be an idea against which his whole moral nature may rebel. Quite frequently such persons realize their helplessness and beg to be restrained before they yield and commit some act fraught with danger to themselves or others. The underlying disease process in all such cases is serious. The prognosis is grave, for the symptom is usually the expression of a degenerative condition. So frequently are obsessions met with in the hereditarily neurotic temperament that they are often regarded as psychic stigmata of degeneracy.

Impulsions may be of great medicolegal importance. Occurring as they often do in those who are intellectually coherent and intelligent, it is difficult for one not familiar with their origin and development to realize their arbitrary involuntary character. Many obsessions are wholly harmless, such as the fear of contamination, the touching of objects, the doubting mania; but others lead to the perpetration of criminal acts, such as the impulse to steal, to set fire to property, even to suicide and homicide. While purely impulsive insanity as a defense for crime should be investigated with the utmost care, it is well to remember that when such attacks do occur in individuals possessing neurotic heredity and unstable mentality there may be such a weakening of the will power as to render them quite irresponsible for their acts.

Especially frequent are impulsive acts in dementia precox. This disease furnishes the favorable soil for just such unpremeditated action. Arrested judgment, suspension of the will, perverted sensation, distorted affectivity, all conspire to make the sufferer from this psychosis an easy victim of any powerful impression that invades the contracted field of his consciousness. The impulse may be suicidal or homicidal, a tendency to sudden self-mutilation, to run away into the woods, hide oneself from others, or perform many other meaningless acts. The impulsivity of the precox patient is characterized by entire absence of any rational or purposeful motive. For this reason the dementia precox case may occasionally become most dangerous to himself and a distinct menace to those about him.

Perturbations and Perversions of the Moral Sense.—Maudsley calls the moral sense a "function of organization." There can be little doubt that the moral sense is the accumulated product of the slow acquisition of ages of human experience, aided by hereditary transmission. Originating in the remote primeval past as a utilitarian expedient for the welfare of families and tribes, this sense of right and wrong has through countless centuries of experience and religious revelation become a thoroughly organized function. From being the product of a narrow and selfish utilitarianism the moral sense is slowly progressing toward a higher, more unselfish, altruistic plane. As might be expected, this latest and most unstable psychical acquisition is one of the first to disintegrate upon the appearance of either functional or structural disturbance of the brain. Whatever comes last in the process of evolution is the first to deteriorate in the retrograde changes of devolution.

Imperfection of the moral sense appears as the result of congenital deficiency, or it may be the product of

functional or organic brain disease occurring in adult life. Congenital moral defect is one of the stigmata of degeneracy. In the normal individual the moral faculty does not attain to its full growth until mature years are reached. The moral development of the individual is in a way an epitome of its development in the race. The child is selfish, seeks self-gratification, and does not have that strong regard for the feelings of others that we consider the ideal condition of later years. Even in the development of the normal child much depends on environment, teaching, and associates. Given a good heredity and environment, and the normal child very early evinces a proper regard for the rights of others, a sentiment of right and wrong, and a desire to reciprocate favors. The accumulated acquisitions of the past are not lost, and in the psychical development of the normal child the moral sense soon shows the advantages of good birth and training. On the other hand, the degenerate child, the offspring of neurotic ancestry, may disclose an utter incapacity for moral development. Such children are selfish, have no regard for the rights and feelings of others, oftentimes delight in the torture of animals or the abuse of younger and feebler children than themselves. Arrived at mature years they are erotic, oftentimes yield to beastly sensuality, and are naturally criminal by instinct in all their desires. The idiot and the imbecile often manifest this imperfection of the moral sense which becomes a true stigma of their degeneracy. As a rule among imbeciles there is a precocious sexual appetite which meets with little restraint because of their innate imperception of moral values. Segregation for this class is recognized as the only safe method for preventing further spread of feeble-mindedness. Sterilization has its advocates, but is not meeting with much encouragement because of legal and other objections. Occasionally there is encountered one of those moral monstrosities in whom there is a bright, keen intellectual development but without any evidence whatever of moral sense. Such individuals, by reason of their cunning, their ready wit and perception, are able to make quite a fair advancement in life, but usually sooner or later their vices bring them into the hands of the law. E. H. Rulloff was a notorious example of this class. Jesse Pomeroy, who early disclosed his degeneracy in the torturing of young children, has shown quite a little intellectual capacity without any accompanying moral sensibility.

Turning from those individuals whose moral imperfections are the stigmata of their degeneracy, we may glance at those whose early life was one of normal development. When such persons become insane, the moral sense manifests some change at an early stage of the disease. In nearly every case of insanity there is marked displacement of the ego. There is exaltation or abasement; self-concentration is a prominent symptom in acute and chronic insanity. With such distortion of the ego there quite naturally follows a selfishness that leads the patient to dwell on personal feelings and ends rather than on the consideration of others. Hence it follows that the insane are very apt to disregard the feelings of those who are nearest and dearest to them, they often become suspicious and abusive of those who have given them no reason for offense. Quite frequently such patients will commit all sorts of depredations on the rights of those who have incurred their unreasonable hatred. So far lost do they become to a sense of right and wrong that they may even take life itself. It is well to bear in mind, however, that knowledge of right and wrong and of the nature and quality of a criminal act may be retained long after the will power to refrain from committing the offense is lost. Particularly is this true of the paranoiac and the subjects of systematized delusional insanity. In these cases the power of inhibition, of making a choice between two courses of action in which the feelings are strongly enlisted, is impaired long before the moral judgment is destroyed.

As might be expected, the insane in whom there is marked structural brain impairment show striking failure in the moral sense. This is especially noticeable in paresis and quite frequently in senile and secondary dementia. Quite often moral lapses in individuals, who have lived blameless and correct lives in the past, are the only evidence of incipient brain degeneration. A weakening of the moral sense is not uncommonly seen in the exhilarated phase of alternating insanity, or in attacks of recurrent mania. Sometimes patients, during the intervals between the attacks, are exemplary in every way, but with the beginning of the excitement and before it is even noticeable they become erotic and so lose their moral perception as to gratify their passion. Upon recovery such lapses from virtue give them the keenest feeling of shame and remorse. In one case in the writer's experience, in a young woman, this was the only evidence of insanity for years. Her conduct was so shameless that in sheer desperation her people had her committed to a hospital for the insane. For two years it was a question whether restraint was legal, so clear were her intellectual faculties. The patient herself continually protested against her detention, claiming that if she chose to live a fast life it was her own affair and no one else had any right to deprive her of liberty for that reason. In about two years from the date of her admission she developed disturbance in the intellectual sphere, becoming incoherent, destructive, and noisy. From that time she has averaged attacks of intellectual confusion once a year. In the interim between the attacks she seems perfectly well. The failure of the moral sense alone at one time, of the intellectual faculties at another, and the frequent association of defects in both the moral and intellectual spheres on still other occasions in the same person are evidences of the unity of mind and its dependence on cerebral cell integrity.

Disturbance of Consciousness, Alterations of Personality.—Consciousness and the personality are physiologically closely related. Consciousness is that state by which the ego is made aware of present and past sensations and impressions. It is constantly changing, being modified by the countless sensations and psychic impressions that are continually flowing in upon the individual mind. By a certain voluntary selective power, that is the inexplicable possession of every normal individual, consciousness can be directed in this or that direction. Irrelevant trains of thought can be excluded and only those conducive to a certain desired end retained in consciousness. This is the power of attention so essential to success in life and so characteristic of a sound and healthy mind. The ego, the personality that is the essential part of ourselves, that part that each one recognizes as his own most characteristic self, and that every one else associates with this or that individual and with no other person, this ego is the complex resultant of all present and past sensations, impressions, and experiences which is recognized by consciousness. Self-consciousness is that power by which we recognize our own immediate existence here and now and identify it with the same individual existence which has passed through definite experiences and associations in the past. Consciousness is the grand inheritance of animal life and serves to distinguish it from plant life. The dawning of consciousness is, as John Fiske[8] says, "one of the most wonderful moments in the history of creation, the foreshadowing of the true life of the soul." Clouding of consciousness is an almost constant accompaniment of many psychoses, and may extend to complete suspension. This clouding of consciousness is frequently shown in disorientation of time, place, and persons. In very slight confusional attacks the patient may lose his sense of time and place. Identification of his own personality as well as that of intimate friends and relatives can only disappear in

profounder psychic disturbance. When consciousness is obscured the patient's insight into his own condition is affected. Loss of insight is one of the most prominent early symptoms of mental derangement. The aphasic patient who cannot recognize his aphasia and who continues talking as though everyone about knows what he is saying is more profoundly affected mentally than one who recognizes his speech impairment. Permanent failure of insight is evidence of a serious interruption of the normal stream of consciousness, a weakening of the corrective judgment, and a certain degree of dementia.

Complete temporary suspension of consciousness is a very frequent accompaniment of the toxemic psychoses. The commonest illustration is the dead drunkenness following excessive alcoholic indulgence. But entire loss of consciousness may follow septic infection introduced from without or elaborated within the intestinal tract. One patient, within the writer's experience, developed a toxic confusional insanity following intestinal septic infection, passed into a delirious condition and remained practically unconscious for three weeks. He was amnesic for the entire period. Consciousness is always profoundly disturbed and usually entirely suspended in acute delirium. It is undoubtedly this flooding of the sensorium with the constant stream of sensations from all parts of the body as well as from the environment in which one lives that that very general and yet very explicit consciousness is derived which has been called the cenesthesia. This is a field of consciousness extremely difficult of definition and yet readily recognizable by everyone. Cenesthesia constitutes that feeling of well-being which we all experience when our bodily organs are performing their functions normally and when sensations from the environment are not perverted. In insanity this cenesthesia is disturbed either because sensation is perverted or because the individual cannot adjust himself properly with his environment.

Consciousness, the power of voluntary conscious attention, and the personality have a close physiological relationship, and for their normal expression depend on the integrity of the neurons. Slight pathological disturbance of the neurons leads to weakening of the power of voluntary conscious attention as well as to alterations of personality. Graver affections of the neurons may lead to actual interruptions of consciousness, to suspension of the normal personality with substitution of automatism, and to a modified personality so unlike the original normal self that it has been called a secondary or subconscious personality. Consciousness is wholly suspended, in sleep, by the influence of drugs, by traumatism, by epilepsy and other conditions. It is partially suspended or interrupted by the functional or organic brain disturbance accompanying insanity.

One of the earliest symptoms of insanity is a weakening of the power of conscious attention. The patient is unable to inhibit irrelevant trains of thought. He neglects his daily advocations, fritters away his time on needless work, or remains so self-centered as entirely to omit the demands of the hour. Oftentimes imperfectly performed work and neglect of necessary details are the first evidences of mental alienation. As the mental disturbance progresses the change in the personality increases. Relatives first and acquaintances later realize a change in the individual. They say he is not the same. He becomes another and a different person. He does not look at things in the same way, he cannot be depended upon to react as formerly to similar influences. It is not always an easy matter to define the exact change. There may be irritability, impulsiveness, or hesitation, incapacity. Among the symptoms of dementia nothing is more noticeable than this gradual reduction of the personality to a simpler entity. In this retrograde metamorphosis consciousness loses its definiteness and in the last stages of the disease becomes all but extinct, leaving a mere subconscious, vegetative existence.

Disturbances and temporary suspensions of consciousness with alterations of personality occur at times. Such cases deserve most careful study not only for their medicolegal importance, but for the reason that they may throw much light on the nature of consciousness and its association with memory and the formation of the normal ego. Consciousness may gradually fade away and lose itself at last in a state of subconsciousness in which automatism is the chief characteristic. This condition is often noticeable in postepileptic states, in hysteria, in somnambulism, in the confused state following the toxic effects of alcohol, and occasionally succeeds profound nervous and mental shock, or accompanies the acute functional psychoses. Such conditions are recovered from but leave no recollection behind them. During the period the individual may have performed many complicated and at times apparently purposive acts, but on recovery has no remembrance of what he has done. The period is an utter blank to him. While in this subconscious state persons have been known to leave their homes, travel to remote places, and live another life, awakening to their normal consciousness to find themselves in a new and unfamiliar locality with no realization of where they are or how they came to be there. These phenomena deserve further consideration.

The disparity between the spheres of mind and matter is so great that we continually forget that there is a most intimate connection between the two. This connection is, however, so subtle and elusive as to confuse and perplex our studies. It is only when we are confronted with some strange and very unusual psychosis, such as hypnotic trance, transitory amnesic frenzy, and the like, that we realize the close relationship between functional activity of the material mechanism and psychic phenomena.

What is the physical basis of consciousness, the obscuring of which plays so prominent a part in these psychoses? Recent physiological research localizes "conscious processes in the cerebral cortex, within which the sensory tracts end and the motor begin." Dr. Jakob also says in this same connection: "Above the reflex arc which is constituted from the two peripheral neurons there is, as it were, a second arc, which is made up of the central motor and sensory neurons together with their connecting pathways in the cerebral cortex. The latter serves for the conduction from a conscious sensation to a voluntarily innervated movement, that is, for the act of the will." Unquestionably the "cortex is the sole organ of consciousness in man."

This being the anatomical substratum of consciousness, what are the physiological condition that underlie its manifestations? Full, complete consciousness presupposes functional integrity of the cerebral cortex. If this continuity and integrity of functions be interfered with there is very likely to result what Janet has called "a contraction of the field of consciousness." This may amount to almost complete obscuration, or even lead to alteration of the personality. In this way Janet has said that hysterical anesthesia is really anesthesia from "lack of consciousness."

It is even possible for normal consciousness to be submerged and dominated, as it were, by a subconscious condition. This subconscious condition with its power to initiate motor processes evidently has an existence and a memory of its own, for it has been successfully recalled by hypnotic suggestion, and thus demonstrated to have had an existence when the normal consciousness was suspended. Integrity of action within the cerebral cortex is thus extremely essential to normal consciousness. This is in accordance with the teaching of psychology. Professor James says: "We see that the mind is at every stage a theater of simultaneous possibilities. Consciousness consists in

the comparison of these with each other, the selection of some, and the suppression of the rest by the reinforcing and inhibiting agency of attention." Such comparison, selection, reinforcing, and inhibition must have their organic substratum in the countless connecting neural pathways of the cerebral cortex. Normal consciousness depends upon an associative action of these various neural pathways. Consciousness will be obscured when there is defective associative action. Dissociation is the chief pathological factor in all long-continued insanity. Hence reductions of the normal consciousness are a prominent feature in the symptomatology of all advanced insanity.

Physical Symptoms.—The physical symptomatology of insanity may be studied under the following heads:

1. Congenital physical malformations—the physical stigmata of degeneracy.
2. Disturbance of function in the organs of special sense—the eye, ear, nerves of touch, etc.
3. Disorders of vital function—sleep, body weight, temperature, respiration, circulation, blood changes, secretions from glandular organs such as sweat glands, salivary glands, and kidneys, general nutrition.
4. Disturbance of motility, including exaggerated and diminished reflexes, as well as those voluntary and involuntary muscular movements that are concerned in facial expression and those motorial activities that lead to the countless postures, attitudes, and automatic movements that form so characteristic a feature in the symptomatology of insanity.

1. Various physical malformations may occur in the different portions of the body. The most striking are those affecting the sutures of the skull. There are no deformities that are pathognomonic of insanity. The lower the type of degeneracy the more pronounced the departure from the normal. Asymmetry of the cranium and of the face is a striking feature in low-grade imbeciles and idiots. Arrest of development of the brain leads to a microcephalic skull. Early ossification of the sutures may cause a distorted cranium as seen in the keel-shaped, sugar-loaf shaped, and kidney-shaped heads of certain degenerates. Unequal development of the orbital cavities, and excessive or atrophied growth of the jaws are asymmetrical types quite frequent in persons of degenerate inheritance. The hard palate is variously affected, and usually it is thought that the high-vaulted, gothic-arched, and saddle-shaped palates are a mark of inferiority. Such palates are supposed to represent a retarded development of the brain in the parietal region, resulting in a coming together of the alveolar bodies and a corresponding encroachment on brain growth.

In the special-sense organs anomalies of the ear and hearing are noticeable. Among the insane we find asymmetrical ears, large, atrophied, pointed, or flat. In the degenerate insane and criminals the ears often project from the skull almost at right angles and present a sriking appearance when viewed from either front or behind. Double or unilateral deafness is not unfrequently met with as an hereditary defect.

The eyelids are not unfrequently deformed in those of degenerate stock. A short upper eyelid leads to exposure of the selerotic. A thickening of the eyelid over the inner canthus gives a peculiar Asiatic expression to the eye and has led to the name Mongolian idiot.

Among other physical stigmata may be mentioned scarcity or abundance of hair, especially in unusual situations in either sex. In many insane women of the chronic and incurable class there occurs quite a heavy growth of hair on the chin and upper lip, and sometimes masculinity of voice is present.

The above-mentioned stigmata are not found in the acute curable insane, they are the physical marks of a congenital degeneracy that is usually associated with criminality and imbecility.

2. Disturbance of function in the organs of special sense plays an important part in the symptomatology of insanity. Cutaneous sensibility is very frequently affected. At times there is hyperesthesia, again anesthesia or paresthesia. Regis calls attention to the fact that an important distinction must be made. He says: "It is not usually the tactile sensibility, strictly speaking, that is modified; that which gives us notions of form, direction, consistence, position, and resistance of objects, that is commonly intact. What is impaired is the sensibility to physical agents, heat, pain" (E. Regis[4]). In many cases a morbid sensation is purely central. A sense conception, originating within, is by its very intensity projected outward and referred to its proper peripheral locality; it is then an hallucination. Such is the force of morbid ideation that no amount of argument can dispel the imagined sensation. In a large number of cases there is undoubtedly a pathological disturbance of the sensory nerves of touch in different portions of the extremities. These are oftentimes wrongly conceived or interpreted by the mind, are very likely modified by the prevailing ideas and emotions, and so become the illusory basis of a delusion. Imperfect circulation in the periphery may lead to a sense of formication, of heat or cold, and such perverted sensations may be misconstrued by the mind to mean electrical shocks from invisible batteries.

The hysterical often have most striking disturbances of tegumental sensation. Local anesthesias and hyperesthesias play a very prominent part in the symptomatology of hysteria. Among the insane nothing is more remarkable than the analgesia that occurs in many cases of acute functional insanity, and in nearly every case, to a greater or less degree, of dementia secondary to structural brain disease. In acute mania and melancholia there is oftentimes the greatest insensibility to heat and cold. In the depressed stage of *dementia preeox* the patients are profoundly insensible to what would, under normal conditions, occasion the most exquisite pain. Patients under these conditions often mutilate themselves with ligations, with scissors, needles, and with hot substances and apparently experience little if any real pain. Among demented patients there is very little sensibility to heat or cold. Such patients must be carefully guarded against extremes of heat and cold in the weather, against scalding in bathtubs, for, owing to their universal analgesia, they are unable to protect themselves.

Disturbance of taste not unfrequently occurs in cases of systematized delusional insanity, and especially in patients suffering from acute melancholia. The obstinate constipation and toxemia following imperfect intestinal digestion may lead to the foul or bitter taste in the mouth which is wrongly interpreted by the mind, but it is also supposable that sensations are imperfectly received at the peripheral terminations of the gustatory nerve and irregularly conducted to the brain. These perversions of function are quite probably the source of many of the hallucinations of the chronic insane.

The olfactory sense is often exalted or depressed, and its perversions are, as in the functional disturbance of the other senses, the starting-point of hallucinations and illusions. The special senses of hearing and vision are perhaps more frequently disturbed than any of the others. In acute mania there is exaltation of functional activity in these special-sense organs. In melancholia there may be perversion of function and illusions as a result. It is not unlikely that the varying blood pressure in the functional psychoses may have much to do with these perversions. The disturbances of sight and hearing soon subside either upon the removal of the toxin from the circulation if it is a case of toxemia or upon the return of the blood pressure to normal conditions during convalescence.

3. Among the disorders of vital function in the insane none holds a more conspicuous place than insomnia. One of the earliest premonitory symptoms of the acute functional psychoses is sleeplessness. Before the attack is actually declared the patient usually passes days and occasionally weeks of insomnia. Sometimes worriment over real troubles, financial, domestic, or otherwise; again excessive and protracted mental work induces such a state of cerebral activity that the individual becomes unable to inhibit special

Fig. 3949.—Case XXXIII. Acute Suicidal Melancholia. Taken at height of attack. Trophic alterations, ocular divergence, and self-absorption well marked. (From photograph taken by author.)

lines of thought on which he is engaged and his normal measure of sleep is reduced fully one-half or one-third. This serious interruption of a necessary physiological process leads to a dangerous increase of tissue waste with imperfect repair. The insomnia thus acquired continues after the mentality is impaired, and becomes one of the most serious symptoms which the physician is called upon to treat. Return of normal sleep after a long period of wakefulness is one of the most favorable indications of returning convalescence. After prolonged insomnia associated with mania or melancholia, beginning recovery is ushered in with deep sleep of many hours' duration.

The toleration of insomnia is occasionally quite remarkable. Days may pass with only a fragmentary sleep, in all aggregating only a few short hours. Subconscious states usually exhibit few signs of fatigue. Von Hartmann says: "The unconscious does not grow weary; but all conscious mental activity becomes fatigued." Among the chronic insane there is often protracted insomnia, but usually in this class there is an adjustment as well as a compensation. Such patients may remain awake and in a state of noisy activity; but, after twenty-four or forty-eight hours, they sleep soundly for several hours and awake refreshed to renew their excitement and volubility. These cases are exceedingly prone to remain awake nights and sleep days, much to the discomfort of their associates. As a rule the chronic insane are good sleepers, and the wards of a hospital in which these patients are located are as quiet as any private house.

A reduced body weight previous to and during the active stage of the acute psychoses, and a gradual return to normal or supernormal weight during convalescence are matters of common observation in hospitals for the insane. Every well-regulated institution pays very close attention to its dietary, and records from time to time the weights of its patients. As a rule there is marked loss of flesh in the early stages of melancholia. Capricious and irregular eating, imperfect assimilation with scanty repair of tissue waste characterize all these cases. They look thin and sallow, their clothes hang rather than fit their bodies, their eyes look hollow and their cheeks and necks often wear a painfully cadaverous expression owing to the disappearance of fat from the subcutaneous cellular tissue. One of the chief objects of treatment is to secure regular and thorough nutrition with an easily digested and assimilable diet. If necessary, tube feeding and lavage of the stomach are prescribed in order that nutrition may be promoted. During treatment it is the custom in most institutions regularly to weigh such patients, for a progressive increase in weight is a pretty sure indication that improvement is at hand. (For illustration note the marked change in Case XXXIII, Fig. 3949, at the height of the attack, and Fig. 3950, at time of convalescence.) The same observation applies to cases of acute mania, though not with the same constancy as in melancholia (see Case XLII, Fig. 3951, during active stage and Fig. 3952 at time of recovery). In mild mania nutrition is often very good and the body weight but little changed from the normal. In extreme maniacal agitation, however, there is often great reduction in the body weight, and in typhomania emaciation is extreme.

Among the chronic insane and the demented there is quite frequently a state of good nutrition and increased body weight. After the first and active stage of paresis there is apt to occur a period of hearty eating with good digestion and assimilation and a remarkable increase in weight, followed still later in the third stage by failure of assimilation and reduced weight. In alternating insanity there are reduced weight during

Fig. 3950.—Case XXXIII. Taken five months later. Convalescence established. Healthy ideation and restoration of physical health. (From photograph taken by author.)

the depressed stage and return to normal or excessive weight during the active stage. During the depressed period there seems to occur a slowing of all the vital processes, nutrition among the rest, while in the active

stage there is an awakening of all the functions, improved digestion and assimilation seeming to be an expression of the increased metabolism. Of so much importance is this matter of body weight considered that it is customary in hospitals for the insane to record on a clinical chart, by a rising and falling scale, the increase or decrease of weight.

The temperature in insanity is not markedly increased. In some attacks of acute mania there is slight elevation of not usually over 101° or 102° F., at most. In melancholia and in *dementia precox* there is not

Fig. 3951.—Case XLII. Acute Mania. Taken during active stage. Morbid innervation, trophic alterations, neglect of personal appearance. (From photograph taken by author.)

only no elevation, but the temperature may be subnormal. In the large number of the chronic insane there is absolutely no change whatever. In paresis and in cases of structural brain deterioration there may be remarkably high elevations of temperature following attacks of embolism, and serous or hemorrhagic effusion. Occasionally in these cases the temperature will range from 104° F. to even 107° F. Such unusual elevations are of serious import and indicate a grave prognosis.

The respiration is not seriously disturbed in insanity. In mania there is little alteration. In melancholia there is apt to be a slower respiration with shallow inspiration, but nothing that can be regarded as especially pathognomonic. In cases of dementia secondary to embolism or to an attack of cerebral apoplexy three may occur a characteristic Cheyne-Stokes respiration with the rhythmical increase of respiratory movements followed by marked decrease. In one case under the writer's observation the rhythmical increase in the respiration was accompanied by a cyclical return of consciousness, which soon subsided as the respiration became slower, and during the period of cessation the patient sank into unconsciousness. This rhythmical ebb and flow of the vital forces continued for some days before death.

The force and frequency of the circulation and the blood pressure among the insane have received careful study. There is a greater frequency of heart disease among the insane than among a corresponding number of sane persons. The frequency of arteriosclerosis in the insane is now a well-recognized pathological fact, and plays a prominent part as an etiological factor in a large proportion of cases of insanity in middle and later life. The muscular walls of the heart are weakened in many cases of chronic insanity, and rupture of that organ is not so very infrequent an occurrence; two cases within one year happened in the writer's experience. A series of sphygmographic examinations were made at the Bethlehem Royal Hospital by Maurice Craig.[9] The article deserves careful study. Among the conclusions arrived at the following are especially noteworthy: 1. The blood pressure is higher in states of depression, and returns to normal after recovery. 2. It is lower in states of excitement, and returns to normal after recovery from such conditions. 3. The blood pressure tends to fall as the day advances, and hence melancholia cases tend to improve toward afternoon, while mania cases grow more excited. 4. In stuporose states the blood pressure rises. 5. The lowered blood pressure following acute mania is exhaustive in origin, and will remain lowered until its return to normal after recovery. 6. Experiments thus far do not enable one to say that insanity is caused by variations in blood pressure. Such variations do, however, suggest a line of treatment. Thus the feeling of weight and oppression on the vertex is undoubtedly vascular in character, and when the blood pressure is relieved by hydrotherapeutic or medicinal measures the distressing sensations disappear. In short, Dr. Craig's conclusions furnish a strong argument for hydrotherapy in the acute functional psychoses. A very rapid and somewhat weakened pulse is frequently noticeable in cases of melancholia and occasionally in mild mania.

The blood itself has been microscopically examined by different observers. Several experiments have been made to test the bactericidal action of the blood of the insane to determine whether the blood of such persons contain toxic elements not appearing in the blood of the sane. D'Abundo "found the toxicity and bactericidal power of the blood increased in all forms of insanity except in the depressed conditions, in which, on the contrary, it was lessened." M. Legrain concludes from his study of the subject that the convulsions of paresis are often due to toxicity of the blood. The blood serum is the vehicle of the toxin, and the toxemia, induced by injections of the blood serum of paretics, reveals itself in symptoms identical with those of uremia.

Fig. 3952.—Case XLII. Taken at time of recovery. (From photograph taken by author.)

Dr. W. Johnson Smyth made a most careful study of the blood and reported his conclusions in the *Journal of Mental Science*, October, 1890, as follows: I. That in insane patients there is a very marked deficiency in

hemoglobin. 2. That the deficiency is greatest in secondary dementia. 3. That there is no very marked difference in its amount in melancholia, epilepsy, and general paralysis of the insane, though in the last disease I found very high percentages during the stages of marked exaltation. 4. That the number of red corpuscles in these insane conditions is below the normal standard. 5. That the number of red corpuscles is least in secondary dementia. That it is greatest in general paralysis of the insane; that the variations in the other diseases are too trivial to attach importance to them.

With reference to the relative proportions of white to red blood corpuscles Dr. Smyth found no variation from the normal. He also concludes that in insanity the blood is usually in a pathological condition, but quite frequently this is a secondary state and not causal to the insanity; he says in "some forms of mental diseases the blood is imperfect *ab initio*, that it fails to supply materials for the growth and development of the brain; while that in other forms of mental disease the blood change is secondary to organic disease, and morbid mentality results owing to the inability of the brain of the unstable to resist the influence of its diseased blood supply."

Dr. F. Percival Mackie[10] draws the following conclusions: "In looking through the grand averages we cannot help being struck by the slight departure from normal which exists in the blood of insane patients. Though in some cases slight changes are noted with some degree of constancy, yet they are so insignificant that they do not appear to throw any light on the pathology, or give any indication for treatment in any class of cases. When they do occur, there is good reason to suppose that the alteration in the blood state is quite secondary to the mental change; and further, the examination of the blood in the present state of our knowledge is not even an aid to prognosis or diagnosis, as it is in so many diseases." Lewis Bruce of Scotland and others have made in recent years exhaustive studies of leucocytosis in various mental states. While these investigations are interesting they have not as yet suggested any rational therapy that has any permanent value. The appearance of any intercurrent disease, an infected traumatism, a serious carbuncle in the course of an acute or even a chronic insanity, as is well known, is often attended by a temporary abatement or improvement in the psychosis. For want of a better term, but really from ignorance, such temporary improvements were formerly called metastases. It was thought that Nature could not sustain two different disease processes at the same time in one individual, or that the morbific process passed from one part of the system to the other. We now know that the appearance of a toxemia creates a leucocytosis and the blood becomes the vehicle for a host of defenses against the invading toxins. Such an influx of defensive cell elements in the blood may temporarily antagonize any toxemia accompanying the psychosis arising from autoinfection. But such benefit is of only short duration. The mental disease process soon reappears with as great intensity as ever. In an insanity of toxemic origin there is commonly a leucocytosis, and nature sets up its usual defense. If the hyperleucocytosis is sufficient to antagonize the special toxemia, then recovery is likely to occur. But in all the chronic insanities and in those of non-toxic origin there is little that can be done in the way of serum treatment because as Bruce says: "The bacterial toxemias of insanity are chronic, and indicate that the real disease lies deeper than the mere toxemia, the disease being rather a failure of the patient to form antibodies" (Bruce[11]).

All the secretions are modified to a greater or lesser extent by insanity. Ptyalism is a very common symptom in idiocy, imbecility, and cases of chronic dementia. It is often surprising to notice what quantities of saliva may be passed by demented patients. This is occasionally a most troublesome symptom necessitating frequent changing of the clothing or the wearing of rubber bibs. During the waking hours this salivation may be incessant. Occasionally excessive salivaton occurs in acute cases, apparently from central or peripheral irritation in nerve tracts. Sometimes the saliva flows freely in apparent obedience to some psychogenetic cause. The writer recalls one case in which a woman suffering from intense systematized delusional insanity was excessively salivated. This patient, who was very intelligent, endeavored to account for the symptom on the ground that poisonous vapors were injected in some mysterious way into her system and showed their deleterious effect in this manner. It would seem that a powerful mental impression produced in the salivary glands the supposed effect of the imaginary poisonous gases.

The perspiration is variously affected in insanity. In many cases of dementia, melancholia, and dementia præcox there is almost entire absence of secretion from the sweat glands. In these patients the skin is dry and scaly, the hair, is brittle, rough, and absolutely free from natural moisture. In other cases there is a cold clammy sweat, due undoubtedly to a relaxed state of the blood-vessels and to feeble circulation. It is a matter of frequent observation that the hands of many insane feel cold and moist and entirely unlike the warm, dry touch of the normal individual. There seems little doubt that a certain peculiar mawkish odor is exhaled from the skin of chronic demented patients. Owing to the lack of healthy muscular tonicity, and the feebleness of the circulation there is imperfect glandular action in the skin, products of tissue waste are retained rather than eliminated, and a disagreeable odor results. One of the strongest arguments in favor of rain in preference to tub baths for the demented insane is the tonic effect of the shower upon the skin. There is imparted to the latter tissue a glow, the circulation is stimulated, and waste products are removed more effectually than by the poorly applied warm tub bath.

One of the most important glandular secretions is that of the kidneys. The exact relationship of kidney disease and insanity, whether the kidney affection is causal or secondary to the mental disturbance, has long been a subject of discussion. There is no question that the two are quite constantly associated. The following conclusions arrived at by different observers during the past nine years are interesting and deserve careful study.

The toxicity of the urine of the insane has been tested. No very positive results have yet been derived. Dr. George T. Tuttle, of McLean Hospital, after citing Purdy, T. Clifford Allbutt, Dickinson, and Savage, all of whom believe in mental anxiety as a chief cause of kidney disturbances, concludes as follows:[12] "(1) Chronic nephritis is sometimes the cause of mental aberration, which may be called insanity. (2) Long-continued anxiety may cause albumin, hyaline, granular, epithelial, and blood casts in the urine, with accompanying edema in some cases. (3) This kidney affection may be temporary, disappearing when the cause is removed, or, the cause persisting too long, may become chronic renal disease. (4) Contrary to the opinion of many observers, disease of the kidneys is quite common among the insane."

Dr. E. D. Bondurant of the Alabama Insane Hospital at Tuscaloosa, made a careful analysis of the urine of the insane and recapitulates his collective results in regard to Bright's disease and insanity as follows:[13] "That albumin, together with renal tube casts, can be detected in the urine of more than half the cases of chronic insanity treated in this institution, and in the urine of quite seventy-five per cent. of the cases of recent insanity admitted. That a large proportion (not all) of the patients whose renal secretion is thus

abnormal exhibit at some time some other evidence of renal disorder. That a small percentage, say twenty-five per cent., of those whose urine contains tube casts and albumin present such clinical evidences of nephritis as should enable any competent practitioner of medicine to make the diagnosis of nephritic disease or complication without examination of the urine. That seventy-five per cent. of the kidneys examined post-mortem show pathological changes. And finally, the facts obtained seem to justify the opinion that many of the patients (not all, be it remembered) in whom insanity and nephritis coexist are insane because of the nephritis, *i.e.* the insanity is one of the mental symptoms of acute or chronic uremic intoxication."

In a comparison of sane patients in a general hospital and insane patients in hospitals for the insane Dr. Prout[14] finds a higher percentage showing gross kidney lesions among patients dying in hospitals for the insane than among those dying of general diseases in a general hospital. Dr. Prout considers that an increased elimination of toxic compounds in the urine would naturally lead to structural kidney change, and he considers the increase of kidney lesions found in autopsies on the insane an argument in favor of the autotoxis theory.

Cleon Melville Hubbard[15] arrives at the following conclusions in regard to the urine of melancholia: "(1) The amounts of urine and solids are generally diminished, and they usually increase with the patient's improvement. (2) The specific gravity is normal. (3) The urea and uric acid, are, as a rule, diminished, (4) The diminution in nitrogenous excretions is due in most cases to a diminished ingestion of proteids, but in some it may possibly result from a lessened absorption of food. (5) The ratio of uric acid to urea shows no constant relation to the mental condition."

Dr. W. L. Worcester, of the Danvers Insane Hospital, arrives at the following conclusions:[16] "Renal disease in some degree is very common among the insane, but it is by no means certain that it is very much more common among them than in the population at large at corresponding ages. Cases in which insanity is due simply to disease of the kidneys are rather infrequent in hospitals for the insane. Taking the term 'Bright's disease' in its broadest significance, however, it is probably one of the most common causes, if not the most common, of mental derangements."

Dr. Worcester calls attention to the fact that in acute delirium without exception he has found urine "heavily charged with albumin and containing large quantities of casts." He doubts whether the starting-point of this condition of the urine is in the kidneys. Dr. Worcester still further calls attention to the great prevalence of vascular degeneration as a cause of the mental decay in senile dementia and its association with degeneration of the kidneys and infers that kidney degeneration and senile dementia may have a common cause.

Dr. M. Allen Starr[17] believes that among several causes of neurasthenia and melancholia a toxic origin occupies a prominent place. In such cases "the urine is irregular in quantity, at times scanty, of high color and of high specific gravity; at other times profuse, light, and of low specific gravity, and at all times it contains large quantities of indican or indoxyl." Exactly what the toxic agent is Dr. Starr does not say. He says that "indican or indoxyl is the one particular thing found in the urine in varying quantities according to the general condition of the patients, and yet I do not suppose that indican is the active poison."

The analyses that have come under the writer's own observation give the following results for melancholia: *Quantity* diminished, *specific gravity* diminished, *solids* diminished, *urophein* increased, *urea* diminished, *indican* increased, *uric acid* diminished or increased, *sulphates* diminished, *earthy and alkaline phosphates* diminished, *albumin* generally absent. From all these observations it may be concluded that in melancholia and neurasthenia there is imperfect elimination from the kidneys of the ordinary waste products of the blood, and that there is impaired intestinal digestion with more or less decomposition of the contents of the intestinal tract. As with the pathological condition of the blood so with the kidney disturbance, it is difficult to say whether these functional irregularities are the cause or the result of the mental disease. The writer inclines to the opinion that in the majority of cases the renal disturbance is secondary to the psychosis, and dependent on the impaired functions of the central nervous system. Not infrequently confusional attacks correspond to imperfect elimination through the kidneys especially in the toxic confusional insanities and the senile dementias consequent on arteriosclerosis. Warm packs and hydrotherapy accelerate elimination through the skin and with return of the renal secretion to normal conditions the confusional attack disappears.

There is probably the same bacterial association between the urinary secretion and insanity that obtains in other pathological conditions. Dr. E. Barton White[18] states that microorganisms are more frequently found in the urine of general paralysis than other forms of insanity, that these organisms through their toxic effect "may accelerate the cause of the disease." He correctly concludes that "no definite connection between urinary bacteria and insanity has been made out." Probably not only in paresis but in other forms of insanity, accompanied by lowered vitality, imperfect digestion and intestinal fermentation, bacteria may be taken up from the intestinal tract, carried on by the blood stream and finally eliminated through the kidneys. Their presence in the circulation intensifies the brain irritability and

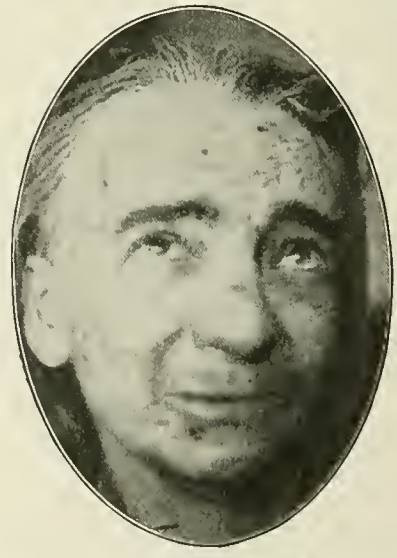

Fig. 3953.—Case XXVII. Chronic Melancholia. Morbid and uninhibited expression of grief. Darwin's "grief muscles" in contraction producing "horseshoe mark." (From photograph taken by author.)

may be directly concerned with exacerbations of excitement or depression occurring in many forms of mental disease.

4. In disturbances of motility, the reflexes may be exaggerated, diminished, or otherwise modified in different psychoses. In the earlier stages of paresis there are usually exaggerated knee-jerk and ankle clonus, followed by a progressive failure and final disappearance of these phenomena as the central degeneration advances. As a rule the deep reflexes are diminished in those varieties of insanity in which

depression is the prevailing feature, such as melancholia, the stuporose stage of dementia præcox, and dementia, and they are exaggerated in those varieties in which activity is a marked symptom, as in mania. The temporary disappearance of the deep reflexes followed by their reappearance in the same patient in different stages of the functional psychoses is an evidence that this symptom alone is not necessarily an indication of organic disease. Absence of the eye reflexes, however, is usually an evidence of organic brain disease, and is most frequently noticed in paresis.

In hemiplegia the Babinski reflex appears in about seventy per cent. of the cases, according to Drs. Walton and Paul, and is also associated with pyramidal-tract disease. The fact that the Babinski reflex occurs only in connection with organic disease makes this symptom an excellent diagnostic test for distinguishing hysterical paralysis from real organic paralysis.

The most noticeable evidences of disturbed motility are seen in the changed physical expression of the insane. All outward muscular movements, whether of the face, trunk, or extremities, succeed definite functional activity of some portion of the central nervous system. If follows, then, that functional or organic disturbance of the brain in insanity must lead to varying peripheral changes, both those of expression in the countenance and those consisting of peculiarities of gait, posture, and other muscular movements. These changes in physical expression when analyzed resolve themselves under the following heads: I. Impairment of healthy inhibition, which is so frequently associated with insanity, and one result of which is weakening of the faculty of attention. II. Excessive or defective nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral structure.

I. In health the inhibitory function is exercised in a twofold manner: First, in checking irrelevant trains of thought, repressing whatever is impertinent to the subject engaging the attention; and secondly, in checking certain muscular movements which, though they naturally follow the stimulations which have preceded them, still, for the time being and with other objects in view, are undesirable and out of place.

In the early development of insanity one of the first symptoms to attract the notice of the friends, and to arouse their suspicions of mental disturbance, is a manifest inability on the part of the patient to concentrate his attention. This will declare itself in various ways. The patient becomes inaccurate. If a mechanic, he either accomplishes less work or is careless; if in business, he makes frequent mistakes and fails to fulfill important obligations. All this inaccuracy and omission of detail are due to varying degrees of self-abstraction. The patient has lost the power of successfully inhibiting the fleeting thoughts or suspicions which crowd his mind and which supplantthe ideas that immediately concern his daily work and life.

The asylum workshop affords an excellent illustration. Here you may study inhibitory incapacity in every stage of development. A stranger enters the room and probably half of the patients will cease working, some will arise from their seats, and possibly one or more will walk about the newcomer, looking him over inquisitively and either talking to themselves or to the visitor. And in what a scattered and desultory way is much of the work performed! Evidently ideas irrelevant to the occupation in hand absorb and divert the attention of these diseased minds into other channels. In just the proportion that the individual possesses inhibitory capacity, to just that extent does he seem capable of performing successful and intelligent work.

Bearing in mind, then, that weakening of healthy inhibition is one of the first results of insanity, we find this impairment of the inhibitory capacity manifested in the physical, and particularly the facial, expression of the insane in two ways:

1. There is inability to control the movements of the facial muscles. The insane make few attempts at concealing the facial expression of their feelings. With them impaired inhibitory power interferes with that slight volitional control which we possess over those facial movements that habitually follow certain emotions. In the familiar language of daily life the insane *look* very much as they *feel*, and their attempts at concealing their real emotions are few and unsuccessful.

Fig. 3954.—Case LV. Acute Melancholia. Marked and characteristic innervation of Darwin's "grief muscles." Intense motor disturbance. (From photograph taken by author.)

2. For the same reason that there is impaired inhibition, there is inability to concentrate the attention, the result of which is an expression of self-absorption quite peculiar and characteristic of the disease.

The insane patient makes few and ineffectual attempts at disguising the feelings which oppress him. The conflicting emotions by which he is disturbed are reflected through the various motor tracts to the face, and as a result we may often read the character of the delusions which preoccupy the mind. Thus the expression of the countenance in acute melancholia is generally quite characteristic of a depressed state of the feelings; and what is especially noteworthy is the fact that this diseased expression is far more intense than would be the expression of similar emotions in the same individual in health. Impaired inhibition does not exercise any restraining influence upon the countenance, and, whether alone or in the presence of others, the melancholiac presents the furrowed brow, the anxious and distressed expression about the eyes and mouth that are characteristic of these especial emotions, whether they proceed from natural or morbid causes. The only difference is that the normal manifestation of grief is modified by healthy inhibition, while morbid sorrow is persistent, intense, and not subject to outward restraints.

Figs. 3953 and 3954 illustrate the complete abandonment of the patient to the predominant emotion, the individual making no effort whatever to control the expression of the feelings. Figs. 3955 and 3956 show the transition of expression in the alternating phases of exhilaration and depression, both cases being subjects of manic-depressive insanity. In acute mania inhibition exercises no restraining influence whatever over the constant nerve-muscular activity which so transforms the physiognomy. Fig. 3951, illustrates how completely has intelligent control over the features been swept away by the storm raging within the cerebral centers.

The faces of the chronic delusional insane show quite clearly the absence of healthy inhibition. Thus the sly, distrustful glance, the bitter, lowering look of hatred and enmity, the self-satisfied air of exaltation, or the dejected countenance of self-abasement, are expressions quite frequently noted among this class of insane, and are another evidence of the inability of the patient, through impaired inhibition, to control the outward manifestation of the inner feelings. These same feelings exist in health, oftentimes with great intensity, and yet how perfectly are they concealed, In this connection it is interesting to note that in the weaker mental conditions of childhood these same feelings and emotions are frequently and as clearly represented in changes of facial expression as are the corresponding emotional states in the face of the adult insane. The main difference lies in this fact, however, that in childhood inhibition through the will has not been developed, while among the adult insane it has been weakened by disease.

Fig. 3955.—Case X. Alternating Insanity. Exhilarated stage.

Case XII, Fig. 3957, quite plainly manifests in his countenance his all-absorbing egotism. In sitting for his portrait he chose his own position, arranging with great care his decorations, consisting of old buttons, bits of glass, brass wash-bowl chains, etc., which, as he imagined, possessed great value. The violin, which he made himself out of limited materials, and with an old knife and awl, he was anxious to display as a Cremona instrument of rare worth. The inconsistency of his real position (that of confinement for life in an asylum) and the utter worthlessness of his jewelry and improvised insignia do not in the least lead to the inhibition of the expressions of morbid vanity and self-importance which pervade his countenance. Indeed, in nearly all forms of acute or chronic insanity characterized by active persistent ideas there will be noticed in the facial expression a complete abandonment to the prevailing morbid emotions, with scarcely any attempt at inhibition.

II. The second manner in which the physical expression of health is modified by insanity is through *excessive, deficient, or automatic nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral cell structure.*

It may be stated that all those movements which are caused by irregular cell activity of the cerebral centers have one characteristic distinguishing them from the ordinary changes of facial expression: they are entirely meaningless, subserve no purpose, and do not conform to any of the well-known expressions of the emotions, as grief, joy, etc. In health the expression of these emotions is always recognized by certain well-known muscular contractions which observation has taught us are characteristic of corresponding mental states. We know, for instance, that

Fig. 3956.—Case X. Alternating Insanity. Depressed stage. Ocular divergence.

laughter will be manifested by contraction of the *corrugators*, of the *molars*, and of the great *zygomatic;* in grief we know that the eyeballs will be rolled a little upward and inward, and that the contraction of the central fibers of the *frontalis* acting upon the *corrugators* will produce a peculiar and very characteristic wrinkling of the forehead above and between the eyes, and that the *depressores anguli oris* will draw down the corners of the mouth. These muscular contractions follow in a certain definite manner their causative mental states. So regularly and constantly do they succeed their antecedent mental conditions that, given the state of mind, the resulting movements of expression can be foretold even before their appearance. Hence the expressions of the emotions can be easily separated into groups; thus we have the expression of joy, grief, disgust, and all the others.

On the other hand, the movements under discussion are not regular, do not indicate any particular

place in acute insanity, and is of very frequent occurrence in the degenerative brain conditions of chronic alienation.

To avoid confusion we may study this phase of the physical expression of the insane under three heads:

I. As representing states of excessive nerve-muscular activity due to central irritation.

II. As representing states of deficient nerve-muscular activity due to central degeneration.

III. As representing states of automatic cell activity in the cerebrum occurring not infrequently in acute insanity, and quite constantly in the chronic form of the disease.

I. *Physical Expression of the Insane Caused by Excessive Nerve-muscular Activity.*—A certain constant and regular transmission of nerve force from the central cells to the muscular periphery is natural and in accordance with health. Indeed, a state of general good health demands this outward relief for the potential energy constantly accumulating within the brain cells. Thus the excessive muscular activity of all young and growing animals, the playfulness of young dogs and kittens, the pranks and follies of boyhood, are oftentimes merely the expression of this great natural law. In adult life the potential energy of cerebral cells is manifested in more practical and useful ways, but still in the most tangible results of a successful business, mechanical, or professional life we recognize the outward manifestation of the potential energy which has been stored up within the brain cells until the proper stimulation called forth its discharge.

In diseased conditions of the brain, however, the pathological irritation of these delicate nerve centers may be so great as to overcome any acquired inhibitory resistance, and thus liberate an excess of nerve force which will seek an outlet in the usual way by passing along the efferent motor tracts to the muscles, and there appearing as muscular movement. Thus it is that in the functional or organic brain disturbances of insanity, abnormal motor activities are a frequent accompaniment of disturbed states of mind.

Pathological motor activity is, as we have seen, spasmodic, irregular, and purposeless. The most striking illustration of this fact is afforded by cases of chorea and epilepsy. There seem to be good reasons for supposing that in these diseases the brain cells are in an unstable condition, owing to hereditary, traumatic, or nutritive disturbances, and that, as Gowers[19] says, the discharge of these same cells "may depend on the production of force within being increased in excess of the resistance, or on the resistance being duly lessened."

In the active stages of mania and melancholia, in the acute excitement which sometimes occurs in paresis and other organic diseases of the brain, this same discharge of nerve force takes place. The unceasing jactitation of acute mania, the restlessness of melancholia, are familiar illustrations. Such patients are apt to be in a state of constant muscular activity, pacing the floor, tearing their clothing, and destroying whatever comes in their way.

These irregular and motiveless movements of the insane are earliest manifested in the facial muscles. The extreme sensitiveness of this region to cerebral conditions and the weaker inhibitory control which the brain possesses over these delicately poised muscles are reasons why the face so often presents the first physical manifestations of the advancing mental disease. Very frequently the muscular disturbance does not extend beyond the face; but it is quite rare that this region does not show some evidence of the morbid irritation of the brain cells. When the face alone is disturbed in this way, the resulting expression is quite peculiar, and resembles those meaningless contractions that are produced when a mild galvanic current is passed through these muscles. The muscles are gently but continuously contracted, particularly those about the forehead, at the root of the nose, and about the mouth, giving to the patient a peculiar kind of *troubled* or *anxious* expression. It is often noticed by the friends at a very early stage of the disease, and they will tell you that the patient does not look natural, that his countenance has a strained, intense look, quite different from his normal expression, but still very difficult to describe.

Fig. 3957.—Case XII. Paranoia. Morbid egotism and fondness for display. (From photograph taken by author.)

In Case XLII (Fig. 3951), the patient was entirely incoherent, and in a state of constant muscular agitation. He was destructive, and almost too confused to eat his meals, so that frequent feeding with the nasal tube became necessary. The staring eyes, wrinkled forehead, dry, dishevelled hair, and torn coat are in striking contrast with Fig. 3952, in which the hair has assumed its natural condition, the face is smooth, and the eyes are calm and quiet.

In cases of melancholia with motor disturbance we see the effects of central irritation reflected in muscular agitation. Sometimes the patient will pace the floor wringing the hands, groaning and moaning, or the excitement will become so intense as to lead to an impulse to tear or destroy whatever comes within reach.

In many cases of chronic insanity almost constant tooth-grinding is a noticeable feature, and another illustration of morbid transmission of nerve force from the central cells to the muscular periphery. Tooth-grinding is not uncommon in nervous children, and is of very frequent occurrence in the insanity proceeding from structural brain disease. It is noticed oftener in connection with paresis than with any other disease. In passing through wards for demented patients it is a familiar sound, and sometimes is made with such force that it can be heard at a distance of thirty or forty feet. Warner thus alludes to this symptom: "Tooth-grinding is produced by the action of the deeply situated pterygoid muscles; champing of the jaws is produced by the masseter and temporal muscles; all these muscles are supplied by the fifth nerve, and it is to their condition that we must look for information as to the

state of mind, but represent rather that irregular and interrupted action of the brain cells which often takes condition of the central origin of the nerve." By means of the Gasserian ganglion and small nerve filaments branching from it, the fifth nerve is brought into intimate connection with the dura mater and adjacent membranes. In chronic insanity associated with dementia these membranes are nearly always found to be in a pathological condition. It is quite natural, therefore, that morbid sensations should be transmitted from these diseased membranes, through the sensory branches of this portion of the fifth nerve, back to its origin in the pons Varolii and medulla, and thence be reflected outward along its motor tract to the pterygoid and masseter muscles.

In many cases of maniacal excitement attention has been called to the dry, rough, and almost bristling condition of the hair. In those patients who have recovered from mania the hair resumes its normal condition, is softer, and more easily kept in place. Illustrations of this are seen in Figs. 3958, 3959, 3951, and 3952. In chronic or in recurrent mania the dry and bristling state of the hair is of common occurrence. One case under the writer's observation, that of a woman, was characterized by exacerbations of excitement, and at these times her hair was exceedingly dry and stood

Fig. 3958.—Case XXXIX. Acute Mania. As he appeared on arrival at asylum from prison. Morbid innervation of facial muscles. (From photograph taken by author.)

out in a striking way all about her head and face. In two cases the hair was naturally curly, but, as one result of the active mental excitement, there seemed to be imparted to it a stiffness quite different from that produced by the curliness; each individual hair, during the period of excitement, appeared to have a special prominence of its own.

This singular condition of the hair, in states of active mental excitement, has been alluded to by Darwin in his "Expression of the Emotions in Man and Animals." His explanation, which is undoubtedly correct, affords another illustration of excessive nerve-muscular activity following cerebral cell irritation. Every hair sac is provided with delicate unstriped muscular fibers—*arrectores pili*. These minute involuntary muscles are exceedingly liable to contract under the influence of strong emotions, such as fear and anger, as well as from the effects of cold. The contraction of these muscles causes a more or less complete erection of the hair shaft. Darwin concludes that "the erection of the dermal appendages is a reflex action, independent of the will; and this action must be looked at, when occurring under the influence of anger or fear, not as a power acquired for the sake of some advantage, but as an individual result, at least to a large extent, of the sensorium being affected."

In the active mental excitement of mania, acute or chronic, persistent irritation of the cerebral cell structure leads to the transmission of nerve force along this channel to the *arrectores pili*—all the more readily because the natural emotions of fear and anger have made this a customary route. Hence in those forms of insanity which are accompanied by excessive nerve-muscular activity this erection of the hair is an almost inevitable result. This condition of the hair is seen only in those forms of mental disease which are characterized by active excitement or marked emotional disturbance. The bristling and erection are intensified by the dryness and roughness of the hair due to the impaired action of the subcutaneous glands. Darwin also informs us "that with man the hairs on the front of the head which slope forward, and those on the back of the head which slope backward, are raised in opposite directions by the contraction of the *occipitofrontalis* or scalp muscle." This muscle is, as we have seen, often kept in a state of unnatural tension in conditions of pathological cerebral excitement, and hence its action would assist the *arrectores pili* in maintaining an erect and bristling state of the hair.

Fig. 3959.—Case XXXIX. Taken at time of discharge and recovery. Disappearance of morbid innervation, improved nutrition. (From photograph taken by author.)

11. *Physical Expression of the Insane Caused by Deficient Nerve-muscular Activity due to Central Degeneration.*—Deficient nerve-muscular activity play a prominent part in the etiology of the physical expression of insanity. A recognition of its existence in any case frequently enables the physician to make a correct diagnosis and prognosis of the mental disease affecting the patient. In nearly all forms of chronic insanity accompanied by mental enfeeblement, deficient nerve-muscular activity corresponds to the degree of mental impairment.

Whatever the pathological alterations in the brain cells may be, varying degrees of motor impairment constitute one very constant result in all cases of chronic insanity attended with mental weakness. We have already noticed how excessive nerve-muscular activity characterizes nearly all attacks of acute mania, as well as the excited stage of paresis, and the temporary exacerbations of excitement occurring in dementia. In these cases the nerve force is discharged in excess of the power of resistance, either because the inhibitory power itself is diminished, or because there is an excess of nerve force generated within the nerve centers. On the other hand, in cases of persistent and long-continued acute insanity, as well as in chronic insanity associated with the varying degrees of dementia above

mentioned, deficient nerve-muscular activity is a prominent symptom. And the inference seems a legitimate one, that this deficient nerve-muscular activity represents or corresponds to certain degenerative processes occurring within the brain cells. This deficient nerve-muscular activity varies from the slightest motor impairment in a few of the delicate facial muscular strands to an extreme degree of general muscular paresis.

This defieient nerve-muscular activity represents imperfect or weakened innervation on the part of the central organ—the brain. All nerve tissue is endowed with one peculiar property, that of *sensibility*. By means of it, "the nerve cells feel excitation from without, and react in consequence, by virtue of the excitement of their natural affinities" (Luys[20]). Impaired sensibility of the nerve cells is a frequent result of protracted attaeks of aeute insanity, and a constant accompaniment of the various forms of dementia. And in such cases there is imperfect reaction to the various sensory stimulations which, in health, are being constantly transmitted from the periphery to the higher nerve centers of the brain. Dementia is characterized by imperfect responsiveness to external impressions. It is difficult to arouse and interest such patients. They care little for their surroundings; they eat and sleep, but their energy seems lost. They lie or stand around in a listless way, and oftentimes it is necessary to speak to them in a louder voice in order to attract their attention.

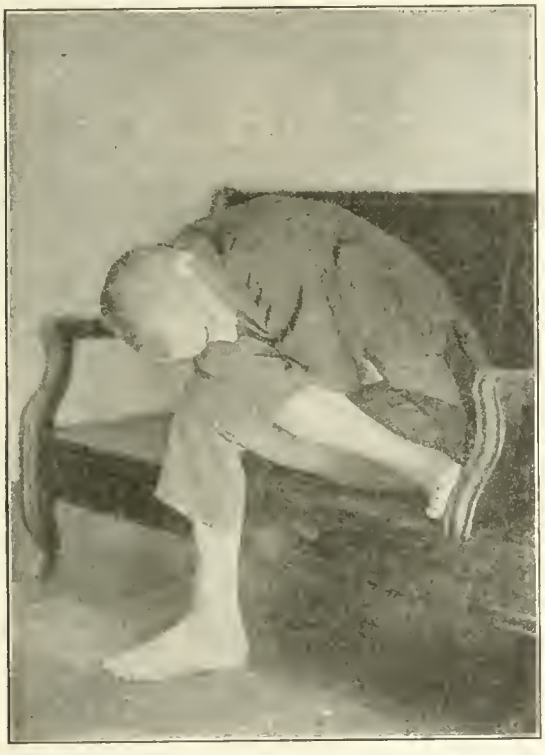

Fig. 3960.—Case LI. Chronic Dementia. Showing peculiar and uncomfortable attitude assumed by demented person as a result of morbid and persistant nerve-muscular activity. (From photograph taken by author.)

Impaired nervous sensibility is attended with imperfect motor reaction, probably for the reason that the afferent and efferent tracts do not transmit impulses to and from the brain as readily as in health, and also because the brain eells themselves are less sensitive. Those regions which in health are most responsive to this excitation are very apt to be the first to become affected in diseases of the central nervous system. For this reason the face, in the earliest stages of dementia, begins to show evidences of impaired innervation. The lines about the eyes, the forehead, and the mouth, which were formerly well defined and which represented the healthy muscular tonicity already referred to, begin to lose their precision and appear to be smoothed out. The peculiar pose of the features, due, as we have seen, to the continuous transmission of nervous force along the various efferent nerve tracts to the muscular periphery, and which gives what we call character to each individual countenance, seems to have lost its definiteness. As a result the face begins to lose its expression, and in the very earliest stages of the disease constitutes a painful symptom for the friends to behold, and leads the physician to make a grave diagnosis and prognosis.

This defective nerve-muscular activity, which is first manifested in the faces of demented patients, in time extends to the larger muscles of the extremities.

Fig. 3961.—Case LVIII. Chronic Dementia. Peculiar and uncomfortable attitude maintained daily for years. Automatic nerve-muscular activity. (From photograph taken by author.)

Demented patients become clumsy, and, if good mechanics gradually lose the muscular precision which formerly characterized their work. Quite frequently such individuals are obliged to give up a certain line of skilled labor in which they formerly excelled, and undertake a less exacting branch of the work, or renounce it entirely before it becomes fully apparent that their mental health is being seriously undermined. At a still later stage of the disease the muscles of locomotion become impaired, and the patient grows clumsy in gait.

In the wards for demented patients in a large asylum one is struck with the slow, lumbering gait of the patients, with their lifeless attitudes and the general absence of healthy muscular activity which is evident on every side. A party of demented persons

is easily recognizable at a distance. Their muscles, like their clothing, seem to *hang*, and there is none of that elasticity of movement characteristic of health.

This progressive muscular failure is quite noticeable in the cases of terminal dementia, which constitute so large a proportion of the population of public hospitals for the insane. Oftentimes these patients are under observation for years. In the earlier stages of their asylum residence they are capable of performing much manual labor. Gradually, as their dementia advances, they become less capable of sustained work; they may grow fleshy, but their muscles become weaker and more unreliable; and finally they cease to be efficient workers, and spend their time in the ward or on the grounds, lying or lounging about in a listless way. In these cases there is a real failure in nerve-muscular force, which is represented by an inability to enter into mechanical employment, as was formerly their wont.

Fig. 3962.—Case LX. Chronic Dementia. Uncomfortable attitude maintained for a long period. Automatic nerve-muscular activity. (From photograph taken by author.)

In cases of structural brain disease the order in which failure of muscular innervation occurs is quite interesting. First the muscles about the mouth begin to show weakness; then those about the forehead and between the eyes; later, the articulation begins to fail and to grow more thick and indistinct; and the muscles of deglutition respond so feebly to innervation that the act of swallowing is rendered clumsy and difficult, and the patient is in danger of choking. Finally, the larger muscles of the extremities begin to weaken; the drooping head, shoulders, and arms, and the shuffling, clumsy gait indicate the steady progress of the brain disease.

Warner[21] says: "In a strong and healthy man the head is held erect and symmetrical, unless some central condition or external agent changes the posture. In a strong man the center of the forehead is in the mid-plane of the body, the anteroposterior and the transverse axes are horizontal, with both eyes on the same level; this is a normal position of quiescence."

In cases of progressive dementia, in the advancing stages of paresis, this failure of innervation is quite commonly seen in the drooping of the head.

In many cases the lower jaw drops on account of relaxation in those muscles which support it; this gives to the face an elongated expression, and quite frequently occasions the open, stupid-looking mouth so often seen in dementia.

Defective innervation, as we have seen, finally extends to all the muscles, and produces that peculiar drooping of the body, shoulders, arms, and even fingers, and that most indescribable, but when once seen never-to-be-forgotten, clumsiness of gait and attitude so characteristic of demented patients.

III. *Physical Expression of the Insane, Caused by or Representing States of Automatic Cell Activity in the Cerebrum, Occurring not Infrequently in Acute Insanity, and Quite Constantly in the Chronic Forms of the Disease.*

Fig. 3963.—Case LXV. Melancholia with Stupor. Showing persistent morbid attitude maintained for hours. (From photograph taken by author.)

—A high volitional power distinguishes man from the lower animals. Even the most highly developed of these lower orders possess limited volitional powers. In them life is largely automatic, and distinct purposive direction of their actions is slight. Many of their acts that seem to display a high degree of intelligence and to suggest the power of voluntary selection prove, on close examination, to be merely the result of an unreasoning instinct which would not have admitted of any other course. In man, on the contrary, while his daily life is largely made up of various automatic activities, still the range of purposive selection is large, so that the "mechanism of thought and feeling" is made to serve the best interest of the individual through the guidance of the will.

In some way, at present obscurely understood, will power and functional activity of the cortex are

mutually interdependent. Hence disturbance of these centers in insanity, caused by impaired nutrition, defective functional activity, or more gross structural lesions, weakens the will power of the individual. The

Fig. 3964.—Case II. Dementia Precox. Cataleptic stage. Muscular rigidity. Negativism.

unctional activity of the cortical centers may be completely disarranged by insanity, and, as a result, the normal exercise of the will may be disturbed, if not entirely suspended. At the same time, however, the activities of the basal ganglia, no longer under the guiding and controlling influences of the cortical centers, continue automatically. As a result, purposeless thought and action of an automatic character are quite apt to follow those serious disturbances of the higher cerebral centers during attacks of severe acute and chronic insanity.

Automatic activity of the cerebral centers in health is subject to the direction of the will, and its results display purpose. Automatic activity of these same centers in disease of the mind seems to be less under the guidance of the will, and the resulting action appears purposeless. In proportion as the will power is weakened by the brain disease do meaningless automatic activities of thought and action prevail.

In passing through the wards for the chronic and demented insane, one is struck with the evidences on every side of automatic activity. Here you will notice a man walking backward and forward in a mechanical way for hours together, until he has worn a beaten path in the floor; there will stand one who picks away at a certain place on his clothing for an indefinite period until he has worn the garment through to the skin. Quite frequently one will hear curious meaningless noises repeated in a mechanical way—singular repetitions of certain words or sentences wholly meaningless. It is not an uncommon thing for chronic patients to have some peculiar word or phrase, or even a single articulate sound, and to repeat it in an irrelevant way for years. In like manner you will meet with patients who make strange motions with the arms and hands, and take singular attitudes in a mechanical way. It is for their diversion. All this variety of automatic action and speech would seem to indicate that the healthy functional activity of the higher cerebral centers has been disturbed and partially suspended,

difficult to arouse the attention of such patients; their monotonous repetition of words and movements continues just the same, regardless of the presence of others, and with little reference to any attempts made

Fig. 3965.—Case II. Dementia Precox. Remission.

and that the lower centers are acting mechanically and without the normal volitional control.

Prolonged automatic activity in thought, speech, and action, among the insane, suggests a serious lesion in the higher brain. The more mechanical and pur-

poseless the words and acts of the patient, the graver is the prognosis.

The nervous system manifests a striking tendency to mechanical repetition of any process once initiated within its centers. One epileptic attack is likely to be followed by another, and a number of seizures renders the prospect of still others quite certain, until in a short time the disease becomes firmly established. Both mania and melancholia manifest tendencies to repetitions of the attack, and each new attack renders the probability of another quite certain, until recurrency or permanent insanity is established.

In the advanced stages of fevers, such as typhoid and scarlatina, the higher functions of the mind are often suspended, either from exhaustion or because the cortical centers have been disturbed by the severity of the febrile action. In these grave physical conditions the automatic and purposeless repetition of words

Fig. 3966.—Case XIV. Dementia Precox. Cataleptic state. Muscular rigidity and negativism.

Fig. 3967.—Case XIV. Dementia Precox. Remission.

Fig. 3968.—Case V. Dementia; remission following a confusional attack. Muscular tonicity restored. Ocular convergence.

Fig. 3969.—Case V. Dementia; an acute confusional attack. Entire absence of normal muscular tonicity; ocular divergence.

and muscular movements becomes quite noticeable. Subsultus tendinum, carphologia, tiresome utterance of some particular sound or word, indicate that the higher cerebral functions have been suspended, and that the lower centers are acting at random and without the direction of the former. In this case the prognosis is grave because the vital forces themselves are waning and volitional activity is suspended through exhaustion of the cortical center.

In chronic insanity the prognosis as to mental recovery of the patient may be equally grave, for the reason that healthy functional activity of the cortex has been permanently disturbed by the disease, which, though not necessarily fatal to life, is most assuredly so to mental restoration.

For the reasons just outlined the chronic insane are very likely to develop objectionable habits. The study of the physiological origin of many of the habits of this class of the insane would be most interesting and instructive. Two laws underlie every form of nervous activity, and furnish a physiological reason for the constant tendency toward automatic and habit action exhibited by the chronic insane in whom inhibitory impairment always exists. 1. The discharge of the nerve centers occurs along those tracts which offer the least resistance. 2. The more frequently the discharge occurs along a given line, and the weaker the inhibitory resistance, the easier does a repetition of the discharge become, and the more certain its permanent automatic establishment.

If, for any reason, in those conditions of mental disease which are characterized by a weakening of the

Fig. 3970.—Case VIII. Dementia Precox. Stuporous state with muscular rigidity and negativism.

will power, one especial route is established either by reason of delusion or by mere fortuitous circumstance, the probability is that this particular route will continue to be the one most frequently traversed by nervous force in its passage from the brain to the periphery. A delusion, an hallucination of sight or hearing, some peculiar condition in the patient's environment may have first initiated certain actions which, by being unresisted and hence repeated, lead to the establishment of a habit. Probably in some such simple and purely fortuitous way are developed the pulling out of the hair, tearing the clothing, walking in a beaten path, making singular motions or uttering meaningless sounds—in fact any of the countless strange habits of the insane. It matters little whether the performance of these habits is painful or disagreeable, no other alternative seems open to the patient when, through weakness of will and intelligence, the morbid route has once been established. Some morbid sensation in the scalp or chin to act as an excitor, or merely the absence of anything of an intelligent character to engage the attention, may lead to the plucking out of the hair or beard, which impulse, meeting with no resistance, soon develops into a persistent habit. A delusion about the bed may lead the patient into the habit of standing up all night and if not interrupted, nothing short of restraint will prevent exhaustion, so persistent will the impulse become to remain on the feet.

The importance of the early breaking up of bad habits among the insane will be readily understood. Fortunately the same tendency to automaticity of action may be utilized in a good as well as a bad direction. By careful supervision we may succeed in breaking up many useless and vicious habits by supplying some simple mechanical occupation for the hands, thereby utilizing the automatic nerve activity characteristic of the disease. And in doing this we may even seem to retard mental deterioration. Judiciously selected mechanical employment among the insane has become therefore a valuable means of treatment. Diversional employment has now become one of the most valuable therapeutic agencies in the institutional treatment of all forms of insanity. Every well-ordered hospital for the insane has one or more industrial teachers, whose duty it is to enlist in various ways the attention of patients. The attempt is made, for instance, to re-educate the dormant faculties of the dementia precox case by class work, calisthenics, any measure that will break up the pathological tendency of nerve activity to seek useless and automatic routes.

It is quite obvious that photographic illustration of the entire subject of automatic nerve activity is impossible, and yet enough in this direction may be shown to demonstrate the important part played by morbid automatic cell activity in the physical expression of chronic insanity, and, to a certain extent, in some forms of acute alienation. It is evident that illustration of this part of the subject must be limited to postures. The significance of postures in health has been referred to by Dr. Francis Warner.[22] He says: "Postures depend upon the ratios of nerve-muscular action, and to some extent they indicate the present ratios of static efferent force proceeding from the centers concerned. Observations show that the postures, when not due to a present stimulus, or when produced by a weak stimulus from without, such as a sound or sight, correspond to and are signs of the general condition of the central nerve system."

The postures maintained, oftentimes for long periods, by the insane possess a special interest because they are a pretty sure index of the morbid condition of the central organ of innervation.

Figs. 3960, 3961, and 3962 illustrate peculiar and somewhat painful attitudes which were taken by patients suffering from secondary or terminal dementia. And in Fig. 3963 is seen a singular position maintained by a patient in a condition of stuporous melancholia. In these and similar cases the intensely interesting question is always suggested, How came such peculiar habits to be initiated? The wards for demented patients present numerous cases of this character which will afford material for physiological and psychological study. The careful investigation into the early development of mechanical movements, attitudes, and meaningless habits among this class of patients would amply repay the time and labor expended in this direction, and throw some light on the

processes of cerebration and their connection with muscular movements.

The singular postures shown in Figs. 3960, 3961, and 3962 were gradually assumed by the patients while under the writer's care, and yet so very slowly were they initiated that they became fixed and habitual positions before any especial attention was called to the fact. In this way the real causes that led up to the final establishment of the habitual posture were lost sight of. From what was known of the patients, the impression would be formed that in Cases LVIII and LX (Figs. 3961 and 3962) delusions of suspicion or a dislike to seeing persons about led to a habit of hiding the face, as is often witnessed among bashful and diffident children. As these particular patients became more demented, a position which was at first assumed as the result of an active delusion finally developed into a permanent habit, simply because nervous force, flowing along this route from center to periphery for so long a time in obedience to impulses derived from morbid ideas, and meeting with little

Fig. 3971.—Case IX. Dementia Precox. Muscular rigidity, ocular divergence, negativism.

inhibition, continued to take this route long after active thinking had ceased.

Another interesting fact concerning these strange attitudes assumed by these patients is, that they seem utterly oblivious to the discomfort and even the painfulness of these constrained positions. Cases LI and LX (Figs. 3960 and 3962) would maintain the posture for hours; and Case LVIII, from the hour of rising until bedtime, was continually in the attitude shown in Fig. 3961. The muscles concerned in the maintenance of these postures were in a high state of tension, showing that a certain amount of "static efferent force" was being transmitted continuously from the centers within the sensorium to the periphery over these morbidly preestablished routes. Nearly all the other healthy activities of mind seemed in these cases to have ceased, with the exception of the mere processes of organic life, and the entire energy of the sensorium was expended in keeping up these automatic and useless positions. Any attempt to move the arms into a more easy position was met by firm resistance, which was not spasmodic but persistent in character. That these attitudes would be painful to a person in health, any one can demonstrate by attempting to maintain similar positions for even a few minutes at a time.

The cataleptic conditions that are such a constant accompaniment of the stuporous state of dementia precox afford a good illustration of automatic cerebral cell activity. During this phase of the disease the muscles become rigid and contracted and cannot be moved without quite a degree of force. The *negativism* so characteristic of the mental operations extends to all the muscles. During the remission all this muscular tension ceases and the patient returns to his normal physical expression. Cases II (Figs. 3964 and 3965), XIV (Figs. 3966 and 3967), VIII (Fig. 3970), and IX (Fig. 3971) illustrate the automatism and rigidity accompanying this disease at its height, with the return to a natural state upon the subsidence of the central disturbance.

Finally, disturbances of motility are quite frequently reflected in the varying expressions of the eyes. In mania there is increased brilliancy of the eye and marked mobility of that organ. In melancholia there is ocular parallelism or divergence, in which condition the person seems to take no interest in his environment. In dementia and in the stuporous states of melancholia and dementia precox there is a dull lusterless condition of the eye. Oftentimes the eyes have a staring look, and in many forms of insanity all attempts at diversion are futile, the patient continuing to manifest that painfully stony and glaring aspect which shows how intense is the mental absorption. Indeed, one of the first symptoms of insanity observed by the friends of the patient is this peculiar expression due to ocular parallelism. They often refer to a certain strange, unnatural, or wild appearance about the eyes which is undoubtedly brought about by the divergence due to almost constant morbid preoccupation of the attention. In health the eyes are in a state of gentle convergence—such a condition being necessary to binocular vision. The least withdrawal of the attention from any object in the immediate environment is at once followed by a partial relaxation of the recti muscles, and as a result the eyes slightly depart from their condition of convergence and appear to be directed forward in nearly parallel or slightly divergent lines. Such divergence is usually quite temporary, lasting only during the mental preoccupation. So too in mental disease the eyes, either from morbid preoccupation or from deficient ideation due to structural or functional disturbance of the brain, are reduced to a condition of quite continuous parallelism, giving that appearance of abstraction so characteristic of the insane. Illustrations occur in Figs. 3949, 3951, and Fig. 3955.

Enough has been said to indicate the prominent part played by physical expression in the symptomatology of insanity. The intimate association of muscular movements and morbid states of mind serves to demonstrate the close functional relationship of the various brain areas and their mutual interdependence.

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References.

1. White, Wm. A.: Outlines of Psychiatry.
2. Bolton, Joseph Shaw: Journal of Mental Science, vols. li, lii, liii, liv.

3. Macpherson: Mental Affections.
4. Regis, E.: Practical Manual of Mental Medicine.
5. Tanzi, Eugenio: Mental Diseases, 1909.
6. Ribot: Diseases of Memory.
7. Grasset, Joseph: The Semi-Insane and the Semi-Responsible, 1907.
8. Fisk, John: Destiny of Man.
9. Craig, Maurice: Lancet, June 25, 1898.
10. Mackie, F. Percival: Journal of Mental Science, January, 1901.
11. Bruce: Clinical Psychiatry, 1906.
12. Tuttle, George T.: Am. Journal of Insanity, April, 1892.
13. Bondurant, E. D.: Am. Journal of Insanity, July, 1895.
14. Pront, Thomas P.: Am. Journal of Insanity, January, 1897.
15. Hubbard, Cleon Melville: Am. Journal of Insanity, April, 1898.
16. Worcester, W. L.: Proceedings of the Am. Medico-Psychological Association, vol. vi.
17. Starr, M. Allen: Medical Record, May 11, 1901.
18. White, E. Barton: Journal of Mental Science, October, 1913.
19. Gowers: Epilepsy and Other Chronic Convulsive Diseases
20. Luys, J. B.: The Brain and Its Functions, p. 81.
21. Warner, Francis: Physical Expression, Internat. Scientific Series, p. 185.
22. Id.: Journal of Mental Science, April, 1889.

Mental Diseases, Treatment of.—The scope of this general article on the treatment of insanity is shown by the following headings under which the subject will be presented, viz., (1) Prevention and State Medicine; (2) Treatment and Care in Institutions and in Private; (3) General Emergencies in Psychiatry; (4) Medication; (5) Surgical Measures; (6) Psychiatric Hygiene (Hydrotherapy and Climatotherapy included); (7) Dietetics; (8) Mental Therapeutics; (9) Convalescence and Protective Aid. The treatment of the special forms of mental disease will be considered in various separate articles by different authors.

Prevention and State Medicine.—Broad preventive treatment of insanity has never been undertaken, but it is time for some concert of opinion and action between physicians and lawmakers to control such causes of the disease as exist widely in the whole fabric of society. Heredity as a chief source might be diminished in a measure by the enactment of wise marriage laws, prohibiting the reproduction of the kind *in vinculo matrimonii* by idiots, imbeciles, lunatics, actual or imperfectly recovered, confirmed epileptics, the chronically alcoholized, and neurotic subjects with a double parental taint of lunacy. The majority of incurables in hospitals for the insane were born weak-minded and with defective nervous centers, and prophylaxis in such cases should begin in childhood and youth by an easy curriculum of school study, healthful out-of-door occupation, the avoidance of tea, coffee, tobacco, stimulants, and all excesses, and the choice of a calling free from much mental or physical stress. In this way those of native inferiority may be fortified against the mental disorder which would otherwise result under trying circumstances of mental strain. The State, financially burdened with the increasing numbers of her insane wards, should adopt various wide and far-sighted measures of prophylaxis. There should be more complete exclusion and repatriation of immigrants of unsound mind. The insane rate as well as the birth rate is greater among aliens than natives in this country and the proportion of insane foreigners will constantly increase. The possible wisdom of the sterilization of criminals, and the whole question of eugenics, demands attention. Syphilis and alcohol, great scourges of the human race, and constant causes of insanity, require more study and legislative prevention. In the broadest sense prophylactic are general measures taken for the amelioration of the laboring people—the overworked and underfed masses, whose poverty and misery prevent healthful reproduction of the species. Such measures are laws for pure food and hours of labor, enforced sanitation in factories, tenements, and entire municipalities and legal protection of workmen from toxic as well as traumatic injuries. The standard of knowledge of mental disease in the medical profession should be raised. Thorough and practical instead of nominal instruction in psychiatry should be made compulsory in all medical schools, and medical degrees or licenses should not be granted on State examinations to those incompetent in this branch, for in nine cases out of ten the general practitioner has to solve alienistic problems without the help of the mental expert. The State should disseminate widely, by free literature and lectures, common-sense ideas of the nature and causes of insanity, of the means of its avoidance, and seek to remove the false dread and stigma which tend to hide the disease until it is past cure. In all the largest cities the State should establish hospitals for the clinical observation and continued treatment of incipient and other forms of mental disease without legal formalities or financial obstructions. This suggestion made by the writer more than a decade ago has of late years been partly put into effect in Scotch, English, and American hospital clinics for mental diseases, in the University of Michigan Psychopathic Hospital, in Pavilion F, Albany (N. Y.) Hospital, in the Henry Phipps Psychiatric Clinic, Johns Hopkins Hospital, Baltimore, Md., and in a similar clinic at municipal expense in Boston, Mass. The officers of such hospitals, known for their skill in nervous and mental diseases, should give prophylactic advice as to feeble children, exceptional curriculum of studies in schools, permissible marriages, and all the adult relations of life in neurotic families.

Treatment and Care in Institutions and in Private.—It would appear from late census returns in this and other countries that about seventy per cent. of those mentally defective and insane are cared for in institutions. Large numbers, however, escape recognition and enumeration.

Colonies are among the best provisions for the insane. The oldest is at Gheel, Belgium, agricultural and under medical and governmental control. Another successful colony is at Clermont-sur-Oise, France. In connection with a central institution agricultural colonies also exist at Alt-Scherbitz, Saxony, Ellen near Bremen, Slup near Prague, Ilten near Hanover, and at Reggio-Emilia, Italy.

The family system of the boarding out of the insane in private families has long been found practical in Scotland and in Massachusetts and Wisconsin also. Something must be done to lighten the public financial burden of the rapidly increasing numbers of the chronic insane in this country. In the economic care of these cases the State Hospitals could be used as a central basis of operations by extending the lines of the system in all radial directions from the main plant on established roads to a distance of one hour's automobile travel. Suitable houses on such roads could be rented and utilized by the State as homes for patients under care of State employees in some instances, while in other cases family care would be provided in the household of actual farmer owners under monthly inspection by State agents. Thousands of men patients now in hospitals for the insane are capable of labor worth more than their board, and in agricultural ways chiefly could be made self-supporting.

Hospitals for the insane, well organized under public supervision, exist in most of the States, and some have a cottage system and agricultural colony provisions. Their chief defects are overcrowding and lack of special wards and adequate means of treatment of acute cases and of the criminal and epileptic insane. Private hospitals for the mentally diseased are found in most of the States. Some of them are

officered by mental experts, and are indispensable resorts for those wishing to avoid public hospitals and unable for various reasons to be treated in their own homes. There are also unlicensed sanatoria, water cures, hygienic hotels, and health resorts, more or less well conducted, in which the insane unfortunately often remain until their best chances of cure have passed. The family physician in the majority of instances will have to consign his mental sufferers to the public hospitals for reliable cure at a moderate rate, but exceptionally the means of the patient will admit of the choice of a well-appointed private hospital with trained nurses, few patients, and the comforts of home and completely individualized treatment. Treatment in private at the patient's house is expensive, in view of fees of nurses and physician expert, and it sometimes reacts banefully on the whole household; while, on the other hand, cure at home avoids publicity and some of the dread stigmata of the disease. The physician must isolate the patient in some part of the house, and guard against suicide and violence by constant supervision of trained nurses, and if the case prove too troublesome a resort at once to a private hospital is better than attempts to improvise hospital facilities in hotels and boarding-houses.

General Emergencies in Psychiatry.—There are certain very urgent conditions in mental disease constituting positive emergencies to be met by prompt treatment. Inanition is one of the most common of these conditions, and it is often not diagnosed until it has reached a degree dangerous to the life of the patient or at least to the prospect of early recovery of brain cells, which degenerate rapidly during acute malnutrition. The waste of tissues in active mental disease is excessive, and a surprising amount of concentrated nourishment is needed to sustain the patient, who may be said by the friends to have eaten pretty well and yet the breath may have a real starvation odor. The best food stuffs and means of forced alimentation will be described under the head of dietetics. If the case borders on collapse, nutrient and stimulating enemata and the injection of saline solutions under the skin may be practised. Another almost constant emergency in acute insanity is insomnia, and it may lead to a fatal issue as surely as starvation and is not always recognized. Sleep is often feigned, or it is fitful and dreamful and partial to a degree which does not admit of that complete restoration of nervous forces which occurs only during physiological repose of the cortical centers. In feeble patients one of the best aids to sleep is long exposure in the open air, and the gentle motion of an easy carriage also favors it. In muscular subjects active exertion out of doors may be effective. Heat and cold, dry or moist, skilfully applied to the head, spine, epigastrium, or extremities, often produce sleep. Other means are warm baths with cold to the head, hot or cold packs with massage, liquid nourishment or hot drinks at bedtime with a cool bedroom and long bed-hours, and a siesta in the daytime if possible as a preparation for the night's sleep. The lower bowel should be emptied by enemata before the retiring hour, and in persons of full habit an active purge may prove the best somnifacient. The most obstinate agrypnia is often due to autointoxication, and intestinal antisepsis should then be used after a full dose of calomel.

Obstipation in some cases is an emergency which prevents physical improvement and cannot be successfully met by ordinary enemata or purges, and requires intestinal lavage and often mechanical delivery of the impacted feces.

In forty per cent. of acute cases of insanity there exists an emergency from the impulse to suicide or violence of some form. Drugs may abate these violent tendencies, but cannot control them except when continuously administered in harmful doses. The only way to meet this emergency is by the incessant supervision of experienced and vigilant nurses. This surveillance will be regarded as an imposition by the patient, who will likely have the sympathy of relatives, but the physician will rue the day if sentiment displaces judgment in these cases.

An emergency which is fatal in a considerable percentage of acute attacks of mental disease is general exhaustion of vital powers, which often escapes notice, owing to a false show of strength on the part of the patient, who may walk about the very hour in which he falls in final collapse. Prodromal symptoms are haggard looks, subnormal temperature, and feeble and irregular heart's action. Patients with such signs are to be at once placed and kept in the recumbent posture, warmed by artificial heat, nourished by concentrated liquid food in small and frequent quantities, and given brandy and strychnine hypodermatically if cardiac failure be imminent.

Medication.—The therapy of insanity is as extended as the vast number of diseased conditions which bear a causative relation to the mental malady. Thus the diatheses, the toxic and autotoxic states, the established neuroses, gross disease of brain, spine, thoracic abdominal, or pelvic organs, and all other etiological factors furnish direct and extremely varied indications for medication. The general practitioner may be assured that there are no specifics in psychiatry, and that the treatment can best proceed only on the broad lines of general therapeutics, and success will correspond precisely to the skill displayed in the general use of drugs and in the scientific diagnosis of pathological physical conditions. In the first place, urgent symptoms described under the last heading as emergencies in psychiatry are to be met. Secondly, all diseased states standing in the light of causes to the insanity are to be combated by appropriate remedies. Thirdly, symptomatic indications as they arise and the hygienic requirements of the case are to govern the continued treatment.

A brief and practical summary of the best drugs and their chief uses in psychiatric practice is here given.

Hypnotics.—Chloral hydrate produces sleep more constantly than other drugs, and may be given alone or combined with morphine or bromide of potassium. It is in full doses depressant of circulation, respiration, and digestion, and is not advisable in cardiac and renal disease. In obstinate agrypnia it is better used only on alternate nights in full doses. It is especially effective per rectum in the "status epilepticus."

The bromides of potassium, sodium, and strontium have a relative hypnotic value in the order mentioned, and are effective in acute mental disease only in large doses. Their action is sometimes heightened by the addition of ergot or cannabis indica.

Opium and its alkaloids relieve pain while they produce sleep, and are occasionally useful on this account, but both tolerance of the drug and a drug habit are readily established. For mental pain and positive anguish opium is the surest remedy. The alkaloid codeine is a useful calmative.

Paraldehyde acts with certainty and celerity as an hypnotic, but it makes the breath and the stools offensive, and in continued doses it is not free from toxic effects.

Sulphonal has decided hypnotic effects, but they are delayed often for many hours, and unfortunately it is cumulative and dangerously depressing in continued use. The allied drugs, trional and tetronal, are more prompt as somnifacients, but if prolonged they have toxic effects like sulphonal. Veronal and medinal also deserve a trial but are not without danger if their use is prolonged.

Hyoscine and hyoscyamine should be used only

in strong maniacal patients. They are powerful nervous depressants and not properly hypnotics. Incidentally they cause sleep in a few moments in some cases, but completely fail in others. As a last resort against maniacal violence, in one-eighth to one-fourth grain doses hypodermatically they are effective.

Methylal, somnal, chloralose, hypnal, chloralamide, and other proposed hypnotics are by no means as reliable as those already named.

Tonics.—Iron is indicated for the anemia so constant in mental diseases. It is a routine remedy often given in too large doses, and should be administered with discrimination in small and continued portions, and never on an empty stomach. Its use should be temporarily discontinued on the appearance of gastrointestinal irritation. Of the vast number of ferruginous preparations none is more reliable than the old tinct. ferri chloridi.

Cinchona and its alkaloids are useful, especially in a large percentage of mental sufferers having a history of malarial attacks even though remote. The mental excitement may even mask the plasmodial crisis, and quinine in full doses will prove most efficacious.

Strychnine in all the toxic insanities is the best tonic, and is of use also in the neurasthenic cases given until its physiological action is evident. Even in cases with gross lesions of the nervous system it may be cautiously employed to advantage.

Arsenic in choreic, malarial, and phthisical insanity and in some other diathetic and toxic forms is a good tonic.

Phosphorus is theoretically indicated in mental disease, and is practically of some real tonic value.

Alteratives and Eliminatives.—Mercury in some of its forms is indispensable in syphilitic insanity, and in urgent cases mercurial inunctions and baths are to be employed. The iodide of potassium is often indicated as an alterative in luetic cases and as an eliminative in toxic psychoses. Iodine, cod-liver oil, and lithium also deserve nominal notice. In general paresis and other mental disorders with syphilitic complications salvarsan may be given a trial though not to the exclusion of remedies mentioned.

Purgatives.—In all forms of mental depression there is a tendency to constipation from diminished peristalsis and secretions. The gastrointestinal tract is often foul and a source of autotoxis, and it is then well to begin treatment with a full dose of calomel and a saline purge, and subsequently to effect intestinal antisepsis by means of salol or salophen. Oleum tiglii is useful in obstipation, in the apoplectic, epileptic, or paretic status, and after ordinary purgatives fail. In maniacs of full habit colocynth or elaterium relieves plethora and favors sedation, and alvine discharges are then to be regulated by laxatives and intestinal lavage.

Emetics.—When mustard and sulphate of zinc fail and the stomach pump is resisted, a fresh solution of apomorphinæ hydrochloras administered hypodermically is the most prompt emetic. Ipecac relieves the violence and the foul stomach of strong maniacs, and incidentally is often a better sedative than some motor depressants in vogue.

Vascular Sedatives and Stimulants.—The cerebral hyperemia of sthenic maniacs and the violent cardiac action are partly to be controlled by aconite, and if there be inflammatory cerebral membranes antimony may be conjoined to advantage. The best cardiac stimulant is alcohol, and its most prompt vascular effect is to be had by the hypodermic use of brandy. Digitalis and belladonna are also valuable.

Nervous Sedatives.—Opium is the best nervous sedative in precordial panic, painful delusive states, senile agitation, and in all kinds of anguish common to the insane. Doses must be increased, and it is never wise to substitute an opium habit for a psychosis. Other sedatives of occasional value are chloral, the bromides, cannabis indica, camphor monobromate, lupulin, and valerian in milder cases; and in powerful maniacs conium, gelsemium, or veratrum viride may be cautiously employed. Organotherapy has been tried, but testin, cardin, cerebrin, ovarin, tuberculin, and other extracts have given no satisfaction, though thyroid extract in myxedematous insanity is of use.

Surgical Measures.—The insane are entitled to such relief as surgical science may afford. The transient aggravation of mental symptoms which a surgical operation may occasion is insignificant if a causative condition or an obstacle to recovery be removed. It is high time for a wide application of conservative surgery in psychiatric practice, and obstructive prejudice must give way to modern science so often as an etiological factor of the mental disease can be removed by the surgical measure, and the patient chance to be in physical condition to bear the operation. It is worthy of note in this connection that recovery from mental disorder has been known to follow unexpectedly from falls or blows, and a like result may be the sequel of surgical operation.

Trephining may be necessary among the insane with cranial fracture and depression, neoplasms of brain membranes, cerebral tumors or abscesses, and penetration by bullets or other foreign bodies.

Craniotomy in arrest of mental development from premature closure of cranial sutures, vertebral puncture in paresis, thyroidectomy in the insanity of Graves' disease, circumcision in masturbatic cases, and phlebotomy in sthenic maniacs with cerebral hyperemia are all operations to be decided upon according to the individual indications in each case. In organic dementia with brain tumors, decompression may afford relief, as also in mental disorder with hypopituitarism and cerebral pressure symptoms.

Transfusion might be tried with reasonable hope of success in puerperal insanity with postpartum hemorrhage and in various persistent anemic cases. Hypodermoclysis is a practical surgical measure in toxic insanity to assist elimination, and also in all states of extreme inanition. Diseases of the organs of special sense may cause or aggravate the insanity, and hence ophthalmic, aural, and other special forms of surgery become necessary. Dental surgery is of importance for the health and comfort of patients, and in every hospital for the insane a competent dentist should render the necessary services.

Troublesome hernias, urethral strictures, varicoceles, hydroceles, and hemorrhoids should have prompt surgical treatment.

The simple fact of insanity does not alter the general indications or principles of gynecological surgery. The diseased uterus and its adnexa must receive due surgical treatment, and even hysterectomy and oöphorectomy are justifiable in certain cases. It is a mistake to suppose that the most confirmed masturbatic habit justifies clitoridectomy or orchidectomy, since the irritative source of the sexual excitement in most of these cases is in the cerebral cortex.

There are a host of minor surgical operations which should be performed to relieve physical discomfort or pain or to improve the general health of the patient. The rules as to local or general anesthesia are the same as in health. Anesthesia may also be required in epileptic, paretic, or puerperal convulsive conditions, or to determine the real state of things in hysterical or feigned insanity, but it is not to be used to suppress maniacal excitement. Vesication, the thermocautery, the electrocautery, acupuncture, and the use of setons all have a legitimate application in occasional cases of insanity.

Electrotherapy is a surgical measure not to be trusted to nurses or even to physicians not skilled in its use.

Galvanism is the form of electricity of widest advantage in psychiatry for sedative, trophic, or antineuralgic action, and for electrodiagnosis. A course

of electrical treatment should extend over some weeks, and desultory séances are only for psychical effect. General galvanization with currents of low electromotive force are most suitable in states of mental depression and to relieve the hyperesthesias of neurasthenic cases. Galvanization of the cervical sympathetic in anemic states of stupor may favorably influence the circulation and the spastic capillaries, while cerebral galvanization may be practised with caution for sedative and soporific effects. Large electrodes and powerful currents are needed for the spinal cord, and galvanization of special organs is hardly practical.

Faradism has qualitative variations determined chiefly by the length of coils, size of wires, and number of interruptions. Long coils, fine wires, and rapid interruptions give a smooth current suitable in neurasthenic and feeble persons. General faradization is most advantageous in melancholic and stuporous conditions, and the hand of the operator is the best electrode in these cases. To arouse strong patients from apathy and muscular inertia larger wires, shorter coils, and fewer interruptions may be used, or the electric brush may be tried. In a vast number of cases refusing to take active exercise faradism may be employed to advantage in the form of electric massage.

Static electricity is chiefly adapted to the production of mental effects in psychiatric practice, and as a stimulant of the sensory peripheral nervous system. Hypochondriacs and neurasthenics mounting the insulated stool before an imposing static machine, and taking the electrical breeze or having sparks drawn from parts which are the seat of imaginary pains, undergo a good form of psychotherapy as well as counterirritation and capillary stimulation.

In general, however, franklinism is of less use in mental diseases than galvanism or faradism.

Electrotherapy among patients very often hyperesthetic or anesthetic must be practised with an initial minimum dosage gradually increased to the desired strength, to be determined less by milliamperage than by actual effects produced.

Psychiatric Hygiene.—Under this head something will be said of hydrotherapy and climatotherapy also. The hygiene of the residence is of prime importance. The habitation should be in a healthful locality, well drained, lighted, and ventilated, and with sunny rooms in winter at least. The hot-water system of heating is best, and open fireplaces are excellent auxiliaries for warming and changing the air. Hardwood and parquet floors are best in sleeping rooms, which should have only necessary articles of furniture and an iron bedstead with hair and woven wire mattress and fine woollen blankets. The bed is to be made a place of comfort, and feeble, rheumatic, and neuralgic patients often sleep best between woollen blankets in winter, and water and air beds are an occasional necessity. Most of the insane have impaired vitality and circulation and need warm underwear. Various minor points in the hygiene of the person determine the major point of bodily comfort or distress. Thus the skin requires special cleanliness, and is subject to various eruptions in mental disease. The mouth must be treated with antiseptic washes for offensive breath and bacterial growths, while tartar and dental caries are to be removed by a dentist. A habit of the regular relief of bowels and bladder must be established, with special attention to local cleanliness even in the most apathetic cases.

Out-of-door life is a hygienic measure never to be neglected, and porches, tents, summer houses, cots, and hammocks are to be utilized, and carriages are available in feeble cases. The rest cure in bed is good in senile and acutely exhausted patients, but the opposite course is generally best for the great majority of the insane, who derive benefit from customary out-of-door occupations, or from walking, horseback-riding, cycling, or golfing. In bad weather indoor games, gymnastics, and massage are to be employed.

Climatotherapy is of special import in psychiatry. The neurasthenic insane do best in northern mountainous regions in summer and in southern climes for outdoor life in winter, where the greatest number of sunny days are to be had with avoidance of extremes of temperature. The senile insane do best in mild climates under high rather than low barometric pressure. The phthisical insane do well in mountainous localities until pulmonary lesions are advanced, when marine climates are preferable. In all mental disease with gross brain lesions, cardiac affections, or diathetic and toxic conditions, rarefaction of air and great diminution of barometric pressure are to be avoided. Residents of large cities benefit by a change to country air; watering-places sometimes combine pure air and water; and foreigners profit by a change to their native climate, but mental sufferers generally do well to avoid the uncertainties and perplexities of foreign travel.

Hydrotherapy in mental diseases is as ancient as Hippocrates, but it is only of late that hospitals for the insane have made some suitable provisions for it. As physician in charge of New York City Asylum for the Insane, the writer first in America made extensive use of the Turkish bath, and published the results of various forms of insanity thus treated in his annual report for 1874, and a few years later printed a monographic article on "Hydrotherapy in Insanity," and for more information than space will here permit reference may be had to the writer's "Text-Book of Mental Diseases," pp. 459–474. The physiological principles of all hydrotherapy are that heat and cold to the surface of the body may be made to expand or contract the capillaries, to increase or diminish cardiac action, bodily temperature, respiration, secretion, and general metabolism. Among the insane these effects are best obtained by warm rather than cold applications, to be regulated by reliable thermometers under the observation of physicians rather than nurses. Sedation of maniacal excitement and relaxation of vasospasm in melancholic stupor are better accomplished by warm than cold baths, just as stimulation of the cutaneous periphery or of the whole nervous system in apathetic states is most promptly effected by hot rather than cold douches. Motor and mental agitation in hyperacute mania may often be controlled by baths graduated from warm to cool, and prolonged from one to two hours, and repeated once or twice in twenty-four hours in strong patients with sound heart and lungs. In the use of prolonged baths, to avoid epidermic maceration it is well to anoint the skin first before the patient is wrapped in a sheet and suspended in netting attached securely to the sides of the tub.

The Turkish bath is more generally applicable than any other in mental diseases. It can be used in the old and the young, in the neurasthenic and melancholic and debilitated, as well as in the strong and maniacal. In toxic cases it increases cutaneous excretion, and it restores the impaired capillary circulation in melancholiacs, and the subnormal temperature in stuporous patients, and in acute alcoholic states it is excellent for both its eliminative and sedative action. It is of wide service too in diathetic insanity; for the syphilitic, phthisical, Brightic, rheumatic, malarial, and podagrous cases all profit by a judicious use of the Turkish bath, and only decided cardiac or pulmonary lesions are contraindications.

Swim baths, sitz baths, foot baths, spray baths, douches (hot, cold, spinal, and Scottish), medicated and Russian baths, drip sheets, and wet packs of all kinds have an occasional special utility in psychiatry, especially when combined with skilful massage. In hyperpyrexia of delirium acutum, of the

paretic or epileptic status, or of toxic maniacal states, the cold affusion may be used to great advantage when friction of surfaces with ice proves inadequate.

Dietetics in mental disease present difficult practical problems. The waste of tissues and need of nourishment are maximum in degree, while appetite and assimilative power are minimum in the acute insanities. A full ration of albuminates, fats, and carbohydrates must be at once enforced, and foods are to be prepared in varied and appetizing form with due regard to individual tastes. In general there is nothing better than fresh milks, eggs, meats, and fruits in season. The nutritive value of preserved foods and liquid preparations of meat is overrated, and shredded or scraped fresh meat should be given in pulp, which may be mixed with liquids to be fed through tubes. Predigested foods, rectal alimentation, and subcutaneous injections of saline solutions are only extreme resorts. Anorexia and foul tongue should not deter the physician from forced feeding, best done by nasal tubes with the patient seated, though esophageal tubes or stomach pump are at times necessary. Meat pulp and vegetables in form of purée and juices of fresh fruits may be thus given in amounts twenty per cent. above average rations, for inanition is a constant danger. In chronic and incurable lunacy stinting of food supplies is justifiable economy, but it is bad State policy to withhold generous diet in recoverable cases, and chronicity is often due to defects of feeding in the curable stage.

Mental Therapeutics.—By this term is understood all those means which directly modify the thoughts, feelings, and emotional states of the patient. In mental disease, as in health, psychic influences continue powerful for good or evil. The patient is first to be removed from the scene of his delusions, from business worry and domestic strife, to an agreeable environment, there to receive the most decided of all psychotherapeutic effects, which is the sympathy and advice of an intelligent physician. Next to the physician the nurse is the constant medium for psychic influences, and should be chosen to suit the patient and also the phases of the mental malady. In the convalescent stage companion nurses, educated and refined in manner, are most useful psychotherapeutic agents. The regularity, discipline, force of example, and confidence inspired by numbers make institutional care effective in the moral treatment of the insane in the majority of cases. Occupation, not forced but customary and of interest to the patient, is a most reliable psychic remedy, and the more useful it is the more serious is the purpose of cure which it serves. Diversions varied and well timed to the occasional moods of the malady play an important rôle in mental therapeutics. Outdoor sports are preferable, but indoor games are available more months in the year.

During convalescence there should be a gradual restoration of the social life of the patient, a renewal of friendships with the nearest relatives, and such hospitality as will restore the self-respect to the patient, and the influence of the opposite sex is not to be ignored.

Religion may be allowed to "minister to a mind diseased," though the religious delusions of some patients forbid it.

Discipline, rewards, and corrective advice are to correspond to the modified responsibility of the insane, who are to be granted or denied privileges, and to encounter moral restraints such as may aid them to suppress insane impulses. The solitary confinement of a violent lunatic is not justified as a punitive measure, but for its psychic effect. The principle of non-restraint is universally indorsed, but some protection from violence is necessary. There are three forms of restraint—chemical, manual, and mechanical. Chemical restraint by powerful drugs is most often used and abused. Manual restraint by the hands of nurses is necessary sometimes and also liable to abuse. Mechanical restraint is best done by a restraining sheet in surgical and violent cases apt to be bruised by persistent resistance to nurses. In the vast majority of even acute cases no restraint of any kind is needed. Hypnotism is not recommended in any class of cases, but therapeutic suggestion of ideas by the physician seconded by nurses may favorably influence the thoughts and conduct of patients; and likewise placebos are of occasional advantage in mental therapeutics. Psychanalysis in rare instances may be experimented with in mental disorders, though it is of less actual known use than many other forms of mental therapy.

In the majority of cases it is impractical from the simple fact that it is such a time-consuming process. It has been ingeniously elaborated and rendered psychologically interesting, but it rests on the unsound hypothesis that the sex-feeling is the chief root principle of mind, while the truth is that self-preservation and not self-propagation is the most primordial instinct, and fear and not sexual libido is the more constant and fundamental feeling. This inherent and instinctive fear in man, modified by environmental forces through long generations of dangerous experiences, becomes the prime governing motive of all his conduct in life, and plays the chief rôle in self-preservation. Even the psychic trauma of sexual experiences or transgressions, so grossly exaggerated in Freudian theory, is only a secondary reflex of this primary instinct of fear. The mental status of a patient for long months inoculated by suggestions and under the durance and dominance of a stronger mind by Freudian methods may become as artificial and unnatural as the mental malady itself.

Psychanalysis, as now known, will not become of general use in mental disorders and a decennium hence will probably only be referred to as an interesting phase in experimental psychiatry.

It has not even the tangible basis of hypnotism, which as a psychiatric remedy has had its day, and is passing into merited oblivion.

Convalescence and Protective Aid.—Recovery from insanity is often apparent before it is real, and though importuned by relatives the practical alienist will not return the patient to business and social life prematurely, and run the risk of a relapse and possible incurability. In case of imperfect recovery the physician has to decide the degree of restoration of the financial rights and the business competency of the patient. Those convalesced with mental defect, capable of self-care and not dangerous to self or others, are legally entitled to personal freedom.

Protective aid for those discharged from institutional care improved only is a desideratum. The writer some years ago published the view that the State should establish a "Bureau of Protective Aid" for patients discharged from institutions as well as for those under great stress of any kind liable to end in insanity. In this way the stigma of insanity would not block the way to self-support of convalescents, and many harmless and industrious inmates of institutions might be returned to the outside world, and the actual public burden of enormous numbers of imperfectly recovered insane might be in a measure reduced. Theodore H. Kellogg.

Mental Diseases: Dementia Precox.—*Synonyms:* Insanity of Adolescence, Hebephrenia, Schizophrenia, Idiotisme, Folie de la Puberté, Démence Précoce des Jeunes Gens.

Descriptive Definition.—Dementia precox is a developmental disease which has its starting-point in adolescence in most cases. Its underlying disease process throughout is an enfeeblement of the hereto-

fore normal mind, a slow decline of mental power through progressive impairment of the will and a deadening of the emotions. At its root is a cleavage of the personality. It ends, generally after a few years, in a state of permanent mental degeneration varying widely in degree but involving the mind in more or less complete disorganization. Among its salient features are variable mental disturbances—often profound—which appear as protracted "attacks" in the course of the disease and consist in the main of irregularly recurring episodical symptom-groups chiefly catatonic stupor, excitement, depression, confusion, and paranoid states. Hallucinations and delusions are common and impulsive acts, negativism, contradictory phenomena and remissions which often simulate recovery and last for months or years, are characteristic of the disease. These conditions may mask for a time the latent and essential dementia.

The designation "dementia precox" was adopted by Kraepelin who was the first to teach that it was a prolonged dementing process from its very beginning to its remote end symptoms and thereby revolutionized and clarified the interpretation of its clinical history. It is not a distinctive name, however, from any point of view. If we regard the dementia as "precocious" because, unlike other dementias it occurs early in life, we are met with the fact that occasional cases develop later than the adolescent period. On the other hand, it is a mistake to term the dementia "precocious" because of the fact that it appears early in the disease, for it is not different in that respect from the organic dementias in all of which dementia is the primary and essential mental condition. If a choice must be made the first explanation, unsatisfactory as it is, seems preferable, as it is very seldom that the psychosis does not make its first appearance in youth and most of the cases, whatever the age of the patient, bear the stamp of immaturity and juvenility.

Age.—It is preëminently a disease of youth. It only rarely happens that it originates later than the completion of adolescence which may be approximately placed at the age of twenty-five, although sometimes mental maturity is not reached before thirty. Formerly many older cases were included and classified under the paranoid type of the disease. Kraepelin, himself, however, has since separated most cases of this type from dementia precox altogether and now classes them under a new and distinctive psychosis which he calls paraphrenia. Moreover he now classes under the head of presenile or involutional psychosis many of the cases which he previously included with the catatonic form of dementia precox. This places a much more restricted and accurate limit upon the scope of the disorder and tends still more plainly to stamp it as purely a disease of adolescence. Moreover, many cases are regarded as "late" dementia precox for want of searching inquiry into the disease history of the patient in youth. When that is done it will very often be found that the initial attack had occurred at that time but had passed for "nervous prostration," neurasthenia, effects of sunstrokes, etc. In others protracted and severe delirious states will have been experienced during adolescence in the course of typhoid fever, meningitis, or acute chorea. These episodes are generally overlooked when, years later perhaps, the lowered mental resistance thus originated yields to the full-blown psychosis.

Etiology.—One of the profoundest influences in originating dementia precox is the normal condition of the organism at the time of life in which the disease develops, the period of puberty and adolescence, of growth, development, immaturity. Almost all modern writers on psychiatry, even those who lay special stress on the influence of faulty heredity, are fully alive to the great importance of this critical time of life in promoting mental disease. Kraepelin in particular, who has little to say regarding heredity as a cause of dementia precox, thinks that in all probability we shall have to seek for the real causes of its origin in the physical and mental variation of the period of development.

There is no dividing line between puberty and adolescence so far as concerns the general formative influences which underlie physiological and pathological conditions in youth. In this article, therefore, the term adolescence alone will be used—and in its legitimate sense—to designate the entire period of development from the advent of puberty to maturity.

To appreciate the possibilities of this epoch in the way of mental deterioration we have only to call to mind the unusually rapid growth of the organism in every tissue, the new and powerful activity of all the functions, especially those of nutrition, in the progress toward complete development and the stamina and often the care that are essential for properly meeting the demands of this revolutionary period. The disturbance of the heretofore tranquil nervous system by the advent of the reproductive functions is a vital change, and the proper adjustment of this part of the system to the working whole is of far-reaching importance, as the genital activities have a profound effect on the entire organism and the developing personality. During adolescence the normal mental condition is not a settled one, and at this time, if ever, should we especially fear pathological disturbance when impressionability, instability of purpose, variation of mood, excitability, impulsiveness, ambition, independence, and intolerance are most likely to be in full play, when the affections, emotions, and newly awakened sexual feelings and passions are most keen, when reflection and judgment are immature, and, above all, when the self-control which should regulate all is itself in an imperfect stage and in danger of being unequal to its function. Nothing is more significant of the causative influence of this period than the resemblance of the clinical picture of dementia precox to these ordinary psychical attributes of development which are all found morbidly exaggerated in the different forms of the malady.

When to the developmental factor is added the special mental make-up of many of these patients the soil is thoroughly prepared for the development of the disease. From childhood these individuals are, as a rule, well behaved and easily trained because they shun opposition and struggles from lack of normal vigor and strength of purpose rather than from any inherent virtue. This tendency to shrink from coping with the world leads directly to the "shut-in" personality which typifies these cases. This factor so important in determining the etiology and prophylaxis of the psychosis was first recognized by Adolf Meyer and Hoch. Hoch found that a large number of his cases "were persons who had no natural tendency to be open and to get into contact with the environment, who were reticent and exclusive and could not adapt themselves to situations, who were hard to influence and often sensitive and stubborn, but the latter more in a passive than an active way. They showed little interest in what went on and frequently did not participate in the pleasures, cares, and pursuits of those about them; although often sensitive they did not let others know what their conflicts were; did not unburden their minds, were shy and had a tendency to live in a world of fancies." He found the "shut-in" personality markedly pronounced in thirty-five per cent. and indicated in sixteen per cent. out of seventy-two cases of dementia precox. Kraepelin adds to this type, a sensitive,irritable, excitable, obstinate type, mostly women; a lazy, unsteady, shiftless, mischievous type, mostly boys, who often become tramps or criminals; and a good-natnred, pliable, conscientious, diligent type.

One cannot fail to be impressed with the number of dementia precox cases which present a neuropathic family history. Nevertheless many distinguished psychiatrists deny that disease-heredity is a powerful

predisposing influence. Kraepelin in the latest edition of his work comes to no definite conclusion on the subject, but seems to be opposed to regarding this disorder as a form of degeneracy. He points out that heredity does not appear to be more frequent in dementia precox than in certain other psychoses and that the best-known constitutional disorders such as hysteria, manic-depressive insanity, and psychopathic states do not lead to a deterioration but to a periodic recurrence of symptoms. Statistics on this point are quite diverse. The writer's cases show hereditary taint to have been present in forty per cent. and Christian's in forty-three per cent. Wolfsohn reports 647 cases of dementia precox in 2,215 admissions. Of these ninety per cent. showed hereditary taint; of four hereditary factors mental disease was present in about sixty-four per cent. In any event there appear to be not a few cases of dementia precox which have been simply acquired if we apply the same tests that are employed in the investigation of other diseases.

A striking fact is the frequency with which the disease attacks adolescents of marked intelligence and promise. A large number of patients who are subject to catatonia are schoolmasters, the sons of schoolmasters, and theologians (Kahlbaum). Christian found the following statistics of Aschaffenburg in accord with his own: 27 per cent. men and 21 per cent. women had average intelligence; 55 per cent. men and 66 per cent. women had good and even remarkable intelligence; 18 per cent. men and 13 per cent. women were below the average in intelligence, but were neither idiots nor imbeciles. Facts such as these bear out Morel's original dictum that these young subjects have reached the termination of the intellectual lives of which they are capable. They live intellectually only up to a certain age after which arrest takes place and they fall progressively into a state which he could only compare to idiocy. "As the French have it, they are stranded on the rock of puberty" (White).

Diseases of early childhood of all kinds that tend to make the system delicate pave the way for dementia precox in the predisposed. Such are the various eruptive diseases, especially scarlet fever and measles with their sequelæ; acute rheumatism, diphtheria, digestive troubles, and anemia. Convulsions in infancy and headaches if prominent in the child, betoken delicate nervous health, calling for special precautions in adolescence. As mental symptoms are common in chorea it is to be expected that its severest form, chorea insaniens, occurring as it does in adolescence almost exclusively might originate the development of dementia precox. A few cases have been reported in which an attack of this disorder has been the first expression of a subsequent dementia precox and closer research into the after-history of cases of chorea insaniens would without doubt reveal others. C. W. Burr describes a class of "cases of acute chorea in which there is stupor or rather stupidity and an acute dementia which may follow a delirious state or appear without any preceding mental symptoms at all severe and which is usually accompanied by trouble in articulation not caused by choreic movements of the lips and tongue but the result of mental hebetude. Patients of this group either die or after recovery from the chorea remain demented."

Badly directed education, moral and mental, may give a wrong turn to the child's tendencies, and thus leave him without defense against the exciting causes of mental disease when adolescence is reached. The protracted strain of mental conflicts and repression arising from sexual experiences and maladaptation which sometimes can only be revealed by psychoanalysis is a potent factor in preparing the soil for a mental breakdown.

The precipitating causes are various, but for the most part are of the nature of exhausting influences. These are the most conspicuous and powerful of the exciting causes of the disease and the contention of Binswanger and Christian that dementia precox belongs among the exhaustion psychoses still holds good. Rapidly growing youth or girls—particularly of the lower classes, apprentices, clerks, train hands, stable boys, mill operatives, domestics—often succumb to the exhausting effects of hard and continuous physical labor combined with long hours, anxiety, little sleep, insufficient food, and in consequence, disorder of nutrition. Insomnia and lassitude arise and mental breakdown follows, sometimes even without the aid of any appreciable predisposition to mental disease. Youthful volunteers, not inured to military discipline and the hardships and dangers of active service, also recruit the ranks of the mentally broken down. Social strain in girls with its attendant factors of famishment and fatigue as well as "banting" may precipitate mental breakdowns in predisposed cases. Intellectual overwork, of itself rarely productive of mental disorder causes many a delicate girl or lad of the "shut-in" type to succumb to mental disease when poor circumstances increase the struggle for education. Rapid and excessive growth in stature is frequent in hebephrenics and precedes by a little the development of the psychosis. In these instances there is not sufficient alimentation provided to meet the demands of the growth of the organism *plus* excessive mental and bodily energy. Habitual masturbation and venereal excesses contribute to the exhaustion, but it should be borne in mind that masturbation is oftener a result than a cause of mental trouble, and its importance as a factor is much exaggerated by people in general and especially by the depressed patient with delusions of culpability. Typhoid and other debilitating diseases not infrequently leave the patient in a permanently weakened mental condition, culminating in dementia precox. The puerperal state with its many disturbing influences in various directions, is a prominent determining cause of the disease. Aschaffenburg found 56 cases of dementia precox in 118 cases of "puerperal insanity." Other determining but far less frequent causes are alcoholic excess, fright or other shock, chagrin, disappointment in love, long engagements with consequent strain on the emotions, and religious revivals. Finally it may be impossible to find any adequate cause for the mental breakdown, a small proportion of the cases occurring in the physically strong and apparently stable and sociably inclined.

No reliable data have thus far been recorded to indicate in which sex the disease is more common. There is, therefore, no accurate knowledge as to whether or not the supposedly debilitating and other effects of menstruation and its irregularities come into play as causes. Not a few authors find the disease more prevalent in young men.

Symptomatology.—In most cases the first indication of the mental deterioration is failure of the power of voluntary attention from which follows inability to concentrate the mind upon work or steady purpose of any kind. Initiative, interest, ambition, and energy gradually fail, a characteristic apathy sets its stamp upon the mental condition and becomes the predominating expression throughout of the underlying dementia. Although the general aspect of these patients is often mistaken for depression and preoccupation it is diametrically opposed to true melancholy as the one results from a loss of mental power and a poverty of thought, the other from their morbid intensity and concentration. Later there ensues a growing inability to continue more than momentarily in one train of thought. The patient quickly jumps from one subject to another. This looseness of thought is conspicious as are the shallowness of the thought content, dreamy states and states of mental confusion. Hallucinations chiefly of hearing and sight become prominent. Impairment of the judgment, a natural consequence of the mental enfeeblement, soon follows

and delusions of culpability, of persecution, etc., are prominent and persistent. Stupor of various degrees is common. Until the terminal stage of the disease is reached failure of memory is more apparent than real as it is largely due to lack of impressibility and attention. In the prodromal stage the memory is usually very good and often long after the disease is fully developed it shows but little impairment except in conditions of stupor when all the mental processes are in abeyance, and during states of excitement. Lucidity of perception except in the pronounced states is relatively well preserved and orientation is seldom affected except in acute conditions of confusion and semidelirium. Insight into their condition is rare and transient in these patients.

In the emotional sphere are found equally characteristic features. Through the general lack of attention and of impressibility, emotional dulness is a prominent symptom. The patient shows little or no response, whether of pleasure or pain, to occurrences which normally would move him more or less deeply. Even in the temporary states of depression and excitement in which the emotions seem to be at a high pitch the same shallowness of feeling is evidenced by abrupt and pronounced interruption of and change in the prevailing mood for no adequate cause, examples of which appear in the descriptions to follow of the various forms of the disorder.

On the volitional side the chief manifestations are negativism which is a pronounced opposition on the part of the patient to whatever is expected or requested of him, and impulses which may be of any form of activity. These arise according to Kraepelin's conception of the psychosis from a failure of harmonious adjustment between the intellectual, emotional, and volitional reactions. Intrapsychic coordination is impaired so that the emotional responses do not correspond to the content of thought and the motor reactions tend to recur independently of the will. In other words, we have to do with a disorder which affects primarily the feelings and the will impulses and brings about an "intrapsychic ataxia." These fundamental disturbances would then account for the failure of interest and energy, the apathy and indifference, the impulsiveness, negativism, and odd behavior, and finally also the discrepancies between ideas, moods, and behavior. (Kirby's "Review of Kraepelin's Latest Conception". *N. Y. State Hosp. Bulletin*, Aug., 1914.)

This antagonism between the volitional and emotional reactions is regarded by Bleuler as a splitting of the personality to which he gives the name of Schizophrenia. Other conditions liable to follow from the same source are muscular tension and rigidity, or catatonic states, waxy flexibility of the limbs, automatism, mannerisms, increased suggestibility, echolalia, echopraxia, verbigeration, and stereotypy.

Premonitory Symptoms.—The early indications of the disease are practically the same whatever form it may afterward assume. It is of gradual onset, as a rule, and the prodromal symptoms though usually of somewhat long standing often are unrecognized. Power of attention is first affected. Kraepelin considers that at this stage the attention is intact, but that the patient makes no use of it, as he has no desire to occupy himself with anything. In all of our cases, however, in which intimate knowledge of the earliest manifestations was attainable, lapse in the power of attention has invariably preceded loss of desire to occupy the mind. An ambitious student complains: "I cannot any longer wield my mind, which has become my master instead of I being the master of it," "I feel no exuberance as before," "Everything is a dead weight," "The feeling clings to me and I cannot fight it off." A bright lad in a preparatory school grows despondent at finding himself becoming "dull," "stupid," and "weak," and begs to be helped, as his utmost endeavors to go on have failed. The girl in this situation feels for the first time that "she must struggle to be like other girls." The patient also becomes more easily fatigued physically than before and loses directive energy and initiative. With increasing mental failure the fruitless efforts are soon abandoned, the mind becomes more inactive, forgetfulness, depression, and indolence replacing alertness, ambition, and energy. He "wants to be let alone," becomes listless, apathetic, and careless, gradually slipping into a dulled condition of mind. Another becomes mortified, sad, hyperconscientious, and self-reproachful. Avoidance of others follows and paves the way for suspicion of those about him, the starting-point it may be of future hallucinations, delusions, and overt acts. Suicidal thoughts may now appear. Patients of another temperament when no longer able to meet even the minor demands of life and physically fatigued are easily upset and very irritable. They become unexpectedly fault finding and angry over trifling matters. Abulic states are common and are shown in marked indecision and constant demand for reassurance regarding the plainest matters of duty. The train of thought naturally becomes interrupted early and may even show signs of the approaching confusion of the next and active stage of the disease. Lapse in judgment is shown in unnatural prejudices, sudden and needless alarm at ordinary occurrences, foolish conduct, etc. Self-control is early undermined. The conduct varies with the nature of the symptoms. Sudden and unexpected acts, forerunners of the more pronounced impulsive states of the acute stage, are common, such as exhausting walks with no object after a long period of idleness, destruction of minor belongings, etc. Sudden transitions of mood and the lack of depth of the patient's depression or anger—characteristic features of the disease throughout its entire course—are early manifestations, as are also inconsequential speech and aimless effort. The general appearance of the patient is that of apathy or mild depression, except at times of sudden and transient animation. Lack of energy also is constant, except during spasmodic outbursts of misdirected activity or prolonged overwork or exercise. Although such patients owing to irregular ways of living sleep more in the daytime, insomnia is developed early. The appetite is capricious. Headache is a frequent, and, as Mairet believes, a highly important symptom at this juncture. It is sometimes severe, persistent and protracted pain, but more often in our experience a disagreeable vague sensation as if, for example, the head were "empty" or "filled with cotton wool." Nightmare appears to be somewhat more common than in the older cases. A generally weakened, relaxed, poorly nourished bodily condition is common and is shown in loss of weight, pallor, dilated pupils, vasomotor disturbances, low temperature, and weak pulse. Menstrual irregularities are rather common.

In not a few cases the group of premonitory symptoms bears a deceptive resemblance to neurasthenia proper, owing to the predominance, for a long period, of purely nervous and bodily debility. When the onset is more or less sudden these minuter changes are masked by the severer symptoms, and the mental fatigue and apathy are less prominent in the history as forerunners, but special inquiry for these indications usually brings them to light.

Forms.—The mental deterioration of dementia precox assumes many guises. Its manifestations are protean and its clinical course subject to many variations. These conditions and the frequent intermingling of symptoms and numerous transitions leave, when we come to group them to a very wide margin of mixed or atypical cases. Nevertheless there are certain recognized forms or symptom-groups covering the mass of these cases which may be differ-

entiated with sufficient definiteness and greatly aid in the study and understanding of the disorder. These subgroups which should be regarded only as types and not necessarily as different disorders or diseases are simple dementia, hebephrenia, catatonia, and paranoid dementia.

Simple Dementia.—This, the pure and uncomplicated variety of the disease, Kahlbaum's heboidophrenia, has few or none of the pronounced manifestations found in the other forms and is characterized chiefly by a moderate exaggeration of many of the symptoms just described as prodromal on a background of almost imperceptibly increasing apathy. It is very insidious in its development, sometimes beginning in childhood. Transitory delusions of suspicion and evanescent hallucinations may arise and disappear early in its course, but this is very rare. Some of the patients thenceforth lead quiet, colorless lives and manage to earn a precarious living, but the majority lose initiative, interest, energy and ability, are incapable of sustained effort and become inefficient if not useless members of the family and the community. They are no longer able to cope with the world about them. Those who are in good circumstances spend their lives in indolence varied by spasmodic and aimless activity. They keep to themselves, are fretful, irritable, and inaccessible and tend to develop antisocial proclivities. They are easily duped and meet with little sympathy or consideration. The poorer patient so attacked is often a tramp, a crank, a criminal, or a prostitute in the making. The hobo class is largely recruited from these mental derelicts. Willmanns in a study of 127 vagabonds found 66 cases of dementia precox. Although the same residual condition may occasionally follow the severer forms of dementia precox, heboidophrenia rarely reaches the extreme states of mental disorganization and helplessness which characterize the latter in their later stages. This form is a common one, and most of the cases probably do not reach the hospital for the insane.

Hebephrenia.—In this type, the "silly dementia" of Kraepelin, which comprises about thirteen per cent. of the cases of dementia precox, the prodromes are slow and insidious and there is seldom any abrupt transition from the previously described initial symptoms to the active stage which in general may be said to be reached when the patient's self-neglect, erratic conduct, impulses, suicidal tendencies, etc., have become pronounced and have reached the point of unmistakable irresponsibility calling for medical interference and perhaps hospital care. Occasionally the advent of this stage is marked by a transient outburst of excitement and by the appearance for the first time of active delusions and hallucinations. Depression with or without stuporous symptoms—Kraepelin's "simple depressive or stuporous type"—which is sometimes prolonged and pronounced not infrequently ushers in the attack. The patient accuses himself of wrong-doing, believes that he is despicable, is bringing trouble on others, etc. In this condition there is often a marked delusion trend with numerous hallucinations. The absurdity of the delusions is a marked feature in some cases. A patient believes, for example, that when taking food she is swallowing human flesh, snakes, or diamonds, that enemies are concealed under her skirts, etc. Another may make more or less determined attempts at self-destruction which he may finally accomplish. He may wander away giving the family great anxiety or refuse to leave his room at all. The feeling of sadness, however, unlike true melancholia, is superficial and readily changes to another mood for no apparent reason. A young man, for example, while in the midst of bemoaning his evil life takes up his guitar and sings a comic song in a mechanical impassive manner. A girl tells with placid and even smiling expression of her terror from the odor of burning bodies beneath her bed. A sudden access of gayety with loud laughter and foolish behavior will often interrupt the melancholy; so, too, anger, however frequent, is soon over—perhaps dispelled by a complete change of mood. The greatest contrasts in the mental states are to be expected in this disorder. Silly behavior and laughter without obvious cause are common. Other patients are affected, grandiloquent, and declamatory. They are given to high-flown sentiment, write disconnected doggerel and draw all sorts of symbolic pictures. Great vanity and absurdly dictatorial manners are common. One is impressed with the shallowness and unreality of their sentiments. Their ideas in general are childish. Their insight is fairly good in that they often realize that they are ill, although they have a wrong idea of their condition. Memory, consciousness, and orientation are usually well retained except on occasions of excitement when there is apt to be marked confusion and incoherence. The understanding is greatly impaired as is shown in unnatural opinions on ordinary matters and in actual delusions. There is often great difficulty in grasping ideas and in following plain explanations. Before they have reached a state of extreme dementia a looseness or scattering of thought is noticeable. Sometimes their thought processes seem to be at a standstill. The psychomotor sphere is equally involved. Such a patient will occasionally strike attitudes, make grimaces, assume a mincing gait, suddenly prance about, repeat the same phrase continually, approaching in other words a catatonic condition. These patients quite frequently will abandon themselves to very sudden, violent, and even homicidal impulses and aimless acts for which they can give no explanation and which in appearance are prompted by mischief or malice. These, however, are more frequently met with in the catatonic type. Such are the salient characteristics of hebephrenia, but the underlying condition throughout is one of listlessness, apathy, indifference, and inertia varying in degree.

Catatonia.—In about twenty per cent. of the cases of dementia precox a condition of more or less pronounced muscular tension, stupor, and *negativism* or extreme resistiveness predominates sufficiently to form a special variety called catatonia (κατά, denoting intensity; τόνος, tension). This condition is very largely peculiar to dementia precox although it is more frequent in other forms of mental disease than is usually supposed. It may appear in the course of senile dementia. Kirby finds it figuring quite frequently in the manic-depressive psychosis and Worcester has shown its occasional occurrence in several other forms of mental disease.

The very frequent association of this striking motor condition with various alternating psychical states: stupor, maniacal excitement, depression, confusion, and dementia led Kahlbaum to regard it as a disease entity and although this view has been long abandoned and catatonia is now accepted as one of the various forms of mental deterioration in dementia precox there is still an unfortunate tendency to use the term as synonymous with the latter psychosis. In this disorder catatonia is closely allied with, if not an outcome or intensification of stupor to which it gives a marked and distinctive character and the designation: *catatonic stupor.* This in its most pronounced manifestation is a more extreme and acute state in the dementing process than the apathy or light hebetude of the conditions already described. Hence the consciousness is more deeply involved and the symptoms both mental and physical more pronounced. Its protracted nature and accompanying phenomena render it characteristic but the stupor of general paresis and epilepsy is similar to it in other respects. Stupor seldom comes on suddenly, although occasional cases are reported to have immediately followed extreme fright, profuse hemorrhages, etc. It may be, however, a comparatively early symptom.

It is usually preceded by certain of the prodromal symptoms above described as common to all forms of the dementia. Apathy and general indifference may simply deepen into stupor. Hallucinations or illusions with fear or intense transient excitement and violence may precede it. Hysterical manifestations may appear before or during the excitement. After a few days or weeks in such cases, in others after months stupor sets in, growing gradually deeper while the hallucinations subside. There is little or no response to questions and mutism is marked. In cases of profound stupor either complete relaxation or rigidity of the muscles may be present. The patient becomes motionless and so remains, except when interfered with by others, for days and it may be for weeks or even months. He will sometimes be found standing rigid with the head flexed upon the chest, the eyes closed or staring vacantly without winking. Flies may crawl over his face unheeded and his evacuations be passed unnoticed wherever he may be. He refuses food, answers no questions, and often there is no response to pinching or pricking. That the patient feels and hears, however, is sometimes evidenced by turning his head to the questioner. The respirations are barely noticeable, the heart sounds clear but faint and the pulse irritable, small, and soft. The extremities are cold, cyanosed, and sometimes edematous, the reflexes exaggerated, the temperature subnormal, the skin dry and harsh, or greasy, the body thin, the face cadaverous. In girls menstruation is arrested. The stupor may be suddenly and unexpectedly cut short at any time by a transient attack of excitement lasting a few minutes or an hour or so, after which the stupor returns. So, also, equally brief and unexpected intervals of apparent rationality may appear and disappear during the profoundest stupor. Cases of intermittent mental stupor are reported by Whitwell and Noble, one in which lucid periods of twelve hours alternated every thirty hours with typical stupor for a year and a half; another in which there was a fairly regular alternation of these states every day for at least five months. Every degree of stupor may be present in cases of dementia precox from the well-developed type described, to a milder apathetic state approximating that of hebephrenia.

In well-developed catatonic stupor all the muscles seem to be strained to the utmost and this state of persistent tension and rigidity enables the patient to maintain even unnatural and difficult positions for a great length of time, perhaps for months. Occasionally for want of proper treatment ankylosis results. This catatonia is intensified by any attempt at interference with the attitude or position of the patient who will often make stubborn and it may be almost unsurmountable resistance. This phenomenon is called *negativism* on account of the patient's determined opposition to any attempt to help him. The efforts necessary to deal properly with these cases are extraordinary because of their dogged resistance. It is occasionally possible to accomplish the end in view by appearing forcibly to prevent what we desire the patient to do. Refusal of food is a prominent example of negativism and the same difficulty in forcibly feeding the patient is regularly encountered with each attempt. There is a like resistance to the functions of defecation and micturition. The saliva also is often retained for a long time in the mouth, the same inhibitory motor condition preventing the patient from swallowing it.

Catalepsy, by which is meant states of stupor associated with suggestibility and often a waxen flexibility of the limbs on passive motion which is in strong contrast to the muscular rigidity of catatonia, is not uncommon. The mental attitude is also opposed to that of catatonia being in many cases manifested in increased susceptibility to external impressions. The patient is sometimes as obedient and pliable as the catatonic patient is contrary and resistive. Sometimes the tetanic rigidity of catatonia and the cataleptic flexibility are associated, the catatonic spasm developing first, a combination difficult to understand on physiological grounds. Certain cataleptic patients are very imitative. They spend much time in mimicking the motions of others and will continue the same movement automatically for hours.

The mental state in stupor may represent almost any degree of intellectual inactivity and in the profoundest states thought seems to be practically suspended. At these times the patient to some extent is influenced by powerful delusions, fears, or hallucinations to remain motionless, etc., as is evidenced by questioning the patient after recovery but more often the mind is found to have been more or less blank as the patient has little or no remembrance of what his feelings or thoughts had been during the stupor and can give no reason for his behavior at that time.

Catatonic Excitement.—The association of a peculiar excitement with the condition of stupor just described completes the picture of catatonia. It usually breaks out suddenly after a transient period of apathy, stupor, depression, or peculiar conduct and may be intense and furious, lasting one or two days or as many weeks to be succeeded by a dull, apathetic state, and returning again with perhaps less intensity. This alternation continues irregularly, the excitement becoming in many cases less and less prominent. As a rule, catatonic excitement consists of a rapid series of impulsive acts of various kinds. The violence is of a senseless nature, delusions are plentiful and hallucinations frequent. Often the patient will stop in the midst of his excitement long enough to answer questions and even to express appreciation of the efforts made for his care. A condition of severe and prolonged excitement in which the catatonic element is less marked is sometimes the main feature of the disease. Circular, agitated, and periodic subtypes of this condition are occasionally met with. *Stereotypy* is common, the patient assuming and maintaining peculiar, fixed, and sometimes difficult attitudes such as keeping the head turned or the hand raised, leaning as far as possible out of the chair or bed, etc. The most violent opisthotonos was maintained at different times during excitement for half an hour or more by two of the writer's patients in one of whom it alternated with extreme emprosthotonos. Continuous repetition of some movement, a gesture, shaking the head, rocking to and fro, rapping on the chair are common. *Verbigeration*, in which words or meaningless phrases are continually repeated in the same tone is also an occasional manifestation. *Mannerisms* are common and hard to eradicate such as stepping off the curb at frequent intervals when walking, stopping for no reason every few rods, turning about in walking, etc. *Impulsive acts* which may be present also in hebephrenia are common in the catatonic and extreme in suddenness and violence. They are entirely unforeseen and usually the patient not only cannot tell what has prompted the outburst, but immediately resumes his former state as if nothing had happened. For example, a patient, a large athlete of great strength sitting quietly at the window suddenly bounds up without warning and catches his nurse by the throat attacking him with the utmost violence. In the midst of the severe struggle with several nurses which follows he suddenly becomes calm gets up and unconcernedly asks his nurse to play a game of cribbage with him. He can give no reason for his attack and treats it as a matter of no consequence. *Echolalia*, a repetition of words and sentences spoken by others, and *echopraxia*, a repetition of the movements of others, are occasional manifestations and result from suggestibility, the opposite state of negativism.

The Paranoid Form.—Just as hebephrenia and stuporous conditions characterize this dementia in the same manner that mild demented states and stupor occur in dementia paralytica, so also pseudo-paranoia

may appear in dementia precox in the same way that persecutory ideas arise and hold the stage in occasional cases of general paresis. In fact, paranoid states are met with in all the various types of mental disease. In dementia precox these states are quite different from true paranoia as will appear when we come to consider the diagnosis. They are designated as paranoid simply because the predominating delusion and attitude are those of persecution. Unfortunately, the boundaries of the classic paranoia of ten years ago have since been so much enlarged that it is difficult to classify the paranoid forms of mental disease. The beliefs that these patients acquire, are not, as a rule, the outgrowth of a naturally suspicious tendency, but are preceded by certain of the usual prodromes of the disease described above as common to all the forms of dementia precox, namely, insomnia, headache, emaciation, depression, cerebral fatigue, loss of interest and energy, etc. There is also in these cases much disquietude, suspicion, and irritability. The onset is gradual in the majority of cases. The active stage is apt to begin with excitement or pronounced melancholy followed by hallucinations and delusions which though quite without sense, inconsistent and unsystematized are nevertheless persecutory in their nature. They may believe that their food is poisoned, that they are excommunicated, that thoughts are dictated to them, that enemies are "sending pain into them," etc. The delusions are often attended with ideas of grandeur and importance. A young man, a chronic dement, was in the habit of dwelling, in the early stages of his illness on long past family misunderstandings as present grievances which demanded redress. Relatives "insulted" him and made derisive motions pointing at him. He ordered people out of the house, grew excited and talked loudly in discussion, was overbearing and conceited, forbade speaking of the President in his hearing, etc. Sometimes these patients are very vain and self-conscious and demand special consideration. Their understanding is much impaired and they are incapable of sustained effort. Impulsive acts are common. Within a variable length of time a certain number show the underlying state in increasing apathy, stereotypy, automatism, mannerisms and negativism and finally a confused dementia supervenes. Remissions occasionally occur as in other forms of dementia precox. They are, however, incomplete and the delusions, which may be dangerous ones, are merely concealed. Paranoid states may appear for the first time late in the second attack of dementia precox or immediately following the original acute stage and are then loosely termed secondary paranoia.

Generally speaking, however, the paranoid form does not show to such a marked degree the apathy, listlessness and other signs of loss of mental power much less the extreme hebetude and personal neglect that are common features of the two preceding forms; the final level of deterioration is higher; there is considerably less disorganization of the personality. Many of them are individuals of a low type, criminals, vagabonds, and prostitutes. This condition corresponds to Kraepelin's *dementia paranoides mitis* to which he has added a smaller group which is characterized essentially by an unusually striking disturbance of speech expression with proportionately little interference with other mental functions. These patients are well oriented and sense falsification play no important part. They may answer simple questions briefly and correctly but soon run off into a string of absolutely unintelligible words and phrases. They conduct themselves well as a rule. About nineteen per cent. of the cases of dementia belong to the paranoid group.

Confusion is common to all of the above conditions. It is denoted by more or less inability to collect the thoughts, incoherence of ideas and speech, a "mixed up" state of mind varying in degrees from mild bewilderment to actual delirium and is a logical outcome of the disease process. The difficulty experienced in most deteriorating cases of this type in sustaining a line of thought consistently if at all; the frequent and abrupt changes and contrasts in moods and symptoms; together with the hallucinatory states all denote mental confusion. Moreover exhaustion so common a forerunner of the infection-exhaustion psychoses is also a common cause of dementia precox and we should therefore look for similar clinical manifestations in both. In fact Chaslin's classic description of "confusional insanity" embodies so many of the well-known symptoms of dementia precox that the resemblance is striking. For example, he classes together as important symptoms of the former, intellectual enfeeblement, stupor, immobility, automatism, dementia, stereotyped movements, impulses, etc. It is also significant that the prevailing age in "confusional insanity" is between twenty and thirty.

Diagnosis.—It is of the highest importance as regards prognosis and prophylaxis to recognize dementia precox in its incipient stage. This is no easy matter, so nearly do its early symptoms of mental and bodily weakness resemble in many cases the nervous exhaustion of true neurasthenia, which however, is ordinarily a postdevelopmental disease rarely terminating in insanity. In early dementia precox moreover, we miss the characteristic symptom groups of neurasthenia; cerebral, digestive, genital, etc. The general hyperesthesia, excitability, pains in the limbs, back, etc., are rarely present; so also the phobias. The fatigue of mind and body on moderate exertion is a common feature of the two disorders, but in the psychosis the signs of mental inadequacy for work or pleasure, owing to loss of the power of sustained attention, will be found to preponderate over those of the more purely nervous and muscular weakness peculiar to neurasthenia.

The chief difficulty in the diagnosis of dementia precox in its active stage is to distinguish early attacks, in which excitement or depression may predominate, from the manic-depressive psychosis, a highly hereditary form of mental disease, which in a fair proportion of cases also makes its first appearance in adolescence. As one is a disease of active mental deterioration and the other a periodical psychosis in which the mind is, as a rule, practically sound until the last, except during the attacks which characterize it, the importance of a correct diagnosis is obvious.

In certain cases it is extremely difficult to differentiate between the two until a second attack has occurred or until the disease, if uninterrupted, has become prolonged and evident signs of deterioration appear. The general features of difference are, that dementia precox has a gradual onset, while the attacks of manic-depressive insanity appear quite suddenly, as a rule, and there is an absence of ascertainable cause. The former has irregular intervals between the attacks, in which the mind usually shows increasing impairment, but in the latter the patient is rational in the intervals. In the one the attacks vary greatly as to intensity, frequency, and uniformity; in the other they are either excitement or depression—one or the other—and always of about the same intensity and duration, are practically identical in their manifestations according to the type assumed, and recur with considerable regularity. In dementia precox too, the degree of mental deterioration is out of proportion to the degree of severity of the depression or excitement. Regarding the special mental processes of the two, the presence of hallucinations is a valuable diagnostic sign as they are much less frequently found in manic-depressive conditions and when present are not prominent. When depression occurs in dementia precox it is not so likely to be attended with psychomotor retardation; the ideas are absurd and, as has been said, there is little depth to the feeling of sadness or shame. Such patients are often

easily diverted, and sudden interruptions of the prevailing mood by a lucid moment or an opposite mental state are not uncommon. The depression of the manic-depressive psychosis, on the contrary, is uniform, consistent and constant and psychomotor retardation is common. The excitement of dementia precox also shows more confusion, the movements are aimless, sudden, impulsive, occasional and possibly stereotyped, with perhaps, intervals of quiet. It appears as a succession of outbursts of intense excitement that are soon over, while manic-depressive cases express themselves in constant restlessness, busy activity and multiform purposive movements. In the former the patient is not exhilarated, but is indifferent and silly, and talks nonsensically or bursts into tears in the midst of his excitement. The admixture in one attack of any degree of stupor, true negativism, stereotypy, catatonic or cataleptic conditions or marked confusion stamps the case as one of dementia precox as a general rule. Attacks of acute hallucinatory confusion of the primary idiopathic variety occur most frequently in youth and should be regarded with suspicion as they are sometimes nothing less than the first active expression of dementia precox. Lugaro notes this in stating that certain cases of amentia do not go on to recovery but terminate in a dementia which from the clinical side is very difficult to distinguish from the final stages of dementia precox. The same disorder occurring in maturer patients is usually secondary and symptomatic and often does not result in dementia owing to the greater resistive power to disease of the fully developed brain.

The stupor of dementia precox, when unattended by catatonic or cataleptic conditions or by marked negativism, resembles the melancholic stupor common to older patients, which may also be present during adolescence as the initial attack of periodical or manic-depressive states. It differs from it chiefly in its relatively less gradual onset and in the absence of the anteeedent and protracted period of melancholia with delusions, which are the starting-point of melancholic stupor and which so strongly influence the patient as to lead to mental preoccupation and absorption finally deepening into stupor. The stupor of dementia precox, on the other hand, is more or less complete, sometimes seeming to extinguish all mental activity and is not only not consequent on depressive delusions, but sometimes immediately follows a stage of excitement. Moreover, the dementia precox patient retains, as a rule, only a hazy memory of his thoughts or condition while in the stupor, but the true melancholiac may have full recollection of a delusion which was dominant at that time.

The excitement and stupor of dementia precox have their closest counterparts in the mania and stupor of dementia paralytica, but the nature of the prodromes and the absence from dementia precox, of memory defect, pupillary irregularities, increased reflex excitability, tongue tremor and especially the employment of the Wassermann test will make the diagnosis certain. It is sometimes difficult to distinguish certain advanced cases of dementia precox from imbeciles and idiots. The appearance and mental status of each are often so much alike that, in the absence of information as to whether the arrest of mental development occurred in infancy or adolescence, dements of this class often pass for imbeciles. All that can be said is that the imbecile is more likely to show stigmata or malformations than the dement and that the latter sometimes affords glimpses of a former intelligence which never appear in the imbecile. Fortunately such an error is immaterial as it could not, in either event, affect the care or treatment of the patient.

The diagnosis of paranoid conditions is sometimes difficult, but it is rare for true paranoia, a postdevelopmental disease, to culminate before the thirtieth year. The essence of paranoia is also absent in these states, viz.; a gradually evolved and logically elaborated set of delusions which exclusively and unchangeably dominate the entire psychic life. In place of this we have an unexpected appearance of new conditions in the shape of variable and unsystematized delusions whose only likeness to paranoia is the persecutory nature of the beliefs. There is also in these hybrid states an absence of physical and mental stigmata of degeneration. True paranoia, moreover, does not end in dementia.

The Disease Process.—It is only by keeping in mind that gradual intellectual enfeeblement is the fundamental condition of dementia precox from first to last growing more and more marked with each successive "attack" and that even in the remissions it is in typical cases more or less apparent, that the true nature of the disease can be understood. Any of the groups described may predominate in one attack and in the next be absent, greatly modified or united with symptoms of another group, but the mental enfeeblement is the one constant feature, source and common bond of union of all the manifestations. Moreover, some of these syndromes are striking and quite different in the character of the manifestations from similar conditions occurring in older subjects of mental disease. The underlying juvenile dementia has imprinted on them its peculiar stamp, making them odd, shifting, and contradictory. Their intensity as well as their irregular character so far conceal the essential dementia in some cases that it is apt to be lost sight of and these accessory symptoms given undue importance. This, and the fact that remissions have been mistaken for recoveries have led observers to consider them disease entities which have been given from time to time a variety of special names. They are really but episodes in the course of progressive dementia and have their counterparts in the excited, depressed, stuporous, confused, and other states that mark the course of dementia paralytica (general paresis). A comparison of the modes of mental degeneration in dementia paralytica and in dementia precox as shown in their nature and course, mental prodromata, general mental symptoms, special mental and physical manifestations and remissions will make it evident that in spite of the difference in their pathological bases the mechanism of the process of mental deterioration is practically the same in both diseases, the extent of the cortical alterations alone explaining the difference in the ultimate results. Dementia precox would therefore seem to stand midway between the so-called functional psychoses: paranoia and the manic-depressive states on the one hand and the deeper seated because structural form, dementia paralytica, on the other.

Bleuler's conception of the fundamental condition of the psychosis is based on the well-known Freudian psychology but differs in that Bleuler practically accepts a bodily disturbance behind the psychological picture. His schizophrenia is as the name implies a splitting process not a dementing one and depends upon the conflict within the personality between unfulfillable desires and wishes, mostly sexual and reality. To escape reality and the conflict the individual takes refuge in autistic thinking, a sort of day dreaming, but the outer world still presses home the conflict and the splitting involves emotions, intellect, speech, conduct, etc. For Bleuler the rambling speech of the dementia precox patient represents a split between word sounds and the properly associated meaning (schizophasia). The catatonia and negativism represent defense reactions and are eroto-psychogenetic in origin. Even granting the soundness of this conception which so far as it is based on the Freudian doctrine Kraepelin rejects as not in accord with experience it cannot be denied that a dementing process exists whether its mechanism be a splitting, a fragmentation or a dilapidation of the personality, or not. The fact remains unaltered that in this psychosis the mind be-

comes enfeebled and disorganized; in other words, that there is a state of progressive dementia. Moreover, impairment of the personality is not peculiar to dementia precox. There is force in Myerson's contention that "an inner splitting of the psyche must be the basis of all functional psychoses no matter what their character. There must be a failure of inhibition here, and overstimulation there a falling off somewhere and an internal splitting is no more characteristic of a single group of diseases than inflammation is peculiar to a skin infection or a meningitis."

Pathology.—The best proof of the fact that a pathology has not yet been established for dementia precox is the existence of a large and able school of psychiatrists headed by Freud, Jung, Meyer, and Hoch who claim a psychogenetic basis for its symptoms. That is to say, the experiences and reaction habits of the individual cause the disease. Nevertheless, most investigators are convinced of its organic nature. These investigations relate to (1) pathological changes in the cortex, (2) disordered bodily changes as manifested in blood, urine, serological tests, etc.

As to the pathological changes in the cortex the researches of Alzheimer, Klippel, L'Hermitte, DeBuck, Deraubaix, Zingerle, Zalplachta, and Southard make it plain that lesions mainly neuronic exist in dementia precox chiefly, affecting the deep cortical layers and associated with gliosis. The question as to the relation of these changes to the disease is unsolved. Their existence can be admitted without necessarily ascertaining a causative relation. It cannot yet be told whether they are incidental to catatonia, excitement, emaciation, tuberculosis, etc., or whether they are etiologic. As regards the clinico-pathological changes, it seems to be established by the work of Hielman, Kruger, Purdum and Wells, Schultz, Itten, and others that there is a lymphocytosis and eosinophilia in dementia precox particularly in the excited and catatonic states and that there is often an increase of red cells. This blood picture is variable and disappears in the remissions and also in the old vegetative cases. There is a remarkable similarity between the white cell picture here described and that found in thyrogenous disease and there is decided evidence of a disturbance in the internal glands. Thyroid therapy has in consequence been generally employed but without result. Kraepelin is still inclined to favor the theory of autointoxication with disorder in the sex glands but admits that "convincing proof is unfortunately not available."

A development of possible importance in the last few years is the use of the Abderhalden reactions in the establishment of pathological processes in the glands of various organs, following the announcement of Fauser that ferments (*abwehr fermente*) were present in the sera of dementia precox patients that digested sex glands and cortex, especially in acute cases. Investigations have been made by Wegener, Fischer, Theobald, Neue, and others which agree in the main with Fauser, while Kafka, Mayer, and Golla cannot substantiate his findings. Orton comes to the conclusion that "even if we accept the theory and the results of the most hopeful investigators we are only brought to the beginning of a wider field of investigation as by the interpretation of the theory the results speak only for a faulty metabolism in specific organs and as yet give no light on the underlying causes."

Prognosis.—It is necessary to discriminate between the immediate and the ultimate prognosis of dementia precox for the two are widely different. Most first attacks, especially if pronounced, result in what are considered by people in general and appear in hospital statistics as recoveries. They are, however, as has been explained, remissions, which vary greatly in completeness and duration. In a certain proportion —Kraepelin once estimated it at thirteen per cent.— all symptoms of disease so completely disappear that the recovered patient can again fill his accustomed station in life practically as well as before. These individuals, however, never appear entirely the same in the opinion of near relatives, in some detail of judgment, disposition, conduct or habits. Their endurance, also, is lessened. Even these cases may relapse after many years and sink into permanent dementia and one can never feel sure that a permanent recovery —which is to say the least a rare event in dementia precox—has taken place. Much more common is the transient remission, in which the patients are happy, easily pleased and irritated, excitable, more childish than before the illness, and become very soon fatigued in mind and body. They experience a relapse very soon after leaving the hospital, from which time the deterioration is rapid. Intermediate cases live comfortably perhaps for two, three or more years, but on a much lower level of mental and bodily power and capacity than before the attack. A few are able to earn a moderate livelihood and find a certain satisfaction in life, but all are regarded as failures by their friends, having lost their spontaneity, energy and much of their interest and being unable to play their part in life are more or less solitary, decline advances and come to be regarded as unsociable and stupid. They are also very often peculiar in conduct, inconsiderate, irritable, perhaps boisterous and ignorant of their real condition. Such patients are readily imposed on and are sometimes as pliable as imbeciles. Girls in this stage of the disease are apt to be easily seduced and give birth to illegitimate children. We may properly make the tentative prediction of "recovery" or decided improvement within a year from the beginning of the active symptoms of the first attack in any patient originally of good mind who has had good individual care, but it is most difficult to foretell with certainty the character or length of the remission in any case. No one can say when a remission is going to be permanent. Severe symptoms if of the acute order, are no bar to temporary "recovery" and stupor, however profound, especially if of comparatively sudden onset, may end in a good remission which is, we believe, more likely to be an extended one than after any other form, although the cases in which confusion, excitement and depression predominate are also frequently followed by long intervals of comparative mental health. The paranoid cases almost never recover. Dementia precox cases originating in the "shut-in" personality are less likely to improve than those of a more normal mental make-up. Sometimes profound stupor may without change, except for flashes of intelligence, deepen into extreme and helpless dementia with fixed postures. The excited and catatonic forms are most likely, according to Kraepelin, to have long remissions, while in the simple, hebephrenic, and paranoid forms remissions are much less common. Of the cases of dementia precox which have come under the writer's notice, those in which the acute condition was prolonged beyond a year and a half without remission have gone steadily on to dementia. Increasing mental inactivity, fixed mannerisms, and stereotypy betoken chronicity.

There is no doubt of the ultimate prognosis in the large majority of the victims of dementia precox, however encouraging may seem to be the outlook on the patient's recovery from the original attack. Another attack sooner or later occurs, others follow and the mind rapidly deteriorates until a condition of dementia results which is usually so extreme as to require constant hospital care or its equivalent. This terminal dementia is often marked by exacerbations of excitement, depression and anergic states which are the rudiments of the original acute manifestations characteristic of the disease. These patients form a large proportion of the chronic dements in institutions. All, however, reach a stationary condition through the arrest of the cortical degeneration and

remain at different levels of mental reduction. A small proportion stop short of extreme dementia and live in considerable comfort, satisfaction and even enjoyment, the life of imbeciles of the higher grades. The progress of the form of degeneration peculiar to dementia precox may be (1) progressive and subacute without critical episodes; (2) slow at first, then rapid after a single acute episode; (3) very slowly and marked by numerous acute episodes (Finzi and Vedrani).

Treatment.—Preventive measures are the most efficacious against the disease and the least likely to be employed. The "shut-in" type of lad or girl described above, in which dementia precox takes root most quickly should be more generally recognized. It should be made common knowledge, at all events among physicians, that just as there is a special physical make-up which betokens tuberculosis, so there is in many cases of dementia precox a special personality which favors its development and calls for precautions in the way of education, environment, and mental and physical hygiene. In families of the ignorant and the unthinking these danger signals pass unnoticed, but intelligent people may learn the lesson and profit by it, if it be brought to popular knowledge as an accepted scientific fact.

First and foremost, especial attention should be paid to the accumulation of a constant reserve fund of bodily nutrition and all possible means availed of to prevent such subjects from taking irregular and insufficient nourishment. Many young people, especially in the case of the only child supposed to be physically delicate are half fed and apt to develop hypochondriacal tendencies. While mental and bodily coddling should be discouraged it should be borne in mind that nervous children become readily exhausted both mentally and physically. They should be guarded so far as possible from strain of any kind and warned against pushing exertion to the point of daily fatigue. At the same time, plenty of open-air exercise graduated to the individual's strength should be encouraged. If the very tall, thin, overgrown youth could always be restrained from athletic competitions and excesses there would be fewer mental breakdowns. For the shy, sensitive, self-conscious perhaps overmothered boy or girl in good circumstances the routine of a well-selected preparatory school at a distance from home where the right moral tone, discipline, physical training, and an out-of-door life are important features of education and where he or she is but one of many pupils is an excellent corrective and up-builder of mental and physical strength. For the more highly nervous this occasionally proves too severe an experience but it never need be disastrous and it oftener happens that the doting parents through fear of the consequences give it an insufficient trial. Clouston's general principles of prevention are practical and to the point. "Build up the bone and fat and muscle especially the fat by means known to us, during the period of growth and development. Make fresh air the breath of life to the young. Develop lower centers rather than higher where there is a bad heredity. Do not give too much flesh and nitrogenous food during growth and adolescence. Do not cultivate, rather restrain, the imaginative and artistic faculties and sensitiveness and the idealisms generally in cases where such tend to appear too early and too keenly. They will be rooted in a better brain and body basis if they come later. Cultivate and insist on orderliness and method in all things. The weakly neurotics are always disorderly, unbusiness like, and unsystematic. Fatness, self-control, orderliness are the three most important qualities for them to aim at."

Efforts among the poor at prevention against mental disease must perforce be confined to the dissemination of instruction in mental hygiene through popular lectures and especially the oversight given to convalescent and presumably recovered patients on their discharge from the hospital, through after-care and social service channels. By following up these cases, regulating their home and family surroundings, helping them to secure employment and in general improving the conditions under which the original mental breakdown occurred it is sometimes possible to ward off or at least delay relapses. This is the most practicable and promising means of prevention available for this class of patients. After-care applies with much greater force to cases of dementia precox in good circumstances. When once an attack has been experienced the dread of a relapse causes the more sensible and intelligent to listen to medical advice. Their limitations more readily become recognized by them and their relatives and their means enable them to escape from sources of fatigue and anxiety to which the poor are subjected. These young patients often emerge quickly from an attack but while mentally clear are far from strong for months afterward. Intervals between attacks may often be prolonged and even an impending attack occasionally prevented by the physician immediately on the appearance of the first signs of overfatigue of mind and body or insomnia which so easily and unexpectedly arise in these cases. There is good reason to believe that it is possible to abort the disease if it be taken at the very outset. Examples of what might properly be termed hypodementia which under proper medical and home guidance have not culminated in actual mental disease are sufficiently numerous to strengthen our belief in the greater curability of the psychosis, at least among the well-to-do. It is here that the great importance of familiarity with the earliest signs of mental fatigue and deterioration becomes evident and it is chiefly for this reason that we have dwelt at such length on the mental make-up and the minor mental manifestations of the disorder in its incipient stage. We look with confidence to the time when cases which are recognized early by the psychiatrist while yet the patient is comparatively normal may be saved from an attack by well-directed medical advice and supervision.

When acute symptoms of depression or excitement set in it is usually disastrous to temporize. There is great danger of the patient's obedience to a sudden impulse to fatal or other overt acts and proper precaution should be taken at once. The well-equipped hospital is the only safe place for such cases. Single care in a private house given over to the patient and his nurses will often answer, but for the best results constant and experienced medical supervision of patient and nurses during the acute stage in a hospital for mental cases is preferable. Not only is absence from home and the family imperative, but disturbing influences of every kind should be discouraged, too zealous attempts to entertain the patient avoided, and quiet surroundings, regular out-of-door exercise in almost all weathers, baths, and above all, an abundant supply of nutritious food insisted upon. Nothing is worse for the so-called mild cases than to be sent to travel. They are quite sure to return after unpleasant experiences, exhausted in mind and body, and in a far worse condition than before. Brain rest at this time, not diversion or change, is the supreme indication. The establishment of a routine in the care and treatment to be closely followed in all stages of the disorder is of great importance. In spite of the opposition of the patient every endeavor should be made to help him to acquire regular habits especially in dressing, bathing, and all the details of personal cleanliness from the start. Should great excitement develop in consequence of efforts in this direction they may be temporarily discontinued but should never be abandoned. A rigid schedule should be drawn up and as far as possible adhered to, specifying the hours of rising, baths, meals, walks, drives, etc. In some cases it is possible even at this stage to

begin upon light occupation to which it is so desirable that they shall become habituated especially in the chronic state. If such a course be persisted in the patient will finally accommodate himself automatically to the routine, his greater comfort will follow, and his care be made far easier. Above all, should the disease become chronic he will not have acquired degraded habits as often happens when such patients are cared for at home or under conditions in which efficient medical supervision and control are wanting. After the routine habit has been acquired attempts to turn the patient from the beaten path should be made with caution. Unusual but well-meant efforts to stimulate his mental activity at any other time than during convalescence or in the condition of pronounced stupor are apt to irritate and lead to outbursts of violence. A quiet, easy, uneventful existence under systematic regimen of work, diversion, and exercise free from disturbing influences brings the best results. To avoid, however, the possibility of permanent dementia and prevent early hospitalization it is sometimes well to make a complete change in the patient's surroundings provided the same or a better standard of care and treatment can be secured.

In this as in all forms of mental disease conditions of acute excitement are best met by the continuous bath or the wet-pack. Hypnotics need be employed but seldom if the patient is in a well-equipped and conducted hospital or sanatorium. If, however, the patient be treated where others are likely to be disturbed by his demonstrations it is necessary often to resort to drugs. In intense and furious excitement the moderate and cautious use of subcutaneous injections of scopolamine hydrobromate is permissible and effective. Profound stupor is sometimes lightened by hydrotherapeutic treatment and calls for especial attention to the bladder and bowels. In all acute conditions the sheet anchor of treatment is abundant nutrition to accomplish which artificial feeding should not be too long delayed in poorly nourished patients.

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REFERENCES.

Alzheimer: Amer. Journ. Insanity, vol. lvii.

Aschaffenburg: Allg. Zeitsch. f. Psychiatrie lviii., 2 and 3 a., 33.

Bianchi: A Text-book of Psychiatry, 1906.

Binswanger: Erschöpfungspsychosen. Berliner klin. Wochenschr., Juni, 1897.

Bleuler: Handbuch der Psychiatrie. Herausgegeben von Aschaffenburg. Spec. Teil. Abteil 4, Halfte 1.

Chaslin: La Confusion Mentale, 1895.

Christian: Annales Méd. Psychologiques 8me série t. ix. and x.

Clouston: Mental Diseases. Hygiene of Mind. Neuroses of Development.

Dercum: Clinical Manual of Mental Diseases, Philadelphia, 1913.

Falret, Jules: Études cliniques et les Malades. Mentales et Nerv., 1890.

Finck: Beitrag sur Kenntnis des Jugendirreseins. Allegem. Zeitsch. f. Psych. xxxvii.

Finzi and Vedrani: Extrait de la Rivista Sperimentale de Frenatria Reg., Emilia, 1899.

Goodell: Journal of Mental Science, April, 1892.

Hall: Adolescence, vols. i. and ii., 1904.

Hecker: Die Hebephrénie. Virchow's Arch., Bd. liii., 1871. Irrenfreund, 1877.

Hoch, August: Personality and Psychosis. American Journal of Insanity, lxix., 1913–14.

Joffroy: Leçons à l'Asile Sainte-Anne, 1896.

Kahlbaum: Die Gruppierung der psych. Krankheiten, Danzig, 1863.

Kirby: The Catatonic syndrome and Manic-depressive Insanity. Journal Nervous and Mental Disease, vol. xl.

Kirchoff: Handbook of Insanity, N. Y., 1895.

Kraepelin: Psychiatrie 8th and former editions.

Lugaro: Modern Problems in Psychiatry, 1909.

MacPherson: Mental Affections.

Mairet: Annales Medico-Psychologiques, 7me sèrie, et seq., Paris.

Meyer, A.: Am. Journ. Psychol., xiv., 1903, Address Child Section, N. E. Ass'n., 1903.

Tanzi: Text-book of Mental Disease.

Saury: Études Cliniques sur la Folie Hered. (Les dégénérés), Paris.

Seglas et Chaslin: Brain, xii.

Singer: Dementia Precox in Kraepelin's Text-book, 8th ed. Journal Nervous and Mental Diseases, vol. xli., 1914.

Southard: Topographical Distribution of Cortex Lesions, Etc., in Dementia Precox, Etc. American Journal of Insanity, vol. lxxi., Nos. 2 and 3.

Noble: Am. Journal Insanity, 1899, lv., No. 4.

Orton: Present Status of Abderhalden Method in Psychiatry, American Journal Insanity, 1915, lxxi., January.

Myerson: Critique on Urstein's Spätpsychosen. Katatonic Art. Boston Medical and Surgical Journ.

Marro: Comptes rendus, viii., Cong. Internal. de Med., Sec. de Psychiatrie, 1900.

White: Outlines of Psychiatry, N. Y., 1913.

Wille: Psychosen des Pubertatsalters, Leipzig-Wien, 1898.

Worcester: The Katatonic Symptom-complex. American Journal of Insanity, April, 1899.

Mentha Piperita.—PEPPERMINT. "The dried leaves and flowering tops of *Mentha piperita* L. (fam. *Labiatæ*)," U. S. P.

Peppermint is a slender, nearly smooth, perennial herb, native of Europe, widely naturalized in temperate regions and cultivated upon a great scale for the herbage, for culinary uses, for flavoring and perfuming, for medicinal employment, and for the distillation of its oil and the preparation of menthol. It spreads by runners, producing frequently dense beds of slender stems about a yard long, ascending from a prostrate rooting base, quadrangular, frequently purplish, and bearing leaves and flowers described below. The stems and leaves are very sparingly and obscurely hairy, the hairs short and stout; usually containing menthol crystals in one or more cells, leaves opposite; exstipulate, petioled, the petioles winged toward the summit, the blades usually less than five centimeters (two inches) long and about half as broad, ovate, with the rounded base very abruptly produced into the petiole, acute, sharply serrate, thin, wrinkled, of a bright and usually light green; flower spikes oblong or oval, one to two centimeters (two-fifths to four-fifths inch) broad, with rounded summit, dense, or somewhat interrupted at the base; flowers about six millimeters (one-fourth inch) long, the calyx tubular, ten-nerved, scarcely two-lipped, five-toothed; corolla light purple, nearly equally four-lobed, or one lobe (consisting of two united) a little larger; stamens four, short, equal; fruit of four ovoid, smooth nutlets; odor strong, but not heavy, characteristic; taste characteristic, pungent, and cooling.

The drug contains, with a little tannin, about one per cent. of a volatile oil, which is the active constituent, is official under the title *Oleum Menthæ Piperitæ* and is required to contain "not less than eight per cent. of ester, calculated as menthyl acetate, and not less than fifty per cent. of total menthol (free and as ester)."

The following is the official description:

A colorless liquid, having the characteristic, strong odor of peppermint, and a strongly aromatic, pungent taste, followed by a sensation of cold when air is drawn into the mouth.

Specific gravity: 0.894 to 0.914 at 25° C. (77° F.).

It forms a clear solution, neutral to litmus paper, with an equal volume of alcohol; also soluble in 4 volumes of seventy per cent. alcohol, the solution showing not more than a slight opalescence.

It is levogyrate, the angle of rotation varying from −25° to −33° in a one hundred millimeter tube, at a temperature of 25° C. (77° F.).

If from 25 c.c. of oil about 1 c.c. be distilled and the distillate poured on an aqueous solution of mercuric chloride, a white film should not form at the zone of

contact after a short time (absence of *dimethyl sulphide* found in non-rectified oils).

This oil contains as its active portion the peculiar substance *menthol*, considered separately under that title. A good article has been found to contain about sixty per cent. of total menthol, about one-fourth of it occurring as ester, the remainder free. However, the percentage and composition of the oil, as produced in different countries, and even in different parts of the same country, varies widely, not only as to the percentages, but even as to the nature of the compounds.

Action and Use.—Notwithstanding that menthol is the active constituent of peppermit and its oil, yet the action and uses of the latter and of that constituent require separate consideration.

Peppermint and its oil are, from their taste and agreeable action, the most generally liked of all the mints, if not of all carminatives. This oil is warming and stimulating to the stomach, very seldom irritating. It is a favorite household remedy for nausea, flatulence, and colic; applied to the skin and evaporation prevented, it is a mild stimulant, useful in neuralgia and rheumatism; applied to the forehead and temples it produces a grateful, cooling feeling, with a little tingling that occasionally relieves slight headaches; this property is mostly due to the menthol it contains. The most common employment of peppermint oil by physicians, however, is as a flavor, vehicle, or adjuvant of other medicines, especially of cathartics, whose griping it undoubtedly diminishes. Like most mints, peppermint is frequently used in hot infusion for colds, etc. It is also a favorite flavor for candies.

The powdered drug is sometimes given in doses of gr. xv.–xxx. (1.0–2.0). There is, properly speaking, no official preparation of it, though the official spirit contains one per cent. It is often given in the form of the infusion. The common form of administration is that of the oil (dose one to five minims), or of the following preparations of it: The Spirit or Essence (*Spiritus Menthæ Piperitæ*) contains ten per cent. of the oil, and there is three and a half per cent. of it in the popular mixture of rhubarb and soda. The dose of the spirit is ♏ v.–xv. (0.3–1.0). Peppermint water (*Aqua Menthæ Piperitæ*) contains 0.2 per cent. of the oil and is given in doses of fl. ʒ ss.–ij. (15.0–60.0). The official troches each contain 0.01 c.c. (about ♏ $\frac{1}{6}$) of the oil.

Henry H. Rusby.

Mentha Viridis.—Spearmint. *Brown, Garden, Lamb*, or *Mackerel Mint.* "The dried leaves and tops of *Mentha spicata* L. (fam. *Labiatæ*)," U. S. P.

Spearmint is a native of Europe and Asia, and has spread widely through nearly all temperate regions, where it is also cultivated to a large extent, and shows a high degree of variation in characters. It usually covers quite large patches, propagating by slender runners. The quadrangular, slender, frequently purplish stems are prostrate below, one to two or three feet long, and much branched. The drug is thus described:

Sparingly and obscurely hairy, the hairs short and stout, without menthol crystals in their cells; branches quadrangular, slender, usually pale green, rarely purplish; leaves opposite, exstipulate, very shortly petioled, the blades usually less than five centimeters (two inches) long and about one-third as broad, lanceolate, or lance-ovate, rounded at the base, acuminate and acute, sharply serrate, thickish and rigid, deep and usually dark green; flower spikes usually appearing clustered at the summit, interrupted, elongated and acute, about five to eight millimeters (one-fifth to one-third inch) thick, flowers about three millimeters (one-eighth inch) long, the calyx tube nearly equally five-toothed, ten-nerved, the corolla light purple, nearly equally four-lobed, the stamens four, nearly equal, rather long; odor characteristic, aromatic, rather heavy; taste characteristic, pungent.

It is readily distinguished from peppermint by the elongated, slender, and acute flower spikes, the relatively longer stamens and style, and the ranker odor. As seen under the microscope, its hairs never exhibit menthol crystals.

The only important constituent of spearmint is about one per cent. of volatile oil, with which there is associated a little tannin. This oil, although quite similar in properties, is very distinct in composition from the closely related peppermint oil. It contains no menthol, nor apparently any other crystalline substance. Its important constituent appears to be carvone (see *Caraway*). Pinene and limonene also exist.

The action and uses of spearmint are almost identical with those of peppermint. It is somewhat milder in action, on account of which it is often preferred for administration to infants.

Powdered spearmint is often given in doses of gr. xv.–xxx. (1.0–2.0). The infusion is also popular. The best form of administration is the oil (*Oleum Menthæ Viridis*), dose one to five minims, or one of its two preparations.

The spirit or essence (*Spiritus Menthæ Viridis*) contains ten per cent. of the oil and one per cent. of spearmint, and the dose is ♏ v.–xv. (0.3–1.0). The water (*Aqua Menthæ Viridis*) has a strength of 0.2 per cent. and the dose is fl. ʒ ss.–ij. (15.0–60.0).

Henry H. Rusby.

Menthol.—($C_{10}H_{19}OH$). A stearopten obtained from the official oil of peppermint, or from Japanese or Chinese oil of peppermint. It occurs in colorless, acicular, or prismatic crystals, having a strong and pure odor of peppermint, and a warm, aromatic taste.

Menthol is only slightly soluble in water, but imparts to the latter its odor and taste. It is freely soluble in alcohol, ether, chloroform, carbon disulphide, or glacial acetic acid. It melts at 43° C. (109.4° F.) to a colorless liquid, boils at 212° C. (413.6° F.), and volatilizes slowly at the ordinary temperature.

When it is triturated with about an equal weight of camphor, thymol, or chloral hydrate, the mixture becomes liquid.

Its alcoholic solution is neutral to litmus paper, and deviates polarized light to the left.

When brought in contact with the tissues it acts as a local vascular stimulant and produces a sensation of cold followed by heat and burning. When its application is prolonged, it deadens the sensibility of the nerve terminals and acts as an anesthetic. This local effect may be very marked but it does not produce any corrosive action.

When administered internally it is a diffusible stimulant, increasing the vascularity and tone of the mucous membrane. Its stimulant action extends to the general circulation, increasing the force of the heart's action and improving the vascular tension. Menthol is also an active antiseptic, but is not available for ordinary use on account of its insolubility in water.

As a local application menthol is of service in neuralgia, myalgia, pruritus, and other painful affections. It may be applied in its pure state in the form of cones; or as an ethereal or alcoholic solution, in strength varying from ten to fifty per cent. Its combinations with other analgesics, as chloral and camphor, are very valuable for all superficial neuralgias.

It is rarely administered internally except for its local stimulating and antiseptic action upon the stomach and intestines. It has been given for atonic conditions accompanied by much flatulence. The dose for internal use is from half a grain to three grains, which may be administered in cachets, or in solution in oil or spirits. The following combinations form a permanent mixture: menthol, ʒ ij.; alcohol, ʒ i.; glycerin, ʒ i.; syrup, ʒ i.

Compounds of menthol have recently been brought into notice by the introduction of *Dioradin* as a remedy for tuberculosis. Dioradin is described as a radioactive iodine menthol. Each dose is said to consist of peptonized iodine 0.75 centigrams, menthol 0.06 centigrams, and 1 drop of esthesial radium-barium chloride solution. This is given in three series of ten intramuscular injections. Other preparations of iodine and menthol without the radium have been recommended as equally beneficial. One that has been much employed is menthol 10, eucalyptol 20, and iodipin 50 parts, 1 c.c. to be given subcutaneously each day.

Menthol has received much attention in the treatment of nasal and pulmonary affections, on account of its local action. A few crystals warmed in a vessel may be inhaled, or a few drops of a concentrated solution may be evaporated and inhaled. As it vaporizes at 109° F. it is easily employed by means of an inhaler placed in hot water. Solutions in oil or ether may be applied directly to the mucous membrane of the nose or throat. In this way it has been recommended in hay fever and in laryngeal phthisis. A five- or ten-per-cent. solution should be commenced with. In pulmonary phthisis its intratracheal use has been adopted, one dram of a ten- or twelve-per-cent. solution in oil being introduced into the trachea twice daily. BEAUMONT SMALL.

Mentone.—Of the famed winter health resorts of the beautiful Western Riviera, Mentone is perhaps the most typical as well as one of the most attractive. It is five miles east of Monaco and fifteen (by rail) from Nice. Like all the Riviera resorts, Mentone consists of a narrow strip of land on the coast shut in by encircling mountains, rising higher and higher as they recede from the sea. It occupies the projecting central point of a shallow bay formed by Cap S. Martin, on the west, and Cap de la Murtola, or Mortola Point, on the east. "From cape to cape this bay is about four miles across, and has a southeasterly aspect." The projecting ridge upon which the town is built divides the bay into two lesser bays, the east, which is the smaller, and the west. The climatic characteristics of these two portions of Mentone, the east and the west bays, differ materially, principally on account of the position of the mountains. In the eastern bay portion the mountains and hills come very close to the shore, leaving scarcely any room for the town, which "consists of little more than a road and a row of houses and hotels squeezed in between the base of the mountains and the seashore." Moreover, there are no considerable valleys, bringing cool air down from the mountains, as is the case in the western bay portion. In consequence of this topographical difference the temperature of the east bay is several degrees higher than that of the west bay. In this latter portion the mountain wall is about three miles distant from the town, permitting a greater extent inland for the houses. There are also spurs running down to the coast at right angles to the mountains forming valleys, of which there are three principal ones. From this it follows that the shelter is less perfect, there is more wind, and the temperature is lower than in the east bay. "Mentone's capabilities as a health station are not a little augmented by this provision of two varieties, two modifications, of the Riviera climate within a radius of less than a mile; and a knowledge of the points of contrast between these east and west bay climates is necessary in selecting the place of residence for an invalid."

In the side valleys, before mentioned, grow luxuriantly the orange and lemon, interspersed with figs, olives, and many other trees and shrubs of a semitropical nature. The time to see nature in her most luxuriant garb is unfortunately when the "season" is over, in the late spring and early summer. The writer, on a visit in June to this place, found a deserted village so far as visitors were concerned, but nature at her best, resplendent in the beauties of a semitropical vegetation. In the west-bay district are the two great resorts for visitors, the "Promenade du Midi" skirting the sea, and the "Jardin Public." Here from eleven to two o'clock the invalids and their friends take their sun and air bath, fanned by the mid-day sea breeze which frequently blows. The old town in the east bay is picturesque with its winding and narrow streets. "The Mentonian amphitheatre is virtually a great natural hothouse; the east bay is the warmer half of the hothouse; the eastern portion of the east bay, the district called Les Cures, is the warmest corner of all" (Richards). The population of Mentone is 9,400, largely augmented by the winter visitors. There are abundant and excellent accommodations of varying prices, though as a rule the Riviera is rather expensive. The drainage is very good, and, so far as the writer's experience goes, so is the water supply. All the visitor's and invalid's wants can be well supplied at Mentone; there are good shops, good doctors and dentists, and several English churches. The excursions about Mentone are most attractive and varied, and can be made either by carriage or afoot. "The best walks and drives are those along the coast extending from Cape St. Martin to the Italian frontier." Mentone can be reached from London in twenty-eight hours, and from Paris in nineteen and a half.

The characteristics of the Mentone winter climate are thus summarized by Dr. Bennet, who spent many years there: "Absence of frost, prevalence of northerly winds, moderate dryness of the atmosphere, complete absence of fog, paucity of rainy days, clearness and blueness of sky, general heat and brilliancy of sun, cool night temperature, a bracing coolness of the atmosphere generally, and a mean difference of 12.8° F. only between the day maximum and the night maximum."

The accompanying meteorological table, from the article on *Mentone* by Dr. Richards in the first edition of this HANDBOOK gives various climatic data.

The average temperature at Mentone, from October to May inclusive, is 55.5° F. In the east bay it is 56.25° F.; in the west bay it is 54.86° F. The absolute minimum temperature at Mentone during ten consecutive winters, according to Dr. Yeo ("Climate and Health Resorts") was 25.5° F. and the absolute maximum 77° F. The mean daily range of temperature was found to be least in December, 9.2°, and greatest in April, 12.5°. The average rainfall from October to May inclusive is 25.61 inches; but if October and May are omitted, it is only 17.87 inches for the remaining six months. The corresponding number of rainy days is 63.8, October and May included, and 45.15 excluding these months. January and February have the smallest amount of rainfall and the fewest rainy days. October is the wettest month. "The average number of very fine days for the six winter months, from November to April inclusive, seems to be about 94.5, rather more than fifteen in each month" (Dr. Yeo). The number of fine days for the year—days on which the sun shines without clouds—is 214; the number of days on which the sun shines with clouds is 45, and the number of days on which the sun does not shine, but which are without rain, is 24. The relative humidity for the year is between 70 and 72 per cent., a little higher than that of the other Riviera resorts, caused by the absence of the dry land winds which are shut off by the neighboring elevations. In regard to the winds, the *bête noir* of all the Riveria resorts, Mentone enjoys greater immunity from them than any other spot on this coast, owing to its better protection. The northwest wind, or mistral, is less common than at some other points on the Riviera, and when it occurs it is most felt on the west bay; while the east bay is

Meteorological Table of Monthly Means for Mentone. (From Sparks' "Riviera.")

Authority and number of years.	October.	November	December.	January.	February.	March.	April.	May.
Mean temperature of West Bay, Freeman, 1863–66	62.2	57.2	51.7	49.2	50.3	51.5	58.6	63.1
Mean temperature of West Bay, Andrews, 1873–78	.....	54.1	49.68	49.05	48.63	50.51	56.69	.....
Mean temperature of East Bay, Farina, and Castillon, 1861–77	65.3	55.3	50.55	49.9	50.6	53.9	58.7	65.76
Mean maxima, Andrews, 1873–78	.....	61.91	58.01	57.51	57.39	59.38	65.25	.....
Mean minima, Andrews, 1873–78	.....	46.38	41.51	40.63	39.60	42.03	47.97	.....
Mean daily range, Freeman, 1863–68	10.7	9.9	9.2	10.5	11.4	11.8	12.5	.....
Barometer, Freeman, 1863–65	29.84	29.91	30.06	30.03	29.86	29.71	30.01	.....
Relative humidity, Freeman	72.0*	75.0*	72.0*	72.0†	70.0†	74.0†	74.0†	.....
Rainfall, Freeman and Andrews, 1863–66 and 1873–78	6.37†	3.73§	3.475§	1.242§	1.45§	3.69§	3.293‖	2.37‖
Highest fall in each month (corresponding period)	13.52	6.94	7.93	2.17	3.26	6.83	6.8	3.9
Lowest fall in each month (corresponding period)	1.55	1.05	0.12	0.03	0.31	0.31	0.09	1.68
Rainy days (corresponding period)	8.0	10.1	7.25	5.1	5.66	9.55	9.33	11.0
Rainy days, De Bréa, 1851–60	9.0	9.4	5.9	7.9	5.5	6.1	7.3	9.3
Very fine days, De Bréa, 1851–60	16.1	15.4	19.5	17.3	16.3	17.7	15.3	15.4
Very fine days, Freeman and Stiege, 1863–68, and Sparks, 1875–78	.....	15.0	15.6	14.8	15.0	12.7	15.0	.....
Calm days, Stiege, 1863–68	.....	22.0	23.0	19.0	20.0	18.0	.....	.....
Windy days, Stiege, 1863–68	.....	8.0	8.0	12.0	8.0	13.0	.....	.....

*Two years. †Three years. ‡Five years §Eight years. ‖Four years.

scarcely touched by it. Although the prevailing winter winds are from the north, such is the protection from the mountains round about Mentone that they are not felt there, and do not touch the Mediterranean until a point is reached several miles out from shore. "Of other winds," says Burney Yeo, "the east wind is felt chiefly along the shore, and shelter from this wind can always be obtained in the walks and drives along the valleys behind the west bay. South, southwest, and southeast winds, all coming across the sea, have free access to Mentone, but these are not, as a rule, cold winds, although they may blow at times with considerable violence. From the north wind it is completely protected." "In October and the early part of November," says Dr. Bennet, quoted by Richards, "southwest winds prevail, bringing the heavy autumnal rains. Then the north winds gain the upper hand, and usually, but with occasional temporary exceptions, reign until the spring months, March and April. At this epoch the southwesterly and southeasterly winds seem to have the ascendency, giving rise to the gales and rains of March." In conclusion Dr. Richards remarks that there is always wind enough for health, seldom enough to cause discomfort; and that upon the occasions when too strong or too chilly a wind is felt along the shore line, it may be always escaped by the invalid who will take shelter in some one of the valleys opening into the west bay. "For those," says Dr. Yeo, "who especially desire warmth and shelter, and a quiet indolent life, with plenty of sunshine, and sun heat, and who like to live close to the sea, there is the mild and sedative climate of the east bay." "For those, on the other hand," he continues, "who find an advantage from a more bracing air, who like to have the sun heat tempered by cooling winds, who cannot feel at ease without 'ample space and room enough' to wander free over hill and valley, or who are irritated by the monotonous beat of the tireless sea against the shore—for those there is the west bay with hotels and villas, some on the seashore, some a little removed from it, some . . . far removed from the sea and high up on the hillside."

The class of cases for which the climate of Mentone can be recommended comprises those who require a warm, sunny atmosphere, and who do best in mild winter weather; the aged, weak, sickly children, scrofula, laryngeal diseases, chronic bronchitis, gouty and rheumatic affections, anemia, convalescence from acute disease, and some favorable forms of pulmonary tuberculosis, although in the writer's opinion, as expressed in the article upon Cannes in this Handbook, the climate of the Riviera is not the most favorable one for the arrest or cure of this disease, notwithstanding the conviction of Dr. Bennet uttered twenty-five or thirty years ago, "that there is a greater probability of the disease (consumption) being arrested, of life being prolonged, and even of a cure being eventually effected if the patient can winter in the south than if he remains all winter in the north of Europe." Since this was written, however, the experience at Davos and at the various sanatoria in Germany seems to have conclusively demonstrated that the systematic use of pure cool air in elevated regions produces better results than mere warm moist air at sea-level. In either case, however, as Dr. Bennet himself says, climate is not alone to be relied on, but the patient must be under constant and judicious medical management. When such medical supervision is available, and particularly if it is exercised in a sanatorium, almost any climate which affords pure air and plenty of sunshine may prove beneficial to the patient. It is said, however, that the climate of Mentone is not suited to certain nervous maladies such as epilepsy, neuralgia, and the violent forms of hysteria. Edward O. Otis.

Meran is situated in the Austrian Tyrol, about forty-five miles south of Innsbruck and twelve miles north of Botzen, in a well-sheltered valley, at an elevation of about 1,100 feet above the level of the sea. It is reached from London, viâ Innsbruck-Botzen, in forty-two hours. The population is 11,570, and the number of visitors is 10,000.

Meran is a health resort of a threefold character, and has three distinct seasons, which, combined, embrace nearly the entire year, with the possible exception of the mid-summer, when the weather is sometimes excessively hot. The three varieties of treatment practised here may with advantage be considered separately.

A Winter Health Resort.—The town of Meran, with the neighboring villages of Obermais, Untermais, and Gratsch, lies in the beautiful Etschthal, well protected from the north, east, and west, and exposed only to the southerly winds. The mean annual temperature is about 54° F. It is colder here in winter than it is in most of the health resorts of southern Europe, but the place has the advantage of a very equable temperature, and of a very unusual number of clear or cloudless days. Although frost and snow are not unknown, the cold is never intense nor of long continuance, and there is a great deal of warm sunshine. The valley is so well protected from the cold winds that the invalids and other visitors are able to take exercise in the open

air nearly every day. The air, in addition to being mild and of an equable temperature, is very dry, and the rainfall is comparatively slight, there being an average of only eleven rainy days during the winter. The mean annual relative humidity is said to be only 67.8 per cent. The following table, arranged from figures given by Knauthe, in the article on Meran in "Eulenburg's Real-Encyclopädie," shows the average temperature for the fall and winter months. These temperatures are not given as strictly accurate, but they will serve to indicate approximately the winter climate of this resort.

	Morning.	Noon.	Evening.
September	58.3° F.	69.8° F.	64.4° F.
October	51.8	60.8	57.4
November	37.2	45.7	37.4
December	30.0	37.2	29.0
January	29.0	36.0	29.0
February	30.0	40.0	34.7
March	39.6	54.3	45.5

Vegetation begins again in February, and the winter, strictly speaking, is limited to the three months of November, December, and January, November being the only one in which the weather is at all apt to be disagreeable.

By reason of the climatic advantages just enumerated—viz., a rather cool, bracing atmosphere combined with equability of temperature, plenty of warm sunshine, and absence of moisture—Meran is frequented during the winter by numbers of invalids suffering from chronic catarrhal affections, especially those accompanied by profuse mucous expectoration from the respiratory passages. As a further indication it may be mentioned that invalids of this class who seem to derive the greatest benefit from a stay at this resort are those of a scrofulous diathesis, and of a languid or even lazy disposition. Children with rickets and those suffering from bone, joint, and gland tuberculosis, cases of chronic kidney disease, fatty degeneration, and premature marasmus are also said to be benefited. Persons suffering from pulmonary tuberculosis in its early stages are often much benefited by a winter at Meran, but a residence here is said to be contraindicated for those in whom the tuberculous process has advanced to softening and breaking down of the lung tissue, with the formation of cavities. People of an excitable, nervous temperament, who are suffering from insomnia and nervous tension caused by overwork, anxiety, or excesses of any kind, often experience a great amelioration of their condition during a few weeks or months spent in the mild, dry, equable climate of this valley. The winter season extends from the first of November, the end of the grape-cure, to the first of April, the beginning of the whey-cure season. Old and delicate persons and those of weak circulation would find this climate rather too cold and exacting.

The Whey Cure.—Whey is made from cows' and goats' milk chiefly. It consists of the serum of the milk remaining after the separation of the fat and casein and is little more than a watery solution of sugar of milk and of various salts, chiefly chlorides and phosphates of sodium and potassium. It is made by adding rennet to milk warmed to a proper temperature, and precipitating the suspended casein by the addition of a small amount of albumin. The whey used at Meran is prepared at a neighboring village, and brought thence, every morning, in bottles kept in warm water (from 97° to 100° F.) so as to prevent the temperature of the whey from falling below the prescribed degree during its transport. The whey is dispensed in a large building which resembles the Trinkhalle or pump-room of a German spa. The usual time for drinking the whey is from six to eight o'clock in the morning. A large glass is taken about once in fifteen minutes until from four to seven have been consumed, the drinkers meanwhile walking about slowly. About an hour after the last glass has been drunk, a light breakfast, consisting usually only of coffee and a roll, is taken. No acids or uncooked food are allowed during the whey treatment and milk, butter, and cheese are also forbidden. These raw-milk products are stricken from the dietary, because they contain precisely the ingredients of the milk which have been abstracted in the production of the whey, and it is regarded as irrational to give with one hand what has been taken away with the other. The whey is taken pure, or it is mixed ("cut," as it is called) with some mineral water, or the expressed juices of certain herbs are added.

The Herb-juice Cure.—This is a mode of treatment practised at many health resorts on the Continent, especially in various parts of Germany and Austria. The juices of various herbs, usually wild plants growing in the neighborhood, are extracted from the fresh plant by pressure, without the aid of water, and are then drunk by the patient. The juice of one herb alone is taken, or those of several herbs are mixed together and prescribed, according to the supposed indications of the individual case. The following are some of the plants from which the juice is expressed and drunk, with their alleged therapeutic properties: *Achillea*, millefolium, milfoil, or yarrow—a remedy which has been used in flatulent dyspepsia, and also by the Italian peasants in intermittent fever. *Allium sativum* (garlic; diuretic diaphoretic, expectorant) and parsley (diuretic and aperient). *Cardamine pratensis*, meadow cress; said to possess antispasmodic properties. *Fumaria officinalis*, called also *Herba melancholifuga*, fumitory; has a popular reputation in the treatment of eczema and various other skin affections. *Glechoma hederacea*, ground ivy; expectorant and tonic. *Leontodon taraxacum*, dandelion; diuretic, aperient, and an hepatic tonic. *Menyanthes trifoliata*, water trefoil; has an intensely bitter taste, is tonic, diuretic, and cathartic. *Tussilago farfara*, coltsfoot; expectorant and demulcent, a popular remedy in coughs. *Veronica beccabunga*, water speedwell; supposed to be alterative and tonic. Many other plants are also used, each locality drawing upon the flora of its own neighborhood.

At Meran the most commonly used herbs are the dandelion, water trefoil, speedwell, and cress. The juices are usually prescribed in conjunction with the whey treatment. The whey is taken in the morning, in the manner described, and in the evening, between five and seven o'clock, from half an ounce to two ounces of herb juice are drunk. At the beginning of a course of whey and herb-juice treatment, the patients are made to rest most of the time, but after a week or so they begin to exercise according to a fixed daily routine, often counting the steps taken, as is the custom in so many establishments of this kind.

Patients suffering from chronic gastritis, certain forms of dyspepsia, hepatic congestions, anemia, and chlorosis are not infrequently greatly benefited by the fine climate and by the regular mode of living enjoined upon those who submit themselves to the whey cure. Patients with respiratory catarrhs or incipient phthisis who have passed the winter at Meran, often remain in the spring to take a course of the whey treatment. The season for the whey cure extends from the first of April to the middle of June although by some it is extended through the summer, until the grape-cure season begins.

The Grape Cure.—This formerly enjoyed a greater reputation as an efficient therapeutic measure than it does at present, but it is nevertheless still employed to a considerable extent. Grape juice contains a varying proportion of grape sugar, vegetable albumin, and a number of organic acids existing alone or in combination with inorganic bases. The immediate effects of the ingestion of a large quantity of grapes

are a little lightness of the head and slight-dyspeptic symptoms, followed soon by a rather active movement of the bowels and increased diuresis. This action on the bowels tends to reduce the blood tension in the internal organs, especially those of close anatomical relation with the intestinal tract.

At Meran the grapes are eaten in the vineyards or at the large building, resembling an ordinary German Trinkhalle, where, earlier in the season, the whey is drunk. The daily dose of grapes is from two to four pounds in the morning, before breakfast, and about one pound after each of the two principal meals. The season extends from the first of September to about the end of October.

The grape cure is recommended in the treatment of habitual constipation, hemorrhoids, passive congestion of the abdominal viscera, some forms of chronic diarrhea and dysentery, cardiac troubles, gout, chronic bronchitis and even commencing pulmonary tuberculosis. Those who intend to pass the winter at Meran, because of threatened or beginning lung troubles, are often advised to go there a little before the regular winter season begins, in order to take a course of the grape cure.

In addition to the therapeutic methods of which mention has just been made, Russian baths and mud-baths are much used, and fresh milk or kumyss is employed to a considerable extent throughout the year. There are also electric baths, massage, the Terrain Kur, and the compressed-air treatment by the use of pneumatic air chambers.

Meran is a most attractive place for the ordinary tourist in search of pleasure, as well as for the invalid seeking health. It lies in a beautiful valley, and in this neighborhood many agreeable walks may be taken to points affording a view of picturesque scenery, or to the numerous castles, many of them in ruins, for which this part of the Tyrol is famous. A large dike, erected to protect the town from the destructive inundations which, in former times, not infrequently caused serious damage to property and loss of life, is the favorite promenade for the inhabitants and visitors. The hotels and boarding-houses in Meran are numerous, and are, as a rule, clean and well kept, while the cost of living is not very high. At the casino may be found newspapers from all the leading countries. There are numerous churches, and persons of the Catholic, Protestant, or Hebrew faith will find opportunities to worship according to their own belief; there are, also, services for the accommodation of English-speaking Protestants. There are many competent resident physicians in the place.

Edward O. Otis.

Mercaptans.—These sulphur containing bodies may originate from proteins by suitable treatment with alkalies. They are also found as decomposition products resulting from putrefaction of proteins in the large intestine. F. P. U.

Mercury.—See *Hydrargyrum*.

Merycism, cud chewing, often described as a neurosis, is rather a deliberate self indulgence, probably beginning with accidental regurgitation and found to be pleasurable in spite of the esthetic objections. It is not so common a habit as is often implied in text-books. Those indulging in it, often claim to be able to bring up any food ingredient at will. It would seem that merycism must be confined to achylics, on account of the deterrent action of acidity, the bitter taste of bile and peptones, etc. None of the achylic patients seen by the writer has had this habit, although some have mentioned the occasional regurgitation of unchanged food. In a recent case of merycism, in a man aged thirty-three, with a slightly contracted liver and alcoholic history, the claim of differential regurgitation and lack of acid taste was made. One hour after a test meal, the total acidity was seventy degrees and the free HCl (to the orange point with di-methy-amido-azo-benzol) 30 degrees. Three hours after another meal, the writer's effervescence test with sodium bicarbonate was negative and the stomach was apparently empty. The results in this case suggest considerable scepticism as to the ability of cud-chewers to distinguish tastes with any degree of nicety. A. L. Benedict.

Mescal (or Muscale) Buttons.—*Anhalonium, Pellote.* The dried tops of several species of *Lophophorus* (*Anhalonium*), especially *L. williamsii* (Lem.) Coulter and *L. lewinii* (Henning) Rusby.

These cactuses grow in high, arid mountain localities of Northern Mexico, and probably also in the adjacent portions of the United States. The stem is mostly subterranean, its upper portion projecting slightly above the surface as a flat disc, roughened with triangular, thick, short, fleshy lobules and bearing in the center a mass of bristly whitish hairs, in which the small pink flowers are partly concealed. These tops are sliced off and dried, which causes them to shrink to button-shaped discs, one or two inches broad and from an eighth to a quarter of an inch thick. These discs constitute the commercial drug. They are wrinkled underneath and bear above the dried fleshy lobules and the central mass of hairs. In this condition, the withered flowers are scarcely discernible, except after soaking. In the first-named species the hairy tufts are somewhat separated, while in the second they are matted together and less white. The first-named species contains nearly one-half per cent. of the alkaloid *pellotine* ($C_{13}H_{19}NO_3$). The second contains a smaller total of the four alkaloids, *anhalonine* ($C_{12}H_{15}NO_3$), *mescaline* ($C_{11}H_{17}NO_3$), *anhalonidine* ($C_{12}H_{15}NO_3$) and, *lophophorine* ($C_{13}H_{15}NO_3$). The Mexican aborigines use this substance as a powerfully narcotic intoxicant, the effects apparently much resembling those from the use of Indian hemp. Ceremonial assemblies are held, at which each participant chews one or more of the "buttons," passing at length into a trance-like state, productive of strange intellectual experiences. Occasionally, when an unusual amount is ingested, the subject does not recover, death resulting.

Nixon found all the alkaloids of *L. lewinii* to act similarly, being non-irritant, sialagogue, constipating in small doses, apt to be purgative in large ones, which were apt also to cause nausea and vomiting, these results occurring from either gastric or hypodermic administration. Small doses greatly strengthen and, for a time only, accelerate the heart's action, and increase arterial pressure; toxic doses paralyze the vagal endings and later the nerve cells. They also produce a rapid and shallow breathing, death, when it results, being due to respiratory failure. There is a primary stage of exhilaration and talkativeness, followed by complete intoxication. The pupils are now dilated, there is increased reflex activity, but with blunting of cutaneous sensitiveness, and there are auditory and nasal hyperesthesia, incoordination and trembling, hallucinations, especially of vision, with kaleidoscopic play of colors and a rapid flow of ideas, without control. Intellection and introspection appear normal, but dual existence is sometimes imagined. Lewin found the toxic symptoms in rabbits to be similar to those from strychnine. Cushney regards the mescaline as the exhilarating constituent, pellotine as the hypnotic. The medicinal uses of anhalonium have been but little developed. Beneficial effects have been secured from its administration as a cardiac and respiratory stimulant in asthma, from two to five minims of the fluid extract being administered. Anhalonine and pellotine have also been administered for the same purpose, in doses rather smaller than those of strychnine. Henry H. Rusby.

Mesenchyma is a term introduced by the brothers Hertwig to designate the non-epithelial portions of the mesoderm. The mesenchyma develops into a great variety of important tissues, so that a knowledge of the histogenesis of the mesenchymal derivatives is indispensable for the pathologist. From the mesenchyma of the embryo arise the connective tissues, the supporting tissue (cartilage and bone), the lymphoid tissue, Wharton's jelly, blood-vessels, blood, lymph vessels and nodes, wandering cells, fat cells, pigment cells, marrow, and smooth muscle fibers. The embryonic mesenchyma consists of more or less widely separated cells connected by intercellular bridges of protoplasm and embedded in a highly transparent homogeneous matrix; it is always covered by epithelium, which may be either ectodermal, mesothelial, or entodermal, according to the location of the tissue.

CHARLES S. MINOT.

Mesoderm is the middle layer of the body of the embryo. Mesoblast is also used as a synonymous term; sometimes, however, the term mesoblasts is applied to the large cells in the segmenting ova of certain lower animals, from which the mesoderm proper is produced. A few writers have sought to alter the application of the term mesoderm, but it is almost universally used as above described, and to use it otherwise would now cause unnecessary confusion.

CHARLES S. MINOT.

Mesotan is methyloxymethyl salicylate, $C_6H_4.OH.COO.CH_2.OCH_3$. It is a clear yellow fluid, with an aromatic odor, specific gravity of 1.2, sparingly soluble in water, but capable of mixing readily with alcohol, ether, chloroform, and fixed oils. Mesotan is rapidly absorbed by the skin, and has its main use in articular and muscular rheumatism, but is also employed in neuralgic conditions. It relieves the pain and swelling of rheumatism, but on account of its irritant action it should only be used for a few days at a time. It is applied to the affected part, *without rubbing*, and is generally mixed with an equal quantity of olive oil.

R. J. E. SCOTT.

Mesothorium.—Shortly after the discovery of the radioactivity of the uranium group of elements, Schmidt, and almost at the same time Mme. Curie, discovered during the course of the investigation of a large number of inorganic substances that thorium, its salts, and also the thorium minerals possessed radioactive properties closely resembling those of uranium; that is, they possessed the power of discharging electrified bodies, of burning the tissues, and of blackening photographic plates in consequence of the emission of alpha, beta, and gamma rays, as do uranium and its compounds.

The detailed examination of thorium salts has shown that a number of radioactive substances can be obtained, which are in all probability formed by the slow breaking down of thorium, which in itself is only feebly radioactive, giving alpha rays merely. Two of these break-down products, mesothorium and radiothorium, are quite active, and as the mesothorium can be separated from the residues obtained in the working up of the thorium minerals, such as monazite, in the course of the extraction of thorium for use in making incandescent gas mantles, it has become of considerable commercial importance, especially as the supply of radium is so small.

The chief sources of thorium at present are monazite sand from Brazil and North and South Carolina, from which almost all of the thorium used technically is obtained, and thorianite, a rare thorium mineral from Ceylon. Other sources have been practically exhausted. Monazite is composed chiefly of phosphates of the rare earths, cerium, lanthanum, præseodymium, and neodymium, with variable amounts of thorium and traces of uranium. Usually the commercial sand contains from four to five per cent. of thorium oxide. The thorium is obtained from this sand by heating it with twice its weight of sulphuric acid, which decomposes the rare earth phosphates; then dissolving the mass, after cooling, in cold water, and leaving it to clear. Mesothorium, forming an insoluble sulphate, remains in the residue. With the thorium goes the substance known as radiothorium, which it is impossible to separate, owing to their close chemical similarities. Hence, all gas mantles are slightly radioactive, as can be shown by allowing a fragment of such a mantle to rest on the surface of a photographic plate inclosed in a paper envelope for some days, and then developing the plate, on which an image of the mesh of the mantle will be found. If the mantle is old it also contains thorium X, which emits only alpha particles and is a decay product of radiothorium, which in turn is derived from mesothorium 2 and mesothorium 1, as shown in the table.

THORIUM SERIES.

Thorium series.	Half-value period.	Radiation.
Thorium	1.3×10^{10} yr.	α
↓		
Mesothorium 1	5.5 years	rayless.
↓		
Mesothorium 2	6.2 hours	$\beta + \gamma$
↓		
Radiothorium	2 years	α
↓		
Thorium X	3.65 days.	$\alpha + \beta$
↓		
Th. Emanation	54 seconds	α
↓		
Thorium A	0.14 seconds	α
↓		
Thorium B	10.6 hours	$\beta + \gamma$
↓		
Thorium C	60 minutes	$\alpha + \beta$
b/ ↓ a		
Th. C_2	very short (?)	α
↓		
Thorium D	3.1 minutes	$\beta + \gamma$

Mesothorium 1 is a substance with an atomic weight of 228, that of thorium being 232, and is formed by the breaking down of thorium. This process is so slow that it requires some ten million years for a gram of thorium to become one-half converted into mesothorium, and in 1,000 kilograms of thorium there is less than 0.5 milligram of mesothorium. Mesothorium can be separated from thorium by precipitation with ammonia, the mesothorium remaining in the solution; but usually, as stated above, it is separated as an insoluble sulphate which is afterward purified by boiling with sodium carbonate thus changing the salts into insoluble carbonates, dissolving in hydrochloric acid, and reprecipitating with sulphuric acid. This carries down the mesothorium and the traces of radium, which are almost always present with mesothorium and cannot be separated from it. The purified chlorides, which include also barium and calcium, are then fractionally crystallized to separate the radium and mesothorium. Mesothorium 1 itself gives off no rays, but a few hours after its preparation it is found to emit beta and gamma rays, this radiation being due to the fact that it breaks down rapidly into mesothorium 2, which gives off the rays. This mixture of mesothorium 1 and mesothorium 2 with radium as an impurity is the substance sold as mesothorium. As there is no method of estimating its

strength by weight, the gamma radiation is taken as a standard of measurement; so that 100 milligrams of mesothorium means not 100 milligrams of the salt of mesothorium, but the amount of mesothorium which emits the same amount of gamma rays as 100 milligrams of pure radium element or pure radium bromide according to the standard employed. It is better to use the pure radium element as a standard, but commercially the radium bromide standard is employed.

Mesothorium falls to one-half its value in five and a half years, whereas radium falls to half value in two thousand years. The mesothorium is, therefore, less valuable than radium, owing to the necessity for allowing for the rapid disappearance of the radiating substance. Mesothorium 2 falls to one-half value in six and two-tenths hours, and is the substance which gives off the beta and gamma rays used in medical and surgical treatment. Radiothorium, giving alpha rays only, diminishes in activity to one-half its initial value in two years. Thorium X, giving alpha and beta rays, has a half period of three and six-tenths days.

The mesothorium of commerce, being a mixture of these substances, increases in activity for several years due to the production of mesothorium 2 and then falls slowly, its half value period being sixteen to twenty years, depending upon the type of radiation tested and the amount of radium present. For example, when freshly prepared the amount of mesothorium 2 is small and the gamma rays only rise to a maximum in about two years and four months, and then decrease. In the course of four and a half years, as the amounts of radiothorium and other lower members of the series increase, the alpha radiation, originally absent, becomes very strong, so that if measured by the alpha rays the radiating effect would have increased very greatly, only beginning to fall after five years. In old preparations the very penetrating gamma radiations from thorium D partially keep up the strength as measured by these rays. As commercial preparations on an average contain twenty-five per cent. of radium, which does not change appreciably, the gamma strength of the mixed product falls to one-half in about twenty years. Finally, only the radium will remain, still giving off all forms of radiation in amounts the diminution of which has as yet escaped our methods of observation as the half value period is two thousand years.

Medicinal use has been made of mesothorium products in the treatment of tumors, and thorium X has been employed in certain anemias and disorders of metabolism, but for further information on these points the reader is referred to the article on *Radiotherapy* in this HANDBOOK. F. C. WOOD.

BIBLIOGRAPHY.

Rutherford: Radioactive Substances and Their Radiations, Cambridge, 1913.

Soddy: Chemistry of the Radio-elements, London, 1911.

Lazarus: Handbuch der Radium-biologie und Therapie, Wiesbaden, 1913.

Mesué, or Mesua.—This name is given to two celebrated Arabian physicians who are distinguished the one from the other by the terms elder and younger.

Mesué the elder was a Syrian in nationality and a member of the sect of Nestorian Christians. His father, who was an apothecary, lived at Nishapur, a Persian town of considerable importance in the eighth and ninth centuries—the period during which the subject of the present sketch flourished. Mesué ranked as the most learned man and the best physician of his day. He was highly esteemed by several of the caliphs of Bagdad, and especially by the famous Harun-al-Rashid, who kept him employed for several years in collecting and translating important Greek writings, particularly those of Aristotle and Galen. During a period of forty years he taught and practised medicine and wrote treatises in the city of Bagdad, but all his writings, except a few fragments that have been preserved in the "Continens" of Rhazes, have been lost.

Mesué the younger, born at Maridin, on the banks of the Euphrates, was a Christian and a pupil of Avicenna (eleventh century of our era). During his career as a physician he lived at Cairo, Egypt, at the court of the Caliph Alhaken. The treatises which he wrote on materia medica and on the practice of medicine were classical works for many years—indeed, well into the sixteenth century. The titles of these works are as follows: "Canones universales divi Mesué de consolatione medicinarum et correctione operationum, earumdem, etc.," Lyons, 1611; "Practica medicinalis particularium ægritudinum," Venice, 1471; and "Mesué Græcorum ac Arabum clarissimi medici opera quæ extant omnia," Venice, 1561 (also several later editions). A. H. B.

Metabolism and Its Disturbances.—Under this caption we enter one of the largest, most interesting and important fields in medicine. Through it must come in large measure all future advances and practical applications of the science of medicine. There is much yet to be learned both as regards normal metabolism—or Stoffwechsel, of the Germans—and its disturbances. This term, metabolism and its disturbances, includes everything pertaining to animal life as it is observed in both health and disease. As most of these processes are chemical in nature, it is the chemicophysiology and pathology of life. It constitutes growth, maturity, and decay.

NORMAL METABOLISM.—Under normal metabolism must be considered the food stuffs, their composition, digestibility, and utilization by and within the system; for it is out of these that we build up the body, maintain life, and repair damages. With a practical knowledge of foods and their use, we can more accurately study disturbances in metabolism, for it is the faulty use of food that is largely responsible for all these disturbances.

All foods are primarily divided into two classes: those derived from the vegetable kingdom and those derived from the animal kingdom. These two are further divisible, chemically speaking, into four distinct classes, to wit: the inorganic, which includes water and salts of various kinds; two classes of simple heat-producing substances—one including cellulose, starch, and sugar, and the other composed of all kinds of fats; and the fourth, including the pure protein and the protein-like bodies, or the constructive tissue-building compounds. For a still clearer understanding of the subject, this fourth class is divided into two: one including the purely protein substances, and the other protein-like compounds, to which an atom of iron or of phosphorus is attached in its synthetic formation. This latter subdivision, or fifth class, for convenience and a better comprehension of the subject, is classed as a hemoglobin- and lecithin-yielding one. Outside the five classes here enumerated, no others of importance are found in the food stuffs.

It should also be remembered that all organic substances are found in many different isomeric forms, but these isomers should not be mistaken for radically different compounds, so far as the number of atoms is concerned. The difference is rather in the relation that the atoms bear to each other. This often causes the protein bodies to assume different physical forms, thus apparently multiplying varieties, while they all still remain protein bodies. The same is true of the glucose molecule.

With this simple outline of the primary origin and chemistry of food stuffs, we are in a position to study more closely their economic value, digestive and assimi-

lative possibilities as applied to the dietetic management of metabolism and its disturbances.

Both the vegetable and animal foods contain these five essential classes, all of which are necessary for the maintenance of animal life. This being true, why is not one type of food just as available as the other? If it is not true, what advantage has one class over the other? These questions can be solved only by a close comparison of the relative proportions of the five classes as found in the two primary divisions, taken in conjunction with the demands of the physiological economy for these five different groups of substances. Chemicophysiologic investigation has demonstrated that a certain amount of each of these five classes must be supplied daily to insure the best nutritive results. Water and salts, a sufficient amount of the purely heat-producing compounds, a certain amount of tissue building or pure-protein material, and the requisite quantity of hemoglobin- and lecithin-yielding material must be supplied. All this must be accomplished and still keep well within the oxygenating capacity of the system.

In this connection, it is well to note that in health nature permits quite a wide latitude between the possible intake of food and the oxygenating capacity of the animal economy. Were this not so, it would be impossible to maintain a perfect state of health. Even with the largest possible latitude between the intake of food and the oxygen supply, neither vegetable nor the animal diet alone, so far as composition is concerned, is absolutely perfect. The latter, however, so far as the human economy is concerned, is more nearly perfect than is the vegetable class, as we shall see a little later in our analysis of the two. (See table.)

Looking a little more deeply into the exact and comparative composition of the two classes (see table of composition), it will be found that the vegetable class contains less water than the animal, while salts are more evenly distributed between the two. The vegetable class contains a very high percentage of cellulose, starch, and sugar—or glucose-forming elements; while the animal, excepting milk and its derivatives, is absolutely deficient in this respect. The vegetable class contains a very low percentage of fat, while the reverse is true of the animal foods. In the purely protein group, it is pretty evenly abundant in both classes. If there is any advantage as to quantity, taken as a whole, it will be found in favor of the vegetable class With the fifth, or hemoglobin- and lecithin-yielding group, the advantage is largely on the side of the vegetable class of foods, in fact, the animal class is deficient in this respect.

Having found these five classes in both the vegetable and the animal foods, the next question is what are the requirements of the system as to the exact amount of each of these groups to maintain the highest grade of nutrition? Careful observation and close study of the chemistry and physiology of the animal economy seem strongly to indicate the necessity for a continuous and quite uniform supply of each of these five classes to secure and maintain the best nutritive activity. This applies particularly to the last four classes—the glucose-forming, the fats, proteins, hemoglobin- and lecithin-yielding substances. If anything, it is more important with the last two of the four than with the first two—they being tissue-builders, while the others are only heat-producers. How the first three of this group of four—or the glucose, fats, and pure proteins—shall be proportioned, is the all-important question.

If we turn to nature and the composition of milk, it will be found that the three are quite near together in percentage amounts, but with a slight preponderance in the glucose column. This correspondence is so near, taken in connection with the marginal latitude of deviation between the food intake and oxygen supply as allowed by nature, and the proportionately larger liver in the child, that milk furnishes an almost perfect diet. Further than this, it should be taken as indicating that these three groups should stand in all dietaries in pretty close percentage relation to each other during health and disease, if the best nutritive results are to be secured. This is especially so in connection with chronic diseases in which there is a low oxygenating capacity from any cause, and is further indicated by the necessity for resorting to a milk diet in the treatment of both acute and chronic diseases.

Comparative Table of Food Stuffs.

Kind of food.	Water, H_2O.	Proteins, or CHNOS.	Starch, sugar, and cellulose or CHO.	Fat or CHO.	Mineral salts.
Human milk	88.28	3.41	4.62	3.48	0.20
Cow's milk	86.23	3.73	4.93	4.50	0.60
New milk	86.00	4.10	5.20	3.90	0.80
Skimmed milk	88.00	4.00	5.04	1.80	0.80
Buttermilk	88.00	4.10	6.40	0.70	0.80
Mares' milk	82.32	4.70	11.00	2.70	0.28
Kumyss of mare's milk	91.62	1.12	2.20	1.20	0.02
Kefair	90.73	2.80	2.00	2.00	0.27
Kumyss, Dr. Brush	90.99	2.04	3.26	1.91	0.44
Matzoon, Dr. Dadirrian	87.69	3.98	2.03	4.91	0.78
Kumysgen, Carnrick	86.81	4.16	8.63	1.02	2.00
Cream	66.00	2.70	2.80	26.70	1.80
Cheese	41.48	29.23	.....	23.84	5.09
Cheddar cheese	36.00	28.40	.....	31.10	4.50
Skim cheese	44.00	44.80	.....	6.30	4.90
Eggs	69.05	15.58	.....	13.96	1.41
Entire egg	74.00	14.00	.....	10.50	1.50
White of egg	78.00	20.40	.....	.....	1.60
Yolk of egg	52.00	16.00	.....	30.70	1.30
Lean beef	72.00	19.30	.....	3.60	5.10
Fat beef	51.00	14.80	.....	29.80	4.40
Lean mutton	72.00	18.30	.....	4.90	4.80
Fat mutton	53.00	12.40	.....	31.10	3.50
Veal	63.00	16.50	.....	15.80	4.70
Fat pork	39.00	9.80	.....	48.90	2.30
Green bacon	24.00	7.10	.....	66.80	2.10
Dried bacon	15.00	8.80	.....	73.30	2.99
Ox liver	74.00	18.90	.....	4.10	3.00
Tripe	68.00	13.20	.....	16.40	2.40
Cooked meat, roast, no dripping being lost (boiled, assumed to be the same)	54.00	27.60	.....	15.45	2.95
Poultry	74.00	8.80	.....	3.80	1.20
White fish	78.00	18.10	.....	2.90	1.90
Eels	75.00	9.90	.....	13.80	1.30
Salmon	77.00	16.10	.....	5.50	1.40
Average meat	65.56	17.51	.....	13.16	3.77
Fat meat	51.22	15.99	.....	28.22	1.57
Lean meat	74.44	19.77	.....	2.56	3.23
Average of fish	75.57	16.98	.....	6.20	1.25
Beef tea	95.79	3.28	.....	0.25	0.67
Butter	11.70	0.50	0.50	87.00	0.30
Bread	36.00	7.50	53.85	1.15	1.50
Wheat flour	12.46	14.66	67.62	1.93	3.33
Rye	13.97	14.27	66.91	2.25	2.60
Rye meal	15.00	8.00	73.20	2.00	1.80
Barley	13.80	12.96	67.18	2.76	3.10
Barley meal	15.00	6.30	74.20	2.40	2.00
Oatmeal	12.05	12.15	67.00	6.55	2.25
Corn	14.80	12.50	62.65	8.80	1.25
Indian corn meal	14.00	11.10	65.10	8.10	1.70
Millet	13.14	12.35	68.35	3.60	2.39
Rice	15.14	7.47	75.69	0.80	0.90
Potatoes	74.50	2.25	21.92	0.15	1.18
Lentils	12.51	24.81	58.36	1.85	2.47
Beans	11.75	24.31	58.03	2.54	3.37
Peas	14.03	23.00	57.80	1.86	2.41
Carrots	83.00	1.30	10.40	0.20	1.00
Parsnips	82.00	1.10	15.10	0.50	1.00
Turnips	91.00	1.20	7.20	0.00	0.60
Cabbage	91.00	2.00	5.80	0.50	0.70
Green vegetables	88.00	2.50	3.25	1.75	4.50
Alcohol(?)	0.75	....	99.25	...	..
Sugar	5.00	....	95.00	....	..
Treacle	23.00	.....	77.00	.	..
Arrowroot	18.00	....	82.00	.	.....
Beer and porter	91.00	0.10	8.70	.	0.20

In my experience, the exact amount of the three classes of food stuffs which have given the best results are as follows: Pure proteins, 150 grams; fats, 105 grams; glucose-forming elements, 135 grams. Total, 390 grams.

The above amounts, when fully oxidized within the body, yield 2,145.15 large calories, and this is accomplished with a saving of twenty per cent., in the oxygenating capacity of the normal system.

With this understanding of the percentage composition of the food stuffs, well illustrated in the comparative table of food stuffs, and knowing the daily requirements of the animal economy as to heat production and protein intake, our dietary is best classified, primarily, as purely vegetable or purely animal; neither one of which, as we have already seen, conforms absolutely to the requirements of chemico-physiology as understood to-day. The animal class, however, as already shown, comes very close to perfection—so much so, that it is the only supply during intrauterine life and also during the first few months of extrauterine existence. Owing, however, to deficiency of hemoglobin- and lecithin-yielding elements in all animal foods, some form of vegetable compound which contains a higher percentage composition in this respect must be added to the dietary just as soon as the digestive system has acquired sufficient strength to accomplish the more difficult task of digesting and assimilating foods derived from the vegetable kingdom.

Again, another radical difference between the two primary classes is encountered, one that is of vital importance in connection with the management of all forms of disturbance in metabolism and which should never be lost sight of in the study of the economies of diet. This is true also in a large measure in the more acute processes and even in perfect health. The vegetable class is so constructed in its synthetic formation that it is very difficult of digestion, while all animal substances are easy of digestion. The difference is so great that from sixteen to eighty per cent. of the vegetable foods pass through the alimentary canal undigested, while with the animal foods the loss ranges between two and nine per cent. From this fact alone, it is easy to understand the greater economic value of the animal as against the vegetable class. It shows also why eating too abundantly of animal food is followed by conditions of suboxidation, especially if there is lowering in the oxygenating capacity. At the same time, it has been proved conclusively that neither class is absolutely perfect in all respects for general use during the whole period of human life, that is, if the aim be to secure the highest results both mentally and physically. While it is true that some animals are so constructed that they can handle to better advantage vegetable foods than is the case with other species, it is not true that man can digest vegetable food more easily than animal food. Therefore, between these two extremes there will naturally be found two other forms of dietaries—one which deserves to be classified as a well-regulated or ideal mixed diet; the other, an imperfectly regulated diet, in which the vegetable and animal class are less perfectly adjusted. (See diet table.)

Porter's Dietary.

For an Absolutely Restricted Diet.—Buttermilk, skimmed milk, or (whole) milk, or some of the fermented milks (kumyss, zoolak, kefir, sumal). Beef tea, bouillon, and plain mutton, chicken, clam or oyster broth.

An Ideal Mixed Diet.—For Breakfast: Two eggs, eight ounces of milk, two ounces of wheat bread and butter.

For the Midday Meal: From one-quarter to one-half pound of beefsteak, eight ounces of milk, three ounces of wheat bread and butter.

For the Night Meal: From one-quarter to one-half pound of beefsteak, eight ounces of milk, two ounces of bread and butter.

At Bedtime: Eight ounces of milk.

Beefsteak is taken as the working standard among the meats, as it is the most easily digested of all the food stuffs. Under the heading of meat, is included lamb, mutton, occasionally veal; all kinds of fish, including the shell forms, such as oysters, clams, lobsters, and crabs; poultry and game of all kinds.

The meats to be broiled, boiled, or baked.

The fish to be boiled or baked.

The oysters and clams to be eaten raw or stewed; the lobsters, plain boiled.

A little crisp bacon may be taken from time to time, also ham and corned beef, *without cabbage.*

Eggs may be taken boiled, poached, or scrambled.

The milk is best taken warm or with a little lime-water added.

Wheat bread is taken as the standard because it is the most easily and perfectly digested. It should be eaten at least twenty-four hours old, or toasted; rye, Graham, zwieback, or the health foods may at times be substituted.

Weak coffee, without milk or sugar, or with a dash of milk, may be taken freely as a beverage. Coffee taken clear aids digestion, but with milk and sugar often disturbs digestion.

Additions to Enlarge the Above Diet.—In the line of vegetables: string beans, green peas, lima beans, spinach, lettuce, asparagus, and cauliflower. These are chosen because they are the least likely to excite intestinal fermentation of an abnormal character. They should be well cooked, and only one vegetable at a meal. When a vegetable is taken with the meal, there must be a reduction in the quantity of meat or milk as given in the above table. To the above may be added boiled rice and macaroni, and occasionally boiled beets, carrots, turnips, and squash.

The ideal mixed diet of the author is so adjusted that it contains the requisite percentage of the five classes supplied in the most easily digestible and assimilable form possible. It furnishes the requisite amount of heat production equally distributed between the hepatic and the pulmonary circuits to bring about a harmonious and automatic balance of action between innervation and inhibition in all parts of the body, thus producing perfect physiological action in this respect. It supplies the requisite amount of pure protein material for tissue construction and regeneration; it supplies the full amount of hemoglobin- and lecithin-yielding material, all of which is fully accomplished well within the oxygenating capacity of the system. This form of diet is best secured by a preponderance of the animal class and by keeping the vegetable class well in the minor quantity. The less perfect mixed diet is one in which the reverse is true. This latter form is often spoken of as a vegetarian diet, implying thereby that vegetables only are eaten; but a truly vegetable diet must exclude all animal foods, even in the process of cooking. In like manner, the animal diet must absolutely exclude all substances of a vegetable nature. It is the loose manner in which these terms are used that has led to so much error in the discussion of this very important subject, and hence many of the deductions have been erroneous.

From the foregoing, it is but just to argue that a well-regulated or ideal mixed diet must yield the highest grade of nutritive activity, both in connection with normal metabolism and its disturbances.

As the food which constitutes an ordinary meal is composed of many different substances derived from both the animal and the vegetable kingdoms, each and every meal is a highly complex mixture. From an advanced chemical and physiological standpoint, such a meal is usually far from being scientifically compounded. At the same time, it is evidently what

nature intended mankind to feed upon. When properly adjusted, however, it can be made, as above outlined, ideal.

Once within the intestinal canal, this complex mixture comes in contact with the various enzymes, catalytic bodies, or activating agents constantly poured into the lumen of the intestinal tract that cause this heterogenous mass which constitutes our food supply to undergo a multitude of successive chemical mutations, until finally it is resolved into the already mentioned five distinct classes—conditions in which they are easily and readily absorbed into the protoplasm of the epithelial cells lining the intestinal tract, namely, the inorganic substances—glucose, fats, proteins, and the hemoglobin- and lecithin-forming elements. From these cells they are being continually discharged into the enterohepatic blood-vessels or lymphatics on the opposing side, as illustrated in Fig. 3972.

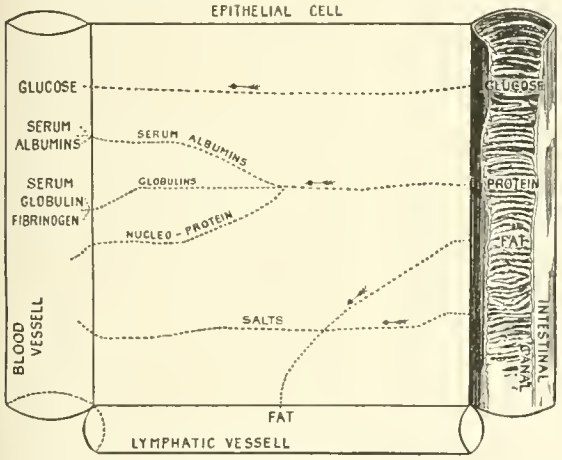


Fig. 3972.—Schematic Drawing of Highly Magnified Intestinal Epithelial Cell; open intestinal canal on one side, with glucose, protein, fat, and salts, passing from the lumen into the cell. Glucose passing through the cell to the blood stream. Protein splitting into three well-known types. Serum albumin splitting into three types. Globulins splitting into serum globulin and fibrinogen. Fats passing to lymphatics. Salts passing to the blood.

First, the purely inorganic substances, such as water and the various salts. In the lumen of the intestinal tract, in the biliary and urinary canals, these inorganic substances undergo various chemical changes. Within the body fluids and tissues, however, they act simply as solvents or mechanical irritants, and enter into the anabolic construction of the body, especially the bones and more solid parts, without chemical (change); hence, they pass out of the system in the same form in which they entered, having undergone no change in transit.

Second, starches and sugars, all of which are calculated as glucose, that being the molecular form which is generally supposed to be the state in which they are most commonly drawn into the protoplasm of the epithelial cells lining the lumen of the intestinal tract. From the protoplasmic mass of these cells they are discharged into the blood stream of the enterohepatic system of blood-vessels. Either within the protoplasm of the epithelial cells, or as the molecules drop into the blood, they undergo some isomeric transmutation, as only a small percentage of the sugar absorbed from the intestinal canal can be recovered, as such, from the blood. The amount found in the blood is always maintained at about the same point, no matter how much may be absorbed. What the activating agent is, or how and just when the transmutation occurs, is not so exactly known, but such seems to be the fact. By the enterohepatic blood stream the sugar ultimately reaches the liver, where, according to the old glycogenic theory, the sugar molecules are drawn into the hepatic cells and there a molecule of water (by a process of cleavage) is separated from the molecule, the sugar thereby being converted into glycogen, thus: $C_6H_{12}O_6 - H_2O = C_6H_{10}O_5$, or glycogen. (See Plate XLVII, cell (*b*1).) What produces this decomposition is somewhat problematic. It must be due to some enzyme, catalytic body, or activating agent. The glycogen so produced is supposed to be stored in the liver, as such, for use at a later time. One theory is that the glycogen, when needed, is passed on to the muscles, there to be finally oxidized into carbon dioxide and water, yielding the caloric force necessary to produce muscular contraction.

Another theory is that the glucose is directly decomposed and oxidized in the hepatic cells. Thus $C_6H_{12}O_6 - H_2O = C_6H_{10}O_5 + 12(O) = 6(CO_2) + (H_2O)$. (See Plate XLVII (*b*1).) The latter theory seems to be the more correct one, and is supported by the fact that once the glucose molecule commences to decompose it goes right on to complete oxidation. Losing, as it were, a molecule of water for a time, after which it is again picked up and joined to the partially decomposed molecule, is not considered good chemistry by some of our modern organic chemists.

Another reason for the belief that oxidation occurs primarily and directly in the hepatic cells, is the fact that the blood leaving the liver by the hepatic vein has a much higher temperature than at any other point in the circulatory system. This high blood temperature at this point cannot be accounted for by oxidation of protein compounds alone, for a portion only is oxidized in the hepatic cells, the larger portions of the protein being oxidized elsewhere, so that the calorie yield from this source alone must be small. The heat impulse generated in the liver can be conveyed by the centripetal nerves of the liver to the spinal centers and back by the centrifugal nerves to the muscles, possibly, just as well as from muscle to center and back in similar manner.

Whichever is the true process, or when and just how effected, the complete oxidation of one gram of sugar, estimated as glucose, requires 1.0666 gram of oxygen for its complete combustion, and each gram so consumed yields 4.1 large calories.

Third: Fats which are derived from both the animal and the vegetable kingdoms, are classed as pure heat producers. The percentage of fat is relatively large in the former and small in the latter.

The animal fats are easily emulsified, taken up by the epithelial cells lining the lumen of the intestinal tract, and discharged therefrom into the intestino-mesenteric lymphatic system. (See Fig. 3972.) From this point, the emulsified fat reaches the thoracic duct, and finally enters the blood stream at the junction of the left carotid and subclavian vein. From this point the fats pass directly into the pulmonary system by way of the left inominate and superior vena cava and right heart.

The fats originating in the vegetable kingdom appear to be less easily emulsified and taken up by the lymphatic system. They are more easily saponified and are apt to be laxative in nature.

The fats appear to be more easily and directly decomposed and oxidized than glucose. As a rule, the fat entirely disappears from the blood in its passage through the pulmonary circuit. In what manner its combustion in the lungs is effected has never been clearly elucidated. The heat thus generated is carried by the centripetal nerves to the cerebral portion of the nervous system. From there it is again reflected by the centrifugal nerves to the various organs and structures which are presided over or are innervated and inhibited by this part of the central nervous system.

Each gram of fat so oxidized requires 2.9023 grams of oxygen, and yields for each gram so consumed 9.3 large calories. A scientific adjustment of the fuel consumed in the lungs and liver, which may be con-

sidered as the two great furnaces of the body, will yield the most harmony in physiological action

Table II illustrates completely the oxidation of the starches, sugars, and fats, while Table III, illustrates the results of oxidizing the same components. By these tables, it will be seen that they are all readily converted into carbon dioxide and water, and are chiefly heat producers.

Table II.

Products of Oxidation of the CH.O Food Stuffs.

Starch	$C_6H_{10}O_5 + 12(O) = 6(CO_2) + 5(H_2O)$.
Sugar	$C_6H_{12}O_5 + 12(O) = 6(CO_2) + 6(H_2O)$.
Palmitin	$C_{51}H_{98}O_6 + 140(O) = 51(CO_2) + 44(H_2O)$.
Olin	$C_{57}H_{104}O_6 + 160(O) = 57(CO_2) + 52(H_2O)$.
Stearin	$C_{57}H_{110}O_6 + 163(O) = 57(CO_2) + 55(H_2O)$.

Table III.

Results of Oxidizing CHO Compounds.

Starches Sugars and Fats	yield to the body	Heat, energy and rotundity, and act as lubricating agents	and are excreted from the body as	carbon dioxide and water.

Fourth: The pure proteins are also derived from both the vegetable and the animal kingdoms. In the latter, the molecular structure is simple as compared with that found in the vegetable kingdom. In the vegetable kingdom it is many times multiple. As a result, the animal proteins are easily transmuted by the digestive ferments into albumoses and peptone. On the other hand, it is a much more difficult task to so transmute the proteins of the vegetable kingdom. Hence, as a general rule, the animal proteins are the more economic, requiring less digestive energy to make them available, and they are the ones which are always selected where the digestive forces have to be conserved, as occurs in disturbed metabolism.

The variation in digestibility already referred to has for its two extremes, beef at one end, aud oats or oatmeal at the other. Ninety-eight per cent. of beef can be digested and utilized, while only twenty per cent. of the protein contained in oatmeal can be transmuted by the digestive ferments, in its passage through the alimentary tract, into albumoses and peptone and utilized.

After the proteins from either kingdom are reduced to peptones in the alimentary canal, like glucose and fats, they are drawn into the protoplasm of the epithelial cells lining this canal. (Fig. 3972) It is further supposed that some of the cells have selective powers, so that some cells take up one kind of substances, while others take up different kinds of substances. However this may be, the different substances reach the blood stream and lymphatic channels through the activity of these cells. From the protoplasm of these cells lining the intestinal tract, the proteins, in the form of a peptone, are discharged into the enterohepatic blood stream. As a rule, however, they do not enter the blood as albumoses or peptone, for the blood normally contains neither of these substances, in fact, the latter is a highly toxic substance.

In view of these two facts—its ready absorbability and toxicity—nature provides, by some transmuting process in these cells—either by isomerism or by decomposition—oxidation reduction and resynthesis a process by which the peptone loses its identity. The protein represented by the easily absorbable peptone on the one side of the cell, appears on the other, as it drops into the blood stream, under several distinct forms recognized by all physiologists, certainly four if we include the hemoglobin- and lecithin-producers. In fact, there may be many more. One is already known to be composed of three distinct subdivisions. The three which are commonly mentioned, however, are: (1) serum albumins; (2) globulins; (3) nucleoprotein, or proteins.

Serum albumin is not a single substance, but is the one known to be composed of one or more closely allied albumins, three having been already isolated. In like manner, the globulins yield serum globulin and fibrinogen. (See Fig. 3972.)

Briefly stated, out of the proteins of the food, all the fluids, cells, and various structures of the body are in part constructed. Exception might here be taken to the urine, but it is not a structural part of the animal organism. The proteins, therefore, are, as it were, the foundation and essential part of all animal life. When in mechanical combination with a small percentage of water and a larger percentage of the salts, they constitute the harder or bony structures of the body; where the percentage of water is larger, with a diminution in the salts, they constitute the fluids and semi-solid portions of the body structure.

Regarding the exact method by which anabolism and the biotic processes of the animal economy are effected, there has been almost endless speculation, theorization, and experimental research work, to enter into the pros and cons of which is beyond the scope of this section. The process may be one of isomeric transmutation and mechanical multiplication of molecules, which are ultimately split into less complex substances; or it may be by a process of cleavage oxidation reduction, resynthesis of simple molecules into the more complex which constitute the various structures, with a final reduction into less complex substance.

Whatever the process, the important fact to be kept in mind is that the proteins are the essential factors; that the main function of animal life is to utilize those complex bodies and reduce them to simple forms; that it can be accomplished most easily and with the least strain upon the digestive and assimilative forces when the animal proteins are used.

The proteins, like the sugars and fats, have a heat-producing power, each gram requiring for its complete combustion 1.3786 grams of oxygen, and each gram so consumed yielding 4.1 large calories. Thus we find that the heat energy or caloric force for the maintenance of animal life is produced by all three of these essential compounds.

The most pronounced function of the protein substance, however, is to enter into the composition, construction, maintenance, and repair of all the fluids and structures of the animal economy. For this reason, in the study of metabolism and its disturbances, they must be considered chiefly as constructive elements, and for the maintenance of the nitrogen elements, or balance rather than for their caloric value. The amount required to maintain this daily balance is variously estimated, and must necessarily vary under varying conditions.

The following Table III gives the main catabolic elements containing nitrogen, the average amount excreted normally during the twenty-four hours, and Table IV indicates the route by which it leaves the body.

Table III.

Giving Substances	Elemental and Amount of Nitrogen in Each.	
35.00 grams of urea	contain	16.331 grams of nitrogen.
2.18 grams of urates	contain	0.642 grams of nitrogen.
0.80 grams of uric acid	contain	0.266 grams of nitrogen.
1.00 grams of kreatinin	contain	0.371 grams of nitrogen.
0.35 grams of hippuric acid	contain	0.024 grams of nitrogen.
73.12 grams of sodium taurocholate	contaio	2.098 grams of nitrogen.
18.28 grams of sodium glycocholate	contain	0.446 grams of nitrogen.
14.60 grams of bilirubin	contain	1.267 grams of nitrogen.
14.60 grams of biliverdin	contain	1.430 grams of nitrogen.
900.00 grams of perspiration	contain	0.330 grams of nitrogen.
0.02 grams of NH_3 in respiration	contain	0.016 grams of nitrogeo.
In desquamated epithelium, ferments, etc.		0 779 grams of nitrogen.
1059.95		24.000 grams of nitrogen.

Upon analyzing this table of composition a little more closely, it is clearly apparent that a large part of the nitrogen is excreted through the kidneys and a considerable amount through the liver, while the balance escapes through the desquamated epithelium, through the mucus secreted by the various mucous membranes, and in the unorganized ferments secreted by the various digestive organs. In this manner, the total amount of nitrogen—twenty-four grams—is eliminated daily from the system and is distributed as follows:

TABLE IV.

Illustrating Route by which Nitrogen is Eliminated.

Through the kidneys	17.634 grams or	73.475 per cent.
Through the liver	5.241 grams or	21.837 per cent.
By perspiration and respired air	0.346 grams or	1.441 per cent.
By other organs and membranes	0.779 grams or	3.245 per cent.
	24.000	99.998

To produce this amount of nitrogen in the excreta, it is absolutely necessary to take into the system through the food ingested not less than 150 grams of protein material daily. Not only must this amount be absorbed into the circulation, but it must also be utilized perfectly, if the animal economy is to be maintained at its full and normal working capacity.

Physiologists have long since demonstrated that, from bare subsistance to hard and forced labor it is necessary to vary the intake of protein material from 100 grams, as a minimum, up to 250 grams, as a maximum. At the same time the glucose and fat must also be largely augmented, in order to produce the full heat energy with which to utilize the proteins and produce the excessive amount of work. Owing to the fact that the starches and fats are more easily oxidized, the overuse of food to produce the excessive amount of work tends to decrease the perfection of oxidation of the protein elements. For this reason, when an unusually large amount of work is accomplished and a large amount of food consumed, there is always a decrease in the urea eliminated and a pronounced overproduction of uric acid—so much so that if this condition is unduly prolonged it must eventually result in a disturbance in metabolism, and finally give rise to easily perceptible pathological changes.

It has also been shown that simply increasing and decreasing the amount of proteins ingested—provided the amount is kept within the oxygenating capacity of the system—modifies the rise and fall of the nitrogen excreted from the animal economy more decidedly than does increasing or decreasing the muscular energy.

Bunge shows also, in his table of complete comparative analysis of the urine—which is the first and only one of its kind ever made—that a purely vegetable diet, as compared with a meat diet, yields an abnormally low nitrogen output. (See Table V.)

TABLE V.

Composition of Twenty-four Hours' Urine after a Diet of

	Meat	Bread
	c.c.	c.c.
Total amount	1672.000	1920.000
Urea	67.200	20.600
Uric acid	1.398	0.253
Kreatinin	2.163	0.961
K_2O	3.308	1.314
Na_2O	3.991	3.923
CaO	0.328	0.339
MgO	0.294	0.139
Cl	3.817	4.996
SO_3*	4.746	1.265
PO	3.437	1.658

* "The entire amount of sulphuric acid, including the conjugated, was determined. The urine was boiled with hydrochloric acid and chloride of barium."

The small amount of nitrogen excreted upon a vegetable diet is easily understood if we bear in mind the highly indigestible character of the vegetable foods as compared with animal foods. Therefore, it is more difficult to maintain the nitrogen balance upon a vegetable diet.

In Table V there is no mention of the urates, and it is clear that the so-called free and combined uric acid and urates were computed together—which is probably what is done in most of the analyses given.

Returning to the preceding statement relative to muscular exercise, it must be remembered that in most of the recorded observations in the past on this point, only the output of urea was computed, and the elimination of the uric acid ignored.

Later, observations along this same line have demonstrated conclusively that excessive work always tends to decrease the perfection of oxidation, lowers the output of urea, and raises that of the uric acid—so much so that for several hours, and in some instances, for days—after forced muscular exertion, the output of urea rises while that of uric acid steadily falls. Therefore, it is necessary to continue the observations and compute the quantity and relation of uric acid to urea for a sufficient time before, during, and after the expenditure of muscular energy, if anything like an accurate result is to be obtained regarding the rise or fall in nitrogen elimination.

Accurate determination of all nitrogen excreted must be made, not only in these two substances but in the kreatinin as well, if the actual output of nitrogen from muscular activity is to be accurately determined. When all this has been accomplished, we find that only 73.475 per cent. of the nitrogen excreted from the system daily has been secured.

In Tables VI and VII we have a schematic illustration of a few of the various possibilities and results of the oxidation of the protein substances that yield this 73.475 per cent. of nitrogen eliminated through the kidneys.

The balance of the excreted nitrogen cannot be secured and determined practically, as can that eliminated through the action of the kidneys. However, a careful study of the relative output of urea and uric acid, as represented in this 73.745 per cent. of nitrogen in the urine, enables us to interpret pretty accurately the metabolic processes of the animal economy. This is especially true if the estimates are made day after day over a considerable period of time.

With this clear understanding of the form in which the foods are introduced into the system, and the known excretory products, we are in a position to speculate with considerable accuracy as to how and when these oxidation reductions occur.

At one time, they were supposed to take place in the blood and fluids of the body. This theory has long since been abandoned, with the introduction of the cellular theory, and the fact that a very small percentage of any of the catabolins are ever found in the blood, these chemical transmutations were transferred to the protoplasm of the cellular structures. Some are inclined to place it largely in the muscular structures, while others place it almost exclusively in the cells of the secretory and excretory glands. The latter seems to accord more accurately with the known facts.

The excretory products are always abundant on what may be called the outside of the glands, or in the ducts leading therefrom, that is when speaking of the glands having ducts, while those products are found in very limited amounts only on the opposite or internal side, or that in direct contact with the blood-vessels, or in the blood. Some are not found there at all under normal conditions. Therefore, it seems more logical to assume that the proteins are transmuted in the cells into the various enzymes that go to make up the various digestive ferments, thus becoming both secretory and excretory products—secretory, in the fact that they have physiological functions to perform after leaving the cell structures; excretory, in the fact that they carry nitrogen out of the body.

The same holds true for the pure catabolins, for

they are found abundantly on the outside, or duct side, of the cell, and in very minute quantities, if at all, upon the opposite side or in the blood. The leucomain product out of which the catabolins are produced must be contained in the blood, but not necessarily the finished excretory product.

Having gained considerable knowledge, as already outlined, regarding the general utility ofthe food products, for a more complete understanding of metabolism and its disturbances, it is essential to have a more exact conception of the possible oxidation reduction and the final products resulting therefrom. This is especially so as regards the proteins, in which the process is most complex and the products quite abundant, as compared with fat and carbohydrate reduction.

It is a well-known fact that all protein bodies contain an element of sulphur. It is also generally conceded that in the catabolism of the albuminoid substances the sulphur is joined to oxygen and hydrogen to form an antecedent of sulphuric acid, and that it finally appears in the excretions as a sulphate, increasing the amount of these salts above the quantity which is taken in daily with the food. But when and how this catabolic transformation occurs, has not heretofore been stated. Theoretically, therefore, we are justified in the assumption that sulphuric acid is formed out of the protein metabolism.

The researches of Troschel,[1] Johannus Müller, and Boedecker are of inestimable value. For Troschel and Müller have shown conclusively that in a whole series of lower animals the commencement of the alimentary canal actually forms or secretes a large quantity of sulphuric acid, thus establishing the law that organic animal life can produce out of the metabolism of the protein substances sulphuric acid.

These observations and results have also been corroberated by Panceri and De Lucca.[2] Brücke[3] has proved by his experiments that the acid comes into existence as a definite and known compound at or upon the free surface of the gastric epithelium.

Taking all this data together, it seems not only reasonable but highly probable that one of the selective functions of some of the gastric epithelial cells is to form, out of the process of protein metabolism, the catabolin sulphuric acid. It certainly is just as reasonable as it is to assume the selective production of the protein substance, pepsin, and the milk ferment, rennin.[4]

Thus, by the action of this sulphuric acid upon the sodium chloride, we have the hydrochloric acid and sodium sulphate formed: $H_2SO_4 + 2(NaCl) = Na_2SO_4 + 2(HCl)$.

The hydrochloric acid thus formed, after having served its purpose as the acid essential to gastric digestion, passes on into the intestines and there comes in contact with the normal sodium phosphate, forming a hydro-disodium phosphate, and *re-forming* the previously decomposed sodium chloride. Thus $2(HCl) + (2Na_3PO_4) = (2Na_2HPO_4) + (2NaCl)$.

Taking this view of the modus operandi of the formation of the hydrochloric acid, a logical explanation of the disappearance of the sulphur contained in the protein molecule is given. It is also the most logical explanation given for the formation of hydrochloric acid, and explains clearly how the sodium chloride balance is maintained, and the output of sulphates made greater than the intake.

The remaining portion of the protein molecule probably passes back into the blood stream as a leucomaine product which finally reaches the renal glands to form a part of the urea, creatinin and uric acid found in the urine.

Still other portions of the protein substances not transformed in the gastric cells reach the hepatic gland. Here the question naturally raised is: What changes may occur in the protein molecule in connection with the hepatic cells? It certainly undergoes a much more complex transmutation than occurs in connection with the glucose or glycogen-like molecule, yet both yield heat

TABLE VI.

Possible Products of Oxidation of the Proteins or "C H N O S" Compounds Effected Through the Kidneys.

Oxidation.	Protein.	Oxygen use.	Urea.	Uric acid.	Kreatinin.	Oxalic acid.	Lactic acid.	Glucose.	Hippuric acid	Carbon dioxide.	Water.	Sulphuric acid. *
Highest	$C_{72}H_{112}$	154(O) =	$9(CH_4N_2O)$							$+63(CO_2)$	$+37(H_2O)$	$+(H_2SO_4)$
Super	N_{18}	151(O) =	$7(CH_4N_2O)$	$+(C_5H_4N_4O_3)$						$+60(CO_2)$	$+39(H_2O)$	$+(H_2SO_4)$
Normal	$O_{22}S$	139(O) =	$4(CH_4N_2O)$	$+(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$					$+55(CO_2)$	$+38(H_2O)$	$+(H_2SO_4)$
Uric acid		136(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$					$+52(CO_2)$	$+40(H_2O)$	$+(H_2SO_4)$
Oxalic acid		129(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$	$+7(C_2H_2O_4)$				$+38(CO_2)$	$+33(H_2O)$	$+(H_2SO_4)$
Lactic acid		94(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$		$+7(C_3H_6O_3)$			$+31(CO_2)$	$+19(H_2O)$	$+(H_2SO_4)$
Diabetes		76(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$			$+5(C_6H_{12}O_6)$		$+22(CO_2)$	$+10(H_2O)$	$+(H_2SO_4)$
Hippuric acid.		67(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$				$+4(C_9N_9NO_2)$	$+21(CO_2)$	$+24(H_2O)$	$+(H_2SO_4)$

* Appears in the urine as a sulphate.

TABLE VII.

Showing Position of Uric Acid in the Scheme of Suboxidation.

Oxidation.	Protein.	Oxyg. used.	Urea.	Uric acid.	Kreatinin.	Xanthin.	Hypoxanthin.	Carbon dioxide.	Water.	Sulphuric acid. *
Normal	$C_{72}H_{112}$	139(O) =	$4(CH_4N_2O)$	$+(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$			$+55(CO_2)$	$+38(H_2O)$	$+(H_2SO_4)$
Uric acid	N_{18}	136(O) =	$2(CH_4N_2O)$	$+2(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$			$+52(CO_2)$	$+40(H_2O)$	$+(H_2SO_4)$
Xanthin	$O_{22}S$	135(O) =	$2(CH_4N_2O)$	$+(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$	$+(C_5H_4N_4O_2)$		$+52(CO_2)$	$+40(H_2O)$	$+(H_2SO_4)$
Hypoxanthin		134(O) =	$2(CH_4N_2O)$	$+(C_5H_4N_4O_3)$	$+2(C_4H_7N_3O)$		$+(C_5H_4N_4O)$	$+52(CO_2)$	$+40(H_2O)$	$+(H_2SO_4)$

* Appears in the urine as a sulphate.

and energy. But out of the protein substances, in their passage through the liver, there must be produced normally the bile acids and pigments, and possibly some if not all of the glycogen.

In Tables III and IV are given the principal catabolic products of normal metabolism, also the paths by which they escape from the body.

To produce the bile acids, pigments, etc., as found in the bile, the protein substances must undergo oxidation reduction. The proteins and the oxygen must reach the cells from the portal blood adjacent to the hepatic cells. Within these cells, some of which have the special function of effecting certain reductions, the various catabolins found in the secretions and excretions are produced.

With each form of transmutation a given quantity of oxygen is required, and a certain amount of heat produced for each gram so transmuted.

In Plate XLVII are shown a few hepatic cells of the acinus very highly magnified, and in which are found chemical equations representing some of the normal oxidation reduction processes. It graphically illustrates how and where these reductions are effected. It shows also that the protein bodies can be split up in various manners with similar end products resulting therefrom.

Certain of these mutations are what occur when the system is working normally, while, when less perfectly formed, they represent disturbances in metabolism.

In cell (*b*1) for instance, we find the glucose-like molecule losing by cleavage one of water with the formation of glycogen, in accord with the older glycogenic theory as applied to the liver, or it may be completely oxidized as noted.

In cell (*b*2) we find the protein element splitting into taurocholic acid, bilirubin, a leucomaine product, carbon dioxide, and water. In this instance the sulphur atom of the protein is eliminated in the taurocholic acid, which acid usually appears in the bile, under normal conditions, as a soda salt of this acid.

In cell (*b*3) we find the protein body splitting into glycocholic acid, biliverdine, a leucomaine product, carbon dioxide, and water. In this instance the sulphur atom has to be eliminated, theoretically as sulphuric acid, the acid, however, joining with soda to form a sulphate which is the form in which it is found in the secretions and excretions.

The glycocholic acid under normal circumstances appears in the bile as a soda salt of this acid.

In cell (*b*4) we find the protein body splitting into bilirubin, biliverdin, taurocholic and glycocholic acid, a leucomaine product, carbon dioxide, and water. In this instance the sulphur atom as in cell (*b*2) is eliminated in the taurocholic acid, and there is no resulting sulphate.

In cell (*b*5) we find illustrated what may be called the new glycogenic theory. Here we find the protein body splitting up into a leucomaine product, glycogen, carbon dioxide, water, and sulphuric acid ultimately eliminated as a sulphate.

In cell (*b*6) we have illustrated what may be called the new glucose or diabetic theory. Here we find the protein body splitting into a leucomaine product, a glucose element, carbon dioxide, water, and the theoretic sulphuric acid. In both these instances the sulphur atom is accounted for as in (*b*3), and as in the formation of the gastric acids.

Thus we find this schematic drawing will illustrate the formation of both glycogen and glucose-like element, out of the protein substances; the former representing a normal process, while the latter is probably an abnormal one. It shows how the constituents of the bile are formed. As some of these substances are essential to a perfect digestion, these products found in the bile are both secretory and excretory. It is not until the bile has served its full purpose in the digestive act that its constituents can be classed as excretory.

The presumption is that the leucomaine products normally pass into the lymphatic or hepatic blood channels, and finally reach the renal cells, from which they are discharged into the lumen of the uriniferous tubules as urea, creatinin, and uric acid, as illustrated in Fig. 3973, thus accounting for the urea of hepatic origin; coming from the liver, however, as a leucomaine product rather than fully formed urea, uric acid, etc.

As only 21.8 per cent. of the nitrogen is eliminated from the system by these chemical mutations in the hepatic cells, while 73.4 per cent. escape through the kidneys, it seems like a very small amount of work to be accomplished by so large a glandular organ.

The presumption, however, is that this large organ and its multitude of cells is very largely concerned in partially transmuting the food elements, so that they become more available for nutritive purposes and are made more easily reducible when they have served

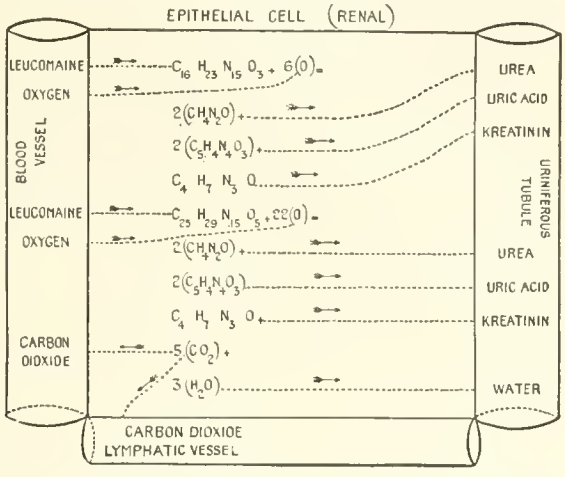


Fig. 3973.—Enlarged Renal Epithelial Cell. Showing leucomaine products and oxygen passing from the blood stream into the protoplasm of the cell to be split into urea, creatinin, uric acid, carbon dioxide, and water. The urea, creatinin, uric acid, and water passing out of the cell into the lumen of the uriniferous tubule. The carbon dioxide and water passing back from the cell into the blood and lymph stream.

their purpose throughout the body and reach the kidneys for final oxidation reduction and elimination.

We know that peptone is transmuted by the action of the liver cells from a toxic to a non-toxic condition. In like manner many other toxic substances are so transmuted. We take advantage of this fact in the management of metabolism and its disturbances when we administer toxic medicinal substances—substances which when they reach the hepatic cells are taken up by the protoplasm and excreted with the bile, thus protecting the system in general from their toxic effect, yet at the same time stimulating sluggish and inactive protoplasms into increased activity. By the intelligent application of these principles much can be accomplished in the management of all forms of metabolic disturbances.

Viewed in this light, we find the hepatic gland one of the most important in the animal economy; one that cannot be neglected if we hope to fully succeed in the management of disturbances in metabolism.

Although the amount of nitrogen eliminated by the liver is small, the metabolic work it accomplishes is unquestionably very large.

The leucomaine products resulting from the incomplete reduction of the protein molecule in the gastric and hepatic cells, finally reach the renal cells and are there eliminated as urea, creatinin and uric acid (see Fig. 3973). If oxidation were more perfect, urea alone might be the only end product. The more nearly normal the process the larger the quantity of area.

The remaining untransformed protein bodies ultimately reach the renal cells to be eliminated as urea, creatinin, uric acid, carbon dioxide, water, and a sulphate. This is well illustrated in Fig. 3974.

Uric acid, like urea and creatinin, is one of the normal products of protein metabolism. It is absolutely essential to a perfect physiological state, as expressed in the animal economy of the human species. It is known to all students of chemicophysiology that uric acid acts upon the neutral phosphate of soda, with the formation of a urate and an acid phosphate—thus $C_5H_4N_4O_3 + Na_2H(PO_4) = C_5H_3N_4O_3Na + NaH_2(PO_4)$. Coupled with this fact it has been proved that the acid phosphate is the normal and essential acid of the urine. It therefore becomes necessary to produce some acid which will transform the neutral phosphate of the blood into the acid form in the urine. Thus we find by the observed laws of nature that uric acid in the human species is the only one produced for this purpose under normal conditions. Hence, uric acid should be classed primarily as a secretory product and an essential constituent of the urine as it is first found in the lumen of the uriniferous tubules, but which under normal conditions becomes a urate, with the formation of the acid phosphate, before the urine escapes from the uriniferous tubules, the urate alone being the true and final excretory end product in the urine as it is expelled from the bladder. See Fig. 3974, which illustrates how, technically speaking, the fluid contained in the lumen of the uriniferous tubules always contains—for an instant, at least—free uric acid, while that found in the ureters and bladder does not. Therefore, the statement that urine does not contain free uric acid normally, is correct.

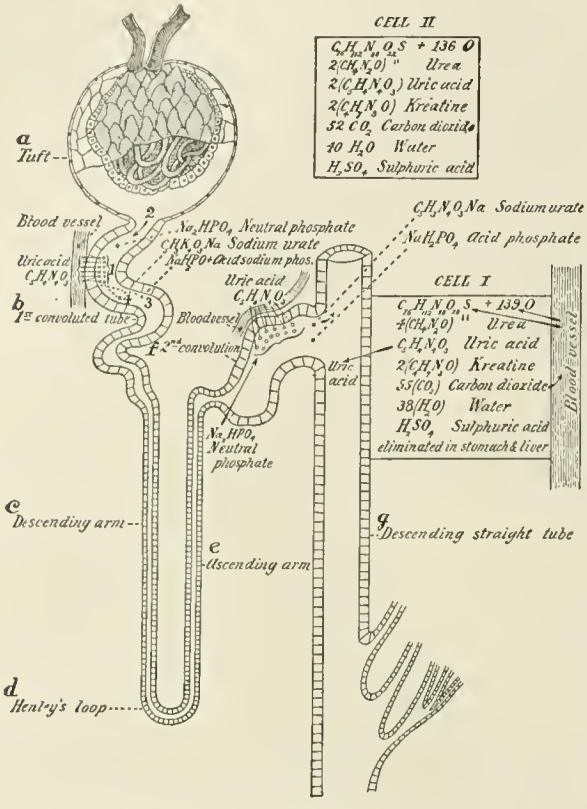


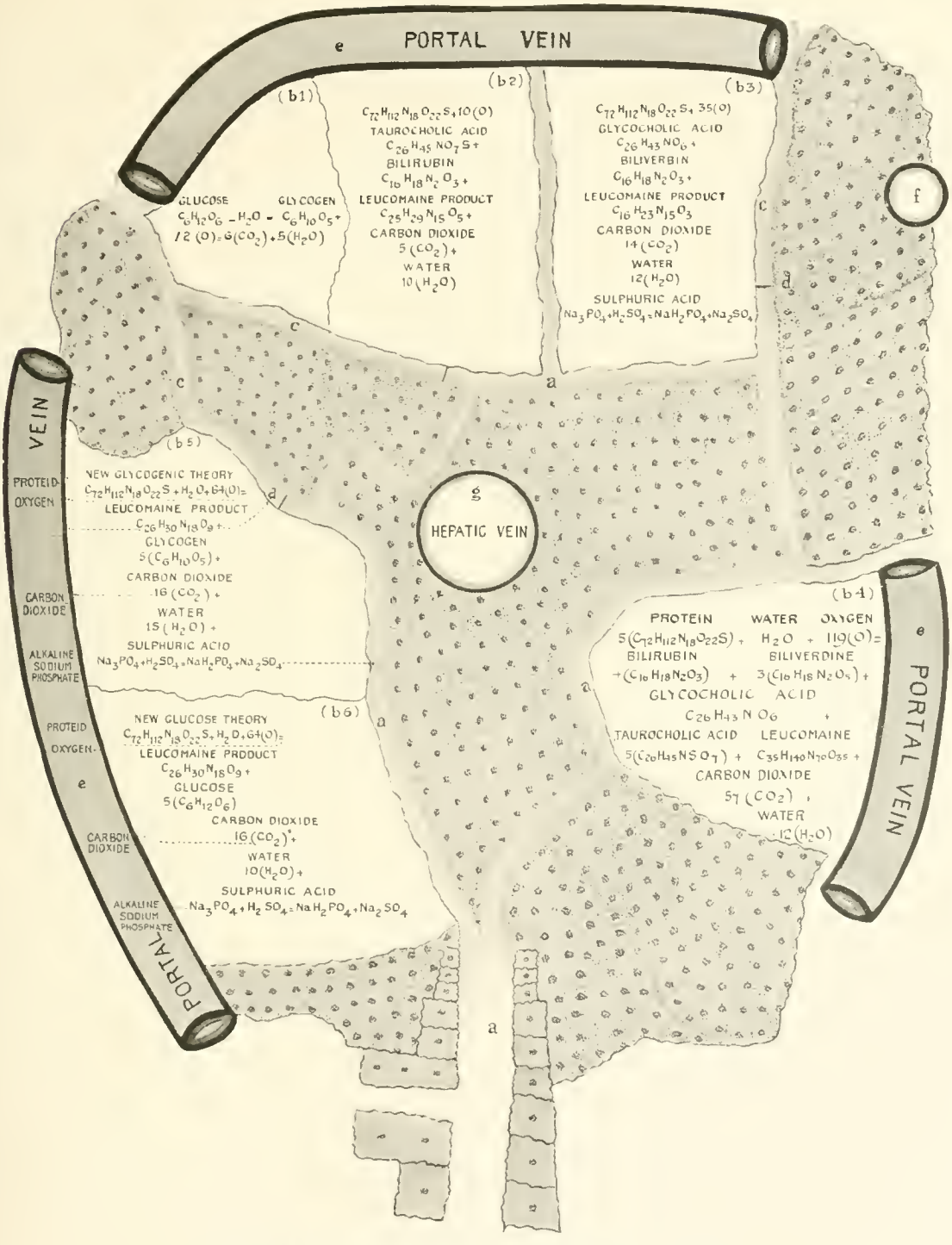
Fig. 3974.—Schematic Drawing Showing Single Uriniferous Tubule from Malpighian Tuft to Papilla or Its Outlet. *a*, Malpighian tuft and blood-vessels; *b*, first convolution; *c*, descending arm of loop; *d*, Henle's loop; *e*, ascending arm of loop; *f*, second convolution; *g*, straight or collecting tube. 1. Uric acid molecule dropping into lumen of tube. 2. Neutral phosphate of soda molecule as it unites with the uric acid to form. 3. The acid phosphate of soda. 4. The urate of soda formed by this chemical mutation. Cell I. Magnified single renal cell, with lumen of the tube on one side and the blood vessel on the opposite side, illustrating normal oxidation of protein molecule within the protoplasm of the cell. The protein and oxygen coming from the blood into the cell, where it breaks up into its reduction products. The uric acid dropping into the lumen of the tube, while the carbon dioxide flows back into the blood. All the other reduction products dropping into the tube as does the uric acid. The sulphur being eliminated as a sulphate. Cell II. Magnified cell illustrating abnormal or suboxidation in the renal cell. Urea diminished one half while the uric acid is overproduced fifty per cent. In both the normal and abnormal oxidation the sulphur is found in the urine as a sulphate.

Accordingly, we are fully justified in asserting that uric acid, pure and simple, is an essential secretory product of the renal cells, but only a true and excretory end product when united to soda or some other alkali to form a urate. The soda salt being the normal alkali of the body, it is the most common and abundant urate found in the urine. Why it is a fact that when the system is working with its normal perfection and precision, only such an amount of uric acid is produced as is required to transform the requisite amount of the phosphate and other alkalies, is hard to fully explain, but such is the observed law of nature.

Regarding the point at which uric acid is produced, there is no end of theoretic speculation and experimental research work recorded, much of which seems to lose sight of the well-known chemicophysiological laws and disregards absolutely some of the simplest laws of chemistry, one of which is the putting of this strong uric acid molecule and carbonate of soda compound in the same fluid menstruum, the blood. Two such bodies, one strongly acid and the other strongly alkaline, according to all the known laws of chemistry, must, under such conditions, unite to form a salt or urate of soda. But all chemists and all physiologists declare that a urate has never been found in the blood. Therefore we are justified in making the assertion that red meat (or any other kind of meat) does not contain uric acid. Assuming even that it does, the chemical transmutations going on continually in the lumen of the intestinal canal, which contains many alkaline substances, would speedily convert the uric acid into a urate. All this being true, the weight of evidence substantiates the fact that uric acid cannot exist under its own form, normally, in the blood or tissues of the body. This being the case, it seems absurd to argue that uric acid is made in some distant portion of the body, as the spleen, liver, etc., far away from the renal glands, and that from these remote points the uric acid is in some mysterious and unknown manner, and in defiance of all chemical laws, carried from these distant parts of the body to the renal glands.

That the antecedents of uric acid exist in the blood, no one can deny. The form in which they exist in the blood, however, is that of a protein compound, or leucomaine product which, when isomerically transformed and released by a process of oxidation in the renal cells, results in the production, under normal conditions, of the requisite amount of uric acid and prevents an overproduction of this acid. Under these conditions the antecedent substance is one which has no perceptible irritating or toxic properties. Thus we find that under normal conditions uric acid is a simple oxidation reduction product of protein metabolism. (See Tables VI and VII.)

It has already been shown that uric acid is primarily a secretory product, so far as its function is concerned —the same as ptyalin, pepsin, and the enzymes of the pancreatic and intestinal glands are secretory, so far as their functions are concerned, yet they are all excretory in this fact, that they all carry waste nitrogen out of the animal economy. Hence, it should be borne in mind that if we reason by analogy alone and observe the common laws of nature, we find that all secretory substances are formed by a process of isomeric trans-



SCHEMATIC DRAWING OF NORMAL LIVER

Highly Magnified, Reduced by ⅓

a. Lumen of bile ducts and radicles. b 1 to b 6. Hepatic cells, very highly magnified, illustrating within them chemical transmutations. e. Lumen of lymphatic channels. d. Basement substance between bile radicles and lymphatic spaces. e. Blood-vessels of the portal system. f. Hepatic artery. g. Hepatic vein.

mutation or oxidation reduction in the protoplasm of the cells of the gland or glands closely adjacent to the point at which these secretory substances are said to perform their functions. Therefore, uric acid is made by the same laws of nature—by isomeric transmutation and oxidation—in the epithelial cells of the uriniferous tubules which are closely adjacent to the point at which it is to perform its further function, before it becomes a fully formed excretory product in the form of a urate.

At this point of formation in the renal cells the uric acid molecule is dropped from the cell into the lumen of the tubules, there to unite with the neutral sodium phosphate or other alkalies, chiefly the former, contained in the fluid portion of the urine as it flows down the lumen of the tubules from the Malpighian tufts. (See Fig. 3974.) This, then, is the point and the manner at or in which uric acid is produced when the animal economy is working normally.

All this has been accomplished along lines of well-known and definite chemical laws, and without bringing in any mythical and unexplained phenomena.

The reason for laying so much stress upon uric acid is the fact that the determination of its overproduction is one of the most important factors in the study of disturbances in protein metabolism, as will be shown later.

When all these mutations are effected in a uniform and orderly fashion, with only normal end products as the result both as regards kind and quantity, we have a perfect metabolism. No abnormal symptoms are present, and the individual is normal and well. When for any reason there is a disturbance in these uniform and regular processes, then we have the conditions commonly classed as disturbances in metabolism. Then we have no end to the variety and intensity of the abnormal symptoms that may be presented. The variety and kinds of end products are unquestionably numberless, some of which are only slightly toxic in their nature, while others may be intensely poisonous; so much so that death may ensue from a disturbance in metabolism without any major or gross pathological lesion being present.

At this point, a word relative to the ductless glands may not be amiss.

While we have no absolutely accurate knowledge as to the exact chemical composition of the internal secretions, or how they are produced, it is highly probable that the same laws that govern the protein secretions of the protoplasm of the cells constituting the glands having ducts control the transmutations which take place in the cells of the ductless glands. It also seems highly probable that it consists in some form of isomeric transmutation of the protein elements as they pass from the blood stream to the cells, from which cells they are again discharged into the lymphatic or blood stream, but are still protein in nature. Whatever the exact composition of the internal secretions is, it is absolutely essential to maintain a perfect metabolism. Whenever for any reason these ductless glands fail to perform fully their function, metabolism becomes more or less disturbed. These abnormal changes must never be of sufficient magnitude to cause perceptible macroscopic lesions in the bioplasm constituting the protoplasm of the various cells, organs and tissues of the body, for if they are, the domain of well-defined pathology is entered. These minor deviations in metabolism, which are in all instances the precursors of well-marked lesions, are best determined by a quantitative study of the intake and output from the system of the nitrogen and carbon supplied in the food.

For practical clinical purposes, however, this study is confined largely to the estimation of the nitrogen in the urea, and of the many excretory by-products of which nitrogen forms an atomic part. Up to the present time this has been necessary because simple and practical methods for estimating quantitatively the elimination of carbon contained in the excretions have not as yet been devised. On the other hand, if the results of metabolism are to be determined absolutely and with scientific accuracy, perfect quantitative analysis must be made of all food ingested and of all the nitrogen and carbon eliminated in the excreta. Failure to attain even approximate accuracy in these two directions is the essential reason for most of the errors that have crept into the clinical deductions in connection with this important subject. Many of these errors, however, can be eliminated by a careful application of the very accurate estimates and tables relative to the composition and digestibility of the food stuffs that have been marked out by Konig[6], Rubner[6], Atwater[7], and others.

By a careful study of the chemical composition of the food elements, the oxygen used, the perfection or imperfection of the excretory products, and especially as regards the production of uric acid and its relation to urea, some very practical clinical results can be determined.

Disturbances of Metabolism.—Beginning with the digestive organs of the alimentary canal, the chief disturbance in their metabolism is indicated by diminution or by complete arrest of their secretory activity. So far as we know, the chemical composition of the unorganized ferment bodies is not changed. In connection with the salivary glands, there is a diminution in the secretion of ptyalin, or its elimination may be completely arrested. Its absence or its decreased elimination indicates that the bioplasm constituting the epithelial cells of the salivary glands, fails to take up the protein constituents from the blood and isomerically transmute them into ptyalin, to this extent interfering with perfect digestion, and later with general metabolism.

In the stomach, similar disturbances are met with, but they are more complicated in character because the gastric mucous membrane has for its function the production, out of the proteins taken up from the blood, of hydrochloric acid, rennin, and pepsin. The acid being formed as we have already seen by oxidation reduction of the protein bodies in certain cells of the gastric mucous membrane, first with the formation of sulphuric acid, which splits the sodium chloride with the formation of the hydrochloric acid and a sulphate. This being true, hyperacidity is indicative of superoxidation reduction of the protein elements in these cells, while a decreased acidity is indicative of an opposite condition, or decreased oxidation reduction of the protein substances. Hence they must be treated accordingly—not simply as increased or decreased secretory processes as is the case with the unorganized ferments, but as true disturbances in the oxidation process of the body. Hence a disturbance in the metabolism of the epithelial cells peculiar to this organ will result in a change in the amount of hydrochloric acid produced, and a decrease in the rennin and pepsin. Only one of the three may be changed, the acid alone may be increased or decreased. Increase and decrease within certain limits is perfectly normal. Beyond a certain point in either direction it becomes a disturbance in metabolism, and must be corrected. The rennin alone may be decreased or arrested; the same may be true of the pepsin alone. All may be decreased or arrested, or the acid may be increased and the unorganized ferments decreased or arrested.

It is clear, therefore, that in this manner there will be produced varying disturbances in metabolism in the metabolic action of the cells of the gastric tubules, disturbances which will cause varying degrees of disturbance in the gastric digestion, and act as another source of general malnutrition and metabolic disturbance.

What has been said regarding the changes in the secretion of the unorganized ferments, of the salivary organs and of the glands of the stomach, applies with

equal force to the secretions of the pancreatic gland. Here, however, owing to the more complex function of the gland so far as its secretion is concerned, disturbance in its metabolism is more varied in character and disastrous in its results. Here, as in connection with other glands having varied functions, it must be assumed that certain cells have varied functions, some producing one ferment, others another kind, and so on until the complete work of the gland is accomplished. There may be a dimunition or an arrest in the secretion of the amylopsin, trypsin or steapsin. One or all may be involved, thus indicating varying degrees and kinds of metabolic disturbances in the bioplasm of the cells. The milk curdling ferment of the pancreatic secretion which coagulates milk, converting caseinogen in presence of calcium salts into casein, may be defective or absent, and this indicates still another type of disturbance. For each enzyme is specific in its action; each enzyme acts only on one class of material, and acts in such a manner that it produces certain specific substances as the result of its action. Thus is explained the great variety of metabolic disturbances, and the difficulty oftentimes to locate exactly the causative factors. This is especially true in connection with infant feeding.

The same may be said of the glands and follicles contained in the mucous membranes of the intestinal wall, the secretions of which are equally essential to a perfect digestion as are those of the larger glands. Perhaps playing a smaller part in the digestive act, diminution or arrest of these secretions points to a disturbance in the metabolic function of the bioplasm constituting the cells that enter into their formation.

Although all these digestive secretions are extrinsic in their actions, they are very largely responsible for the intrinsic biotic processes.

While it is impossible from a practical standpoint to secure directly the secretions of the pancreatic gland and that of the different intestinal glands for analysis in the human subject, indirectly we are readily made aware of a decrease or arrest in the output of the various enzymes contained in these secretions by an imperfect digestion of the food stuffs, or by a putrefactive instead of the normal fermentation of the starches, sugars, fats, and proteins contained in our complex meals.

The decrease or arrest in the hepatic secretion must also be taken into account in the study of disturbed metabolism, when analyzed from the digestive viewpoint. While the bile is not generally considered as important a digestive fluid as some of the other glandular secretions that are poured into the alimentary canal, it must be given a more prominent position than has been done in the elucidation of disturbed metabolism. The bile, as we have already learned, must be considered first as one of the essential digestive secretions; and secondarily as an excretion, in that it eliminates a portion of the utilized carbon and nitrogen from the system.

Transmutation of the food products in the alimentary canal is in a certain sense an extrinsic process, and is usually excluded from the discussion of "metabolism;" but, as Schaefer says, in his admirable article on metabolism—"There is no special reason . . . . why this should be the case, for the digestive changes in the food must, like all other chemical changes occurring within the body, influence the general conditions of the economy." It is just this fact that they do influence the transmutations, both under normal and abnormal conditions, which technically are more directly within the body, as already outlined, which makes it so essential to give prominence to the changes in the food stuffs in the intestinal tract. This is especially true in reference to the putrefactive changes in the protein constituents of the food, resulting from abnormal fermentation of these substances in consequence of defective formation or arrest of secretion of the enzymes necessary for a perfectly normal transmutation. To overcome this defect in enzyme formation is the chief problem in the management of disturbed metabolism.

So far as can be determined, the *Bacillus putrificus*, and to a certain extent, *Bacillus coli communis*, which are always present in the alimentary tract, are the chief bacterial agents responsible for the putrefactive transformations of the protein elements under these circumstances—that is, assuming that the detrimental action of the bacteria of putrefaction is ordinarily held in abeyance by the digestive secretions and their active constituents when they are normally produced, both as regards quantity and quality.

This inhibitory action and loss of inhibitory power exerted by the digestive secretions over the bacteria of putrefaction, is the essential factor to be considered in connection with the chemistry and therapeutics of this most intricate chemical problem, commonly discussed under the term indicanuria and its relation to disturbances in metabolism. It is also by acquiring a clear conception of these processes taking place in the alimentary canal, both as regards cause and effect, that our therapeutic management of these very common conditions is to be placed upon a truly scientific foundation.

When the inhibiting power of the digestive secretion is removed from these bacteria of putrefaction, the protein elements are at once attacked by the bacteria, in direct proportion to the loss of inhibition upon the *Bacillus putrificus* and *B. coli communis*. Under these circumstances the protein molecules are broken up, with the formation primarily, of indol, sulphurous acid, and a by-product. This change is graphically illustrated by the following equation: when the two protein molecules, $2(C_{12}H_{112}N_{18}O_{23}S)$, are split up by the action of the bacillus coli communis, three less complex substances are produced, or $2(C_8H_7N) + 2(H_2SO_3) + 2(C_{64}H_{103}N_{17}O_{22})$. The unsatisfied and active sulphurous acid thus produced, causes still further chemical activity, so much so that the indol, sulphurous acid, and a potassium salt during intermediary transmutation, are combined into a single and more complex molecular formation; thus we have formed the immediate forerunner of the oxidation product known as indigo blue. This newly formed and more complex molecule is known as indoxyl potassium sulphate. The method of its formation is fully expressed in the following chemical equation, or the indol, plus sulphurous acid, plus alkaline phosphate of potassium, plus oxygen results in the formation of the indoxyl, neutral phosphate of potassium in place of the alkaline form, and water. Thus $C_8H_7N + H_2SO_3 + (K_3PO_4 + 2(O) = C_8H_6NKSO_4 + K_2HPO_4 + H_2O$.

The indoxyl potassium sulphate, by virtue of the contained atom of potassium is classed as an inorganic compound, and consequently obeys the law common to all of that class of substances in connection with their transit through the animal economy. This law, briefly stated, is that all inorganic substances and compounds pass in and out of the body unchanged; that is, they act solely by virtue of their mechanical presence, often being inert, as it were, acting simply as solvents or by catalysis. In other instances, they have irritating properties, by virtue of which they excite dormant and sluggish protoplasmic masses into increased activity, thus stimulating nature to utilize to better advantage the nutritive pabulum, and thereby change an abnormal or pathological condition in the minute chemical structures of the body to one that is normal or physiological.

So far as has been determined, the indoxyl potassium sulphate is not toxic or irritating, and therefore has no detrimental effect, *per se*, upon the animal economy, in its transit through the body from the intestinal tract to the urine. When the indoxyl potassium sulphate is reduced in the voided urine by the action of oxidizing agents, indigo blue is formed, and it is positive evidence that the protein elements are undergoing putrefactive fermentation in the intestinal tract,

while they are in transit through the alimentary canal. The change in the indoxyl potassium sulphate as the result of its oxidation under the influence of hydrochloric acid and potassium permanganate, is expressed fully by the following chemical equation: $C_8H_6NKSO_4 + HCl + 2(KMnO_4) + H_2O = C_8H_5NO + HCl + HKSO_4 + 2(HKMnO_4)$.

This test (Fig. 3975) is one of great value in the study of disturbed metabolism. By it we can determine if the alimentary canal is free from all putrefactive changes, which must be the case if the digestive function is being perfectly performed.

The assumption that indican can ever be a normal constitutent of the urine is absolutely false and unscientific. Such statements are consummately misleading; because many do have indican in the urine does not make it a normal constituent of the urine. The processes must be normal or abnormal. One cannot have a partially rotten process going on at any point of the body and still be normal. This loose use of terms is what leads to much error that has crept into the study of disturbed metabolism.

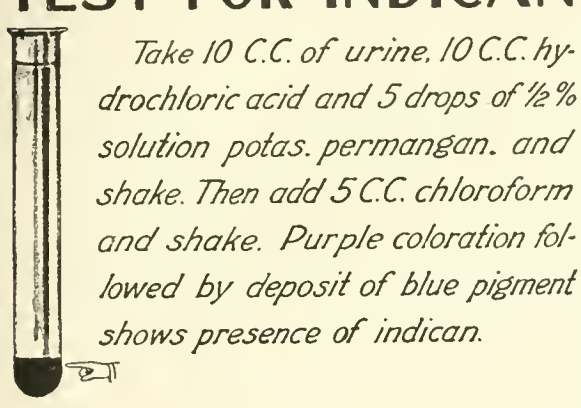


Fig. 3975.

If a clear blue reaction is secured with the indican test, it indicates a simple putrefactive process at some point in the animal economy, usually of the proteins in the alimentary canal. If instead of a pure blue, there is a dark purple, or even black sediment, it indicates putrefaction with the formation of more or less highly toxic products.

As for instance: The larger by-product, $C_{64}H_{103}N_{17}O_{20}$ already referred to, which was developed at the time of the formation of the indol and sulphurous acid, may or may not be toxic in nature, its toxicity being dependent entirely upon the arrangement of its contained atoms. It may be further reduced also, as in the following equation, into a number of less complex substances: $C_{55}H_{103}N_{17}O_{20}S + 26(O) = 4(CH_5N) + 2(C_2H_7N) + C_8H_9N + 2(C_7H_{10}N_2) + C_4H_{12}N_2 + 2(C_5H_{12}N_2O_2) + 20(CO_2) + 2(H_2O)$.

The reduction products thus obtained are: first, methylamine; second, dimethylamine; third, skatol; fourth, an unnamed product; fifth, putrescene; and sixth, a larger, highly toxic product also unnamed; carbon dioxide and water.

Some of these substances may be simple inert reduction products, or they may be highly toxic in nature; some are unquestionably highly toxic. The above list indicates only a few of the many reduction products that are produced, for with the large number of pentad nitrogen atoms and the other atoms contained in this by-product, the possibility for oxidation products is almost unlimited.

When those that are toxic gain access to the blood, glandular structures, and the nervous system, they give rise to a great variety of symptoms, while the only positive indication of their presence in the system is evidenced by the indoxyl or indican reduction reaction and its modifications, as given by the author elsewhere.[8]

In some instances the train of symptoms is quite uniform and well defined, as if a specific kind and amount of poison had been introduced into the system. In other cases, the symptoms are so imperfectly defined and varied in character as to lead to the supposition that the amount and form of toxic elements introduced into the system is constantly changing. In both instances a common etiological factor is present, but the breaking up of the by-product is subject to a great variety of changes, and hence the large number of reduction products and the great multiplicity of symptoms.

When these toxic products reach the liver, the hepatic cells often attempt to remove them, either by isomeric transmutation, oxidation reduction, or by throwing them out in the biliary secretion. This naturally imposes extra and abnormal work upon the hepatic cells, which may interfere with the perfect and normal leucomaine products formed in connection with the formation of the bile acids and pigments, etc. Under such circumstances the leucomaine products formed in the hepatic cells often become abnormal and highly toxic in character, thus adding still further to the toxicity of the system, and augmenting the final excretory work to be accomplished by the renal glands.

Until we can acquire greater certainty in our chemical knowledge of these by-products—which are toxic and which are not—and can determine the exact *modus operandi* of their formation, we have not solved fully this interesting and all-important problem; for it is this abnormal transmutation of the protein molecules which is largely the forerunner of all the ills to which the human race is subject.

In the chemical transmutations, as here expressed, we have the foundation principles which govern this perplexing question, and by its amplification will come the complete solution of these complicated phenomena, and finally the absolute guide for its scientific therapeutic management.

This same indican enables us in a large measure to determine the perfection or imperfection in the action of the hepatic cells. When the hepatic cells are overtaxed, they tend to swell and occlude the internal bile radicles. When this occurs, the bile salts and pigments flow backward into the lymphatic spaces adjacent to the hepatic cells. When this occurs and the indican test is applied to the urine, instead of the clear blue, dark purple or black precipitate, a decided green or reddish-green hue will be the result. If biliverdin predominates, the green hue will be very positive. If bilirubin predominates, a reddish green will be the result. In such cases the conjunctiva is bile tinged. Thus we have positive proof that the liver is at fault, and that some of the bile is being eliminated through the kidneys. The indican test, therefore, when rightly interpreted enables us to say that the digestive process is free from putrefactive fermentation or that there exists various grades of putrefaction, in a similar manner it indicates perfect or imperfect hepatic action.

So long as the deviation in the biotic processes does not give rise to profound changes, or only such as are chemical in nature and do not produce changes recognizable by careful microscopic examination, the process may be classed as a functional disorder, so-called, or simply as a disturbance in metabolism. Beyond this point we enter the realm of organized disease. This primary imperfect exchange of chemical substances in the bioplasm, unrecognizable except through changes in the composition of the urine, is unquestionably the beginning of many—if not all—of the more profound disturbances which sooner or later give rise to absolute and easily recognized changes in

the various tissues and organs of the body. This is well illustrated in connection with the changes in the liver already referred to; changes in which the liver cells become swollen and occlude the internal ends of the biliary radicles. Allow this process to go on, the continued irritation will give rise to the development of new connective tissue between the cells and around the acini. The former or cloudy swelling can only be determined by the aid of the microscope, while the latter are apparent to the unaided eye.

It is very essential to recognize these minor disturbances in metabolism early, and correct them before more extensive changes occur. If allowed to go on, they lower the nutritive tone of the bioplasm, and of the fluids and tissues of the body, thus decreasing the resistance of the system against all forms of toxic and germ invasion. In this manner a suitable soil is developed in which the various microorganisms can grow, and produce diseases which their presence within the animal organism is associated.

Thus it is found that faulty transmutation of the protein constituents of the food in the alimentary canal is very largely responsible for the disturbances in metabolism carried on more strictly within the system; a fact which is not as generally recognized as it should be. Furthermore, this defective transmutation of the food stuffs in the alimentary canal must be fully corrected before disturbances in metabolism in the inherent structures of the body can be overcome. From a practical, therapeutic standpoint, therefore, a discussion of both the extrinsic and intrinsic modifications in the exchange of material is absolutely necessary, if a clear understanding of disturbance in metabolism is to be acquired and successfully treated.

Looking into the system, it is necessary still further to consider the pancreas and the results of its defective secretion as one of the essential factors in disturbed metabolism. The experiments of von Niering and Minkowski[9] and others have conclusively shown that the removal of the pancreas prevents a perfect exchange in the carbohydrates and proteins, with the appearance of glucose in the urine. These results have frequently been confirmed. It has also been shown experimentally that the arrest of metabolism following this operation is entirely independent of any disturbance in the digestive function. Thus it would appear that certain portions of the pancreatic gland, possibly the cells of the central acini or islands of Langerhans, instead of pouring their secretion into the ducts of the gland, discharge it through intercalary ducts into the blood-vessels or lymph channels, from whence it enters the blood. In other words, certain cells of this gland take up from the blood protein elements and isomerically transform them, or they are transformed by decomposition and resinthetic formation, thus making them of further use in effecting general metabolism. The change may be in a similar manner to the formation of the enzymes that pass out of the gland through the main duct into the alimentary canal. In this instance, however, the secretion passes back into the system. That this internal secretion is essential for perfect metabolism appears to be conclusively established; at the same time it should always be kept in mind that all these experiments are performed on healthy animals, and that the resulting changes are brought about by suddenly developed pathological changes, which is not the case as a rule when dealing with disturbed metabolism as the general practitioner meets the case.

Therefore, it is not wise to draw too direct deductions from one to the other. At the same time, if the system is deprived of this particular isomeric form of protein which ordinarily reenters the blood, either by removal of the pancreas or by the introduction into the system of artificial chemical substances (the latter of which is probably the more common as we meet the cases) that destroy the special secretory power of that gland, the normal exchange in the food elements is interrupted and glucose appears in the urine. It is also possible that chemical substances are at times developed within the system that may arrest this particular function of the pancreatic gland, thus causing the appearance of glucose in the urine.

Owing to the fact that there are two theories as to the formation of glycogen and glucose, one from the carbohydrates and the other from the imperfect oxidation of the protein elements, the whole question is in a very unsettled condition. However it is brought about, the presence of glucose in the urine always indicates an abnormal exchange within the system. In this particular instance, accepting the pancreatic theory, it is indicative of metabolic disturbances in the bioplasm of these special cells of the pancreas, as well as of imperfect exchange of the carbohydrates and proteins. On the other hand, it may be the result of imperfect transmutation of the proteins in the hepatic cells, independent of pancreatic action.

If it can be unquestionably established that such internal secretion of the pancreas is always absolutely essential for perfect transmutation of the carbohydrates and proteins, and that a suspension of, or decrease in this special function causes the arrest of exchange in the substances enumerated, then the etiology of diabetes will be greatly simplified, even though there are many diverse conditions that appear to give rise to the secretion of glucose in the urine. On the other hand, there is much in the experimental work and the clinical observations of these cases that appears to render so simple a solution as almost an impossibility. Thus far it has not been possible to arrest this form of disturbed metabolism by the administration of the raw pancreas, nor by the use of extracts made from the gland, as can be done with some of the so-called internal glands—the thyroid, for example. On the other hand, much can be accomplished by a suitable diabetic regime, and rational therapeutics. So much so that in many types actual cures are effected.

Fat metabolism, like the exchange of all other food elements, has been the subject of innumerable experimental research work, much of which is highly contradictory; so much so that the exact status of normal fat exchange cannot be given. That it is easily decomposed and oxidized, cannot be doubted; at the same time it is generally conceded that fat may accumulate in the system from fat, carbohydrates, and proteins. Its formation from incomplete oxidation of the protein accords most closely with what is observed in connection with chemical data.

The secretions of the various so-called ductless glands, for instance the thyroid, pituitary body, and suprarenals, must also be considered in the elucidation of disturbed metabolism, as well as with normal metabolism. It seems reasonably certain that the bioplasms of the cells constituting these organs possess the power of taking up from the circulation some of the protein constituents. The proteins thus absorbed in passing through the cells of these various organs is isomerically or otherwise transformed, and is then discharged directly into the blood, or it reaches this fluid by way of the lymphatic channels. On the other hand, the protein taken up by the cells might be changed by a process of oxidation reduction, thus causing the essential chemical element in the blood to establish perfect metabolism. It seems probable, however, from the general absence of oxidation reduction products in the blood, that the change is one of isomeric transmutation, and of such a nature as to cause the protein elements thus transformed to differ in their chemical activity, thus making them essential to the normal exchange constituting metabolism and its disturbances. They become as it were unorganized ferments or active agents working intrinsically but similarly to those acting extrinsically in the alimentary canal. Rightly transmuted, normal metabolism results; but when imperfectly transformed, disturbed

metabolism, varying in degree with the character and intensity of the imperfection occurs.

There are two theories advanced in explanation of the mode of action of the enzymes of these glands. One is that the newly formed substance is toxic in nature, and gives rise to what may be termed a true "autoinfection" of the system. The other theory is that the substance formed is not toxic, but is elaborated in a manner similar to that described in connection with the internal secretion of the pancreas; and furthermore, that this newly formed substance is protein in character, but not necessarily a ferment, since it is concerned chiefly in the metabolic exchange of proteins. The reason for this line of argument is shown by the fact that removal of the thyroid, or its destruction by disease, has a decided tendency to arrest the normal exchange between the blood plasma and the connective tissue, the disturbance being so great as to cause a peculiar hyperplasia of the connective tissue substance. The protein molecules entering into the construction of the tissue having undergone an isomeric change so that they occupy as it were a larger volumetric space than normally is the case. At the same time there is no increase in the number of molecules; in fact, they may be diminished. This gives rise to a peculiar appearance of the tissue, so much so that the structures seem to be edematous but are not so in the strict sense in which the term is applied.

It must be remembered in changes of this character, however, we have passed beyond the realm of minor degrees of disturbed metabolism. Interruptions in the secretion of the thyroid gland are unquestionably the cause of many of the lesser disturbances in metabolism in which the changes are not of sufficient magnitude to produce perceptible organic lesions accompanied by characteristic signs or symptoms.

In like manner, the pituitary body produces a secretion which in a measure also seems essential for perfect metabolism, for its removal results in death or profound changes in metabolism. Its method of action is entirely different from what occurs when the thyroid secretion is interfered with. When the pituitary body is involved, the effect is noticed chiefly in connection with the bones of the extremities and face. In some cases there is also hypertrophy of the skin and mucous membranes, but without the gelatinoid consistency so characteristic of myxedema. Minor changes of this character appearing before marked "acromegalia" occurs, might be classed as a disturbed metabolism. How to interpret its influence upon less pronounced disturbances in metabolism is one of the points for further investigation. That its secretion does have a decided influence upon the action of the heart and vascular tension is generally admitted. Through its action upon the nervous and vascular systems must come the explanation for its influence upon metabolism.

In a similar manner the internal secretion of the suprarenal bodies is essential for perfect metabolism. Here the action seems to be more especially confined to changes taking place in the muscular structures. This is noticeable in particular in the muscular tunics of the blood-vessels. Its special function is to cause contraction of the blood-vessels through action on their muscular tissue. Hypersecretion will cause unduly high tension; decreased secretion results in abnormally low tension. Overproduction, diminution or arrest in the secretion of the suprarenal will, therefore, cause imperfect exchange in the proteins passing from the blood plasma to the muscular structures, and *vice versa*. There must necessarily be a difference in the disturbance of the exchange, between hyper and decreased secretion. So long as the disturbance in the secretion of these bodies is moderate in character in either direction, only milder degrees of metabolic derangement result. On the other hand, if the secretion is largely or more completely cut off, grave disturbances in metabolism of the muscular tissue supervene. Under these circumstances there are developed great muscular weakness, pigmentary discoloration of the skin and mucous membrane, and organic changes such as are commonly found in the condition known as Addison's disease. While these latter are indicative of truly organic changes, they go to show that the action of these secretions is not only one of modified tension, but of decided changes in the molecular structures in their passage through the tissues.

Owing to the very close interdependence between the action of the various internal secretions, it is often exceedingly difficult to determine just which is most at fault in minor disturbances in metabolism. At the same time, there is no question that disturbance in metabolism is the result of a more or less decided modification in the secretion of one or more of these various secretions which are either extrinsic or intrinsic in nature, since they all appear to be essential for perfect exchange between the food and oxygen taken in and the excreta eliminated. These minor disturbances are the forerunners and causative factors in a very large measure of all the more pronounced organic changes, well illustrated in some of the examples already cited. It is, therefore, often very difficult to draw a sharp line of demarcation between simple disturbance in metabolism and a genuine pathological condition, especially as all lesions are the direct result of imperfect exchange between the food products and oxygen in the bioplasm of the organs and tissues of the body. The innumerable cases met with which present no well-defined symptoms upon which a positive diagnosis of a pathological state of the system can be based, yet in which wide deviation from the normal standard exists, are good examples of simple disturbance in metabolism. This is especially so in many of the vague and indefinite nervous conditions. They constitute a special class illustrating disturbance in metabolism, and one of the most difficult to manage successfully, one in which it is exceedingly difficult to say which internal secretion is most at fault, or whether the use of extracts of the glands will be of avail.

The chief and most practical evidences of disturbance in metabolism are found in the catabolic products excreted in the urine.

First in importance among these catabolic bodies is the indoxyl potassium sulphate, already referred to quite fully in connection with disturbances in intestinal digestion and the functional activity of the liver. This substance is easily detected in the urine. Its entire absence from the urine indicates that the digestive system is free from all putrefactive changes, and that there is practically a normal transmutation of the protein elements in the intestinal tract. When indican is present in the urine, it indicates putrefactive transmutation of the proteins in the alimentary canal. As its presence is made possible by a decrease or an arrest of the digestive secretions, we know that all the digestive functions are imperfectly performed. The quantity and type of the indicanuria, as we have already indicated, determines in a pretty accurate manner the degree of digestive disturbance. As we have already shown, the test for indican indicates in large measure the functional activity of the liver. So much so that it registers pretty accurately the digestive processes in the intestinal canal and the hepatic action. A rise and fall in the amount and character of indican eliminated in the urine is positive evidence of increase and decrease of the putrefactive fermentation of the proteins of the food in the intestines, and of the relative production of the digestive enzymes, for it is their decrease or absence that makes possible these putrefactive changes. Therefore, careful daily estimation of the output of indican gives a pretty exact idea of the state of the digestive system, so far as the proteins of the food are concerned. Still more accurate results are obtained by making the estimate every twelve hours or night and morning. In some instances even more

frequent determinations are advisable. This was found to be true in one instance in which the author had the opportunity to employ the test twice daily, and sometimes oftener in one case, for more than two years. It was not until this series of observations that the true value of this test was made fully apparent. It shows how rapidly conditions can change, often within a few hours. A morning sample, for instance, might give absolutely no indican reaction, while a night sample will give a very positive indican reaction, or *vice versa*. Or for a day or two there will be no indican reaction, when suddenly it would again become very positive. Therefore, this test should be made twice daily for a week at least if one is to gain a true register of the digestive system. The same is true regarding the hepatic action. The presence or absence, especially as regards the type of indican, is also in a very large measure an index of the degree of intoxication of the system, and of the perfect and imperfect metabolism; because perfection in metabolism is chiefly dependent upon perfection of digestion. For the most perfect results in the application of the test, it should be made by the practitioner fully familiar with every phase of the case. Many laboratory reports are often very misleading. Speaking as they often do of indican as a normal constituent of the urine, and further, they often fail to specify the type of indican present in the sample. Calling indican in the urine a normal condition would be like the surgeon calling a partially gangrenous finger normal because many times fingers become partially gangrenous.

Having established the fact that indican in the urine in its final analysis, in the vast majority of instances, is dependent upon a decrease or arrest in the formation or elimination of the digestive enzymes, its presence in the urine must always be regarded as indicating an abnormal process. Viewed in this light, the indications are not so much to arrest artificially the action of the putrefactive bacteria, as they are to reestablish fully the formation and flow of the digestive enzymes. This accomplished, the bacteria of putrefactive fermentation will be normally inhibited, transmutation of the proteins of the food in the alimentary canal perfectly effected. Under these conditions not even a trace of indican can be found in the urine. It may be true that this state of perfection is not often found, but it can be produced and maintained.

A suppurating process may be infected with the bacteria of putrefaction. When this occurs, indican will appear in the urine. These cases are exceedingly rare, however, and are simply exceptions to a general rule.

Overproduction of Uric Acid.—Having previously established the fact that uric acid is one of the normal oxidation reduction products of protein metabolism, and that free uric acid is never found in the urine under these conditions, its overproduction and the presence of the free acid in the urine, is another of the interesting problems in connection with disturbed metabolism.

As compared with urea, uric acid is a lower oxidation reduction product of protein metabolism. (See Tables VI and VII.)

Apparently, however, both are produced independently, a slight difference in the number of the atoms of oxygen used, or two per cent. less oxygen, being all that is necessary to produce this marked suboxidation, lowering the production of urea fifty per cent. and raising the output of the acid fifty per cent. This acid, as already stated, is first a secretory product, while urea is a final and finished reduction product, so far as the animal economy of the human species is concerned. Uric acid, therefore, should be considered as a suboxidation product, and when overproduced, is caused by an unusually large number of protein molecules being imperfectly oxidized, so much so that the output of urea falls as the uric acid rises.

There are several somewhat dissimilar conditions under which uric acid is overproduced, yet in a measure they all act alike. The first is a condition in which we find an overproduction of uric acid in those who have abnormally small lungs.

From an anatomical standpoint, this can diminish the aerating capacity of the lungs to the extent of seventy-five per cent. This might be compensated for in a measure by a high hemoglobin blood content, also by a more active blood current with low vascular tension. With all conditions most favorable, however, including a careful regulation of the diet, it is impossible to compensate fully for this anatomical defect. Subjects with such a build cannot, even under the most favorable conditions, supply sufficient oxygen to oxydize fully the protein substances and maintain the requisite caloric units, and a more or less incomplete oxidation of the proteins is the final result. Such persons are very prone to become overfleshy and to have a large overproduction of uric acid, which, as a rule, is not held in solution in the urine, as is the case in some instances to be cited later. In these cases the uric acid is readily deposited in the urine without the aid of any chemical reagent, and forms the typical brick-dust deposit. This is always the result when the antecedent protein molecules in the blood follow what may be called their normal or physiological course in transit through the system, but in which there is not sufficient oxygen supplied to fully oxidize them when they reach the renal cells.

Such patients often appear to retain, in a large measure, a fair degree of good health, even in the face of this large overproduction of uric acid. This is explained by the fact that it requires a diminution of only two per cent. in the oxygen supply to double the output of uric acid. So long as this is the case and the system remains free from toxic invasion of all kinds no serious damage occurs.

The second class of cases are those in which the oxygenating capacity is fairly normal, so far as the pulmonary anatomical condition is concerned, but in which there is more or less constantly an overindulgence in food, as estimated by sound physiological standards; the overindulgence being usually in starches, sugars and fats—principally the former two. It may also include an excessive use of the protein group, but not necessarily so. In fact, this is not the rule. While the uric acid is always produced from the protein class only, its overproduction is always a question of defective oxidation, and this is more frequently due to the excessive use of the hydrocarbons and carbohydrates than of the proteins. The former being very easily oxidized if taken in too large quantities, will exhaust the oxygen supply or capacity of the system in burning these more easily combustible compounds; so much so that there is not sufficient oxygen left with which to accomplish the more difficult task of perfectly oxidizing the protein substances. The reduction of the proteins, being a slower and more difficult task, uric acid is produced to a varying extent, sometimes in very large amounts; at others, to a limited extent only.

Here, as in the former instance, the protein antecedent substances undergo a nearly normal transmutation in their passage through the animal economy, but without sufficient oxygen to oxidize them fully. Hence there are but few, if any, typical abnormal symptoms, even though there is often a very large overproduction of uric acid. Even though there are no well-pronounced or abnormal symptoms in these two instances, an overproduction of uric acid always indicates imperfect oxidation reduction of the protein compounds. If this faulty oxidation is continued, it can represent only one thing—faulty assimilation and imperfect nutrition, a condition which, if allowed to continue, will ultimately be followed by more pronounced pathological conditions in due course of time.

This, then, is a very common form of disturbance

in metabolism, that in some subtle manner undermines nutrition and causes many an untimely death.

A continuation of these two establishes what may be called a *third type* of uric-acid overproduction. In this third form, following or resulting from the impaired nutrition, there is developed a defective flow of the digestive secretions and their ferments. This results in a putrefactive fermentation of the food stuffs in the alimentary canal, causing the indicanuric condition (see test for indican, Fig. 3975), often with the formation of various toxins. These toxins, which have not yet been fully studied and named, when they gain access to the blood stream and reach the nervous system appear to disturb the normal isomeric transmutation processes, and cause the imperfect oxidation reduction of the protein substances. Under these conditions the antecedent protein bodies, which ultimately give rise to the overproduction of uric acid in the renal cells, assume more and more the type of toxalbumins, which are irritating or decidedly toxic in nature; so much so, that alone or in conjunction with the toxins absorbed from the alimentary canal, they give rise to a large variety of ill-defined symptoms or sensations which persist so long as the overproduction of the uric acid lasts and the toxic condition of the system is maintained—symptoms which disappear completely when the overproduction of uric acid is arrested and the digestive processes rendered normal, and the uric acid is again produced within physiological limits only.

TEST FOR OVERPRODUCED URIC ACID

After boiling the upper strata of urine add a few drops of 4% acetic acid. Let it stand for 3 or 4 hours, after which the overproduced uric acid will crystallize out just beneath the surface of urine in test tube.

Fig. 3976.

There is a fourth type of cases in which there is an impairment of the hepatic function, such as occurs with a mild type of intralobular occlusion jaundice, while the intestinal digestive functions remain fairly normal. In these cases the faulty hepatic action is a pronounced factor in exciting the imperfect transmutation and oxidation reduction of the protein bodies, with an overproduction of uric acid in the renal cells. In all cases in which there is a faulty digestion, faulty hepatic action, or with the two combined—which latter may be classed as a *fifth* type—instead of the overproduced uric acid being spontaneously deposited, as before mentioned, it is usually held in solution in the urine in considerable quantities and quite persistently. This is a very curious fact. What the element or elements are that hold the uric acid so positively in solution in the urine, has not been discovered, but such is the fact, and in many instances, owing to this strange phenomenon, the overproduced acid is often overlooked by those who analyze urine.

In most instances the overproduced uric acid thus held in solution can be detected quite easily by a very simple and certain method. Porter's test for overproduced uric acid (see Fig. 3976) is one the author originated, and has employed for more than twenty years, in thousands of specimens. Fill a test-tube with urine; boil the upper strata only, then add a few drops of a four per cent. solution of chemically pure glacial acetic acid; reboil, and set the tube aside in a cool place. If only the physiological amount of uric acid is being produced, no change will be observed, no free crystals of uric acid will develop in the fluid so tested, because the acetic acid is not strong enough to decompose the urates and liberate or set the uric acid free.

If, on the other hand, there is an overproduction of uric acid which is free but being held in solution, if the urine is treated as already described, the uric acid will be gradually crystallized out. The crystals will first form directly under the free surface of the urine in the test-tube. (See Fig. 3976.) The amount so formed indicates the amount of free uric acid produced above what is required to maintain a perfect physiological state and form the normal urates. If there is a very abundant formation of these crystals, it indicates a very large overproduction of uric acid. Judging by the amounts so brought out, one can read off practically the degree or percentage of overproduction of this acid.

This test can be made an absolutely quantitative test by collecting all the overproduced uric acid on a weighed filter; when reweighed the difference will be the actual overproduction. For all practical purposes, however, the differences as observed in the test-tube is all that is required. By it one can tell whether the overproduction is increasing or decreasing. So far as known this is the only practical method for estimating the overproduced uric acid. As it is the determination of the overproduction that is the chief problem in connection with this uric acid question, it is absolutely necessary to have some practical method by which the estimate can be made by every practising physician. In some instances the free uric acid will so crystallize out in a few hours, but it more often takes from twelve to twenty-four, or even forty-eight hours, before the full amount comes out. In some very rare instances it takes from four to five days before the crystals make their appearance, at which time they will appear in very large amounts. In one case that has been under my observation for a number of years, it is usually the fifth day before the crystals appear, and then a very large number will be seen in the urine so tested. In those cases in which the uric acid comes out slowly there is usually an associated faulty hepatic action, already described, a highly toxic condition of the blood with marked neurotic or neurasthenic symptoms.

As a rule, the more positively the uric acid is held free and in solution the greater the toxicity of the system, the more persistent the symptoms, and the harder they are to overcome. In fact, it is this complex form that is the most difficult type we are called upon to treat. This, too, is the type which tends to maintain an unduly high vascular tension of the arterial system, a condition that is often wrongly diagnosticated as arteriosclerosis, while in reality it is simply an overtension without any pathological changes in the vascular walls. A high arterial tension of this kind, if it continues, becomes in itself a further factor in decreasing oxidation and in augmenting the overproduction of uric acid, for it further interferes with the free distribution and utilization of oxygen by the renal cells. This, naturally, further reduces the possibility of a perfect and full oxidation.

The vascular overtension may be so excited and kept in motion in connection with suboxidation conditions from truly extraneous sources, but they are more frequently intrinsic in origin, as already described.

A profound anemia is often a cause of defective

oxygen supply, and thus augments or causes overproduction of uric acid, but much that has already been outlined goes before, and is in large measure the cause of the anemia. These complex conditions are so often intertwined that cause and effect are easily confused, yet they are readily distinguished if one keeps the complete chemicopathological picture clearly in mind. Viewed in this light, uric acid becomes not so much the true pathological problem, but its overproduction is the true index to a very large series of serious and complex chemicopathological problems, changes which it is most important to understand thoroughly in connection with this great field of disturbances in metabolism and clinical medicine in general, if we are to give our patients the best that scientific medicine affords.

In some rare instances of this particular type of disturbed metabolism, the uric acid antecedents, which are toxic in nature, are not as rapidly reduced as might be expected. When this is the case, the urine may be temporarily free from overproduced uric acid. Then the abnormal symptoms due to the general toxemia continue, often with increasing intensity, until more active oxidation of the uric acid antecedents is established. As soon as oxidation is again active, the overproduced uric acid will again appear in the urine, and usually is of the toxic type. With the reappearance of the free uric acid in the urine, the symptoms will become less intense. In instances of this kind one can be easily misled by the urinary findings, unless fully familiar with the case and all the symptoms connected therewith. With apparently normal urine, there must be also no symptoms indicative of a disturbed metabolism. Otherwise there is retention of toxic elements within the system, and normal metabolism has not been completely established.

With more profound disturbances in the transmutation and oxidation reduction of the protein elements, oxalic and lactic acids and glucose appear in the urine. (See Table VI, VII.) Albumin may at times also be present in the urine.

In some instances the disturbance in metabolism seems to be centered chiefly in the nervous structures. It is usually preceded by, or associated with a disturbance of the digestive and hepatic functions, and an overproduction of uric acid. It may occur independently but seems hardly probable that it can occur when digestion is perfectly performed, and the proteins normally transformed. However, in all instances in which the metabolism of the nervous system is disturbed, there is one characteristic urine sign—namely, an overelimination of earthy phosphates either alone or with the oxalates. The former is indicated by a decided white precipitate in the urine when boiled and when the urine is acid in reaction. The upper portion in the test-tube only is brought to the boiling-point. Prolonged boiling intensifies the precipitate. This precipitate to the untrained eye strongly resembles one due to the presence of a trace of albumin. But this precipitate, in contradistinction to albumin, is quickly dissipated upon the addition of a few drops of a four per cent. solution of glacial acetic acid, while the albumin is intensified. The oxalates are detected by the aid of the microscope.

Lactic acid is generally associated with those conditions commonly classed as rheumatic; usually in conjunction with an overproduction of uric acid.

It is through this same law of suboxidation, toxemia, vascular modifications, and faulty nutrition, that we find the true explanation for some of our so-called rheumatic conditions, which range from what are best termed rheumatic neuralgic pains, to pronounced local congestions in the deep intermuscular plains and to the ligamentous structures in and around the joints, with varying degrees of pain and impairment of function. If this condition becomes more intense around the joint, there will be very pronounced edematous swelling, with great pain, and partial or complete loss of function, yet without any true inflammatory changes. Up to this point the condition is one of disturbed metabolism, rather than one due to organic changes. Therefore, it is only those cases with more decided lesions that are strictly speaking deserving of the name true rheumatism.

The intermittent and transitory appearance of albumin in the urine (cyclic albuminuria) may be regarded as evidence of simple disturbance in the exchange of protein materials. On the other hand, if albumin is persistent and in considerable quantity, it must then be considered as indicative of a profound and often serious disturbance in metabolism, or as evidence of a true lesion.

As the starches, sugars, and fats are, in all probability, rapidly converted and oxidized directly into carbon dioxide and water, it is very difficult to trace their perfect or imperfect exchange. The same is in a large measure true in regard to their transit through the alimentary canal.

If we accept the theory of glycogen formation from saccharine compounds, and that the glucose in the urine is the result of imperfect transformation of glycogen, then the presence of glucose in the urine indicates imperfect transmutation of the starches and sugars. On the other hand, if we accept the more probable theory, and the one which is more in harmony with well-known chemical laws—namely, that glucose in the urine is the result of imperfect transmutation and oxidation reduction of protein elements, there is no definite method for practically determining from the composition of the urine whether the saccharine elements are perfectly or imperfectly exchanged. In both instances, the presence of glucose in the urine often indicates simply a disturbance in metabolism. In other instances it is indicative of a more profound disturbance in metabolism, and is associated with organic changes. But, as already pointed out, the pathology of diabetes is yet an unsolved mystery. Glucose is known to exist in several isomeric forms. The isomeric forms of glucose in the urine in connection with the simpler forms of this type of disturbed metabolism, do not readily cause a reduction of the copper, when this test is used. When the reduction does occur, the resulting color is a yellowish red. On the other hand when the metabolic disturbance is of a more intense type, the reduction is almost instantaneous and of a decided brick red color. By this fact we can differentiate between the two forms, and prognosticate accordingly.

In a general way, if nutrition is well sustained and the urine practically normal after making due allowance for all possible exceptions, it is reasonable to suppose that all the ingredients of the food are perfectly transformed, both extrinsically and intrinsically, and that metabolism is normal. On the other hand, if the urine contains abnormal nitrogenous catabolic bodies, and there is a positive loss of flesh, this is conclusive evidence that the sugars and fats are too rapidly exchanged, which is equivalent to imperfect exchange of these elements. Under similar circumstances, if there is rapid production of adipose tissue, it is reasonable to suppose according to one theory that the sugars and fats are being too rapidly transmuted into fat, and deposited throughout the system. According to the opposing theory, the sugars and fats are supplied too abundantly and too rapidly oxidized, thus exhausting the oxygen supply to the system. This leaves too little oxygen to perfectly oxidize the protein elements, and a superabundance of fat becomes one of the resulting products of imperfect protein metabolism, and thus accounts for the undue accumulation of adipose tissue. This accords best with known chemical laws.

With this conception of this very complex problem of intestinal and hepatic incompetency or faulty action, uric acid overproduction, and general faulty metabolism, we can more intelligently consider the management of all the disturbances of which the ab-

normal findings in the urine are the index or representation.

Each case presenting one or more of these abnormal conditions of the urine must be carefully analyzed, and its cause and effect accurately determined. Then a suitable line of treatment can be instituted, which will yield satisfactory results to both patient and physician. The management of these highly complex problems, covered by the term disturbed metabolism, is no easy undertaking, and often taxes the physician's ability to its utmost extent.

In the management of the indicanuria problem, it is not simply an arrest of putrefaction that has to be accomplished, but a building up of all the digestive organs and glands, so that sufficient enzymes will be produced to inhibit the action of the bacteria of putrefaction in a normal manner, accompanied at the same time by sufficient digestive zymotic action to perfectly transmute the starches, sugars, fats, and proteins in the alimentary canal into easily absorbable substances. This accomplished, the hepatic cells will have less work to perform when the nutritive pabulum reaches them, so that abnormal metabolism in the liver will be replaced by that which is more nearly normal. This accomplished, saccharine and protein transmutation and oxidation reduction will be more perfectly effected by the hepatic cells and their activating agents. The leucomaine by-products found in the liver will become more normal in their isomeric composition, and much less toxic in nature.

In relation to the uric acid problem, it is not a simple question of increasing the production of uric acid, or even the elimination of all excess of uric acid from the system. The true goal from start to finish is how best to decrease the production of uric acid, and maintain its formation within the exact physiological limits, as previously outlined in connection with its formation in normal metabolism. This, and this only, is the task that confronts the truly scientific practitioner.

As there are so many factors constantly arising to baffle us in our very best efforts, one has to be constantly on the alert when attempting to manage even the most simple disturbances in metabolism. To say that the whole problem is to bring the body oxidation processes and the exchange of all food elements within physiological limits, is correct, simple, and easy. To accomplish all this satisfactorily is one of the most difficult tasks in modern therapeutics.

Regulation of the diet is of first importance. Knowing as we do the composition, digestibility, caloric and nutritive value of all food elements, and the methods by which the food products are utilized, from a theoretical standpoint we can with ease arrange a perfect diet; but when one tries to regulate the diet according to practical and scientific laws, and to maintain it within physiological limits, it usually proves to be no easy undertaking, simply and chiefly because a large number of patients will not do their part, no matter how well the physician may accomplish his.

When we come to the management of the more severe and complex types of disturbed metabolism—those in which the digestion is still more faulty, the hepatic functions still less perfectly performed, the uric acid overproduction of a more severe type, the blood stream highly charged with the toxins of various kinds, and the nutrition of the nervous system very much impaired (in consequence of which it is in an undue state of irritability, and there is established as a result of all these disturbances a state of undue high or low blood pressure), we have the most severe type of disturbance in metabolism. Beyond this point the condition becomes more decidedly abnormal, and passes into the realm of organic disease; one that must be followed by changes which will result in pronounced pathological lesions in the near future, if indeed they do not already exist. In these more severe instances, it is often very difficult to tell just when the disturbance in metabolism ends and the other begins.

In these severe forms of disturbed metabolism, our ability as scientific therapeutists is taxed to the very utmost limit, even when the patient does his or her very best. All the conditions mentioned have to be met with scientific precision, and this calls for consummate skill on the part of the practitioner. Each and every faulty point must be recognized in its full relation to cause and effect. One by one each deviation from the normal must be corrected in mathematical order, and brought back to a physiological state.

The scope of this article will not permit taking up in full detail all that can or must be done to set these deviations in metabolism right; nor would it be wise to attempt to do so, for there are so many different methods by which each and every deviation from the normal standard can be met. That which may work well in one case, will not do so in another, because the two are not just alike in their deviations. Furthermore, different practitioners will differ in their opinion as to how best to meet these abnormal conditions, and as there is no question that they can be met full well by different agents and methods, there never can be any specific medication in these profound or simple disturbances in metabolism. The varying factors and the inflexible laws entering into this great problem must be fully understood, and all forms of treatment brought into conformity with these laws; otherwise, the best efforts will prove futile. The more perfectly this is accomplished, the more certain and rapid will be the success obtained in the management of this great class of disturbances in metabolism. Under these most favorable conditions, which must include dietetic, therapeutic, and hygienic measures, cures can be effected which upon their face appear little short of miracles. In fact, conditions that have in a measure resulted in minor pathological changes can be overcome, and a normal physiological function of the organs reëstablished. William H. Porter.

References.

1. Troschel: Poggendorff's Annal., vol. xciii., p. 614, 1854; in Jour. of Pract. Chem., vol. lxiii., p. 170, 1854.
2. S. De Lucca and Panceri: Compt. Med. t lxv., pp. 577–712, 1867.
3. Brücke: Sitzungsberichte der Wiener Akademie, vol. xxxvii., p. 131, 1859.
4. Foster: Physiology, 5th Edition, p. 419 from the albumin.
5. König: Chemie d. menschl. Nahriugs- u.-Genussmittel, Berlin, 1882, 2 teAuf.
6. Rubner: Zeitsch. f. Biol., xv., S. 115; xvi., S. 119; xix., S. 45; xxx., S. 73.
7. Atwater: U. S. Dept. Agric. Bulletin, No. 109, Washington, 1892.
8. Porter, W. H.: The Post-Graduate, 1907, p. 983; Archives of Diagnosis and Prognosis, April, 1908, p. 173.
9. v. Niering and Minkowski: Arch. f. exp. Path. u. Pharmakol., Bd. xxvi.; Minkowski; *ibid*, Bd. xxxi., p. 85..

Metaplasia.—The direct transformation of one tissue into another without the formation of an intermediate embryonal tissue is known as metaplasia. Such a change can occur only in tissues closely related to one another genetically, as are the different forms of connective tissue. Under certain conditions any one of these may become changed into another; thus, fibrous connective tissue may become adipose or myxomatous tissue, cartilage may be changed into bone, lymphadenoid tissue into fat tissue, etc. In the majority of these changes the intercellular basement substance is chiefly affected; thus, in the transformation of connective tissue into cartilage, the basement substance loses its fibrillæ and becomes homogeneous; by a further change into a denser hyaline substance it may assume an osteoid character, and this through the deposit of lime salts may become bone-like. Likewise, in the change of fibrous tissue into myxomatous tissue the basement substance undergoes a mucoid change. On the other hand, in

the transformation into fat tissue the change is brought about by the connective-tissue cells themselves taking up the fat; so also in the change into myxomatous tissue the cells become stellate; in the case of cartilaginous or bony metaplasia they assume the characteristic appearance of either cartilage or bone cells.

That epithelial metaplasia occurs is still a matter of some doubt; the change of tall columnar cells into squamous cells, which apparently takes place under certain pathological conditions, while theoretically explainable as a true metaplasia, is probably in the majority of cases brought about through the agency of intermediate stages of cell forms which are essentially embryonal cells. In the upper respiratory tract such changes may take their origin from the small islands of squamous cells found there normally, these increasing in size under certain pathological conditions. In other cases the apparent epithelial metaplasia may be explained by the presence of fetal inclusions of undifferentiated tissue or by a transplantation of neighboring squamous epithelium. The occurrence of islands of gastric mucosa in the esophagus, intestinal glands in the stomach, pancreatic tissue in stomach and intestine, squamous epithelial islands in trachea, urethra, uterus, and prostate, uterine mucosa on the cervix and inner surface of hymen, etc., are not to be regarded as examples of metaplasia. According to Schridde these findings are to be regarded as *heteroplasias*, and can be explained as the result of a heterotopous or heterochronous persistence of fetal anlage or a primary inhibition or failure of differentiation. Schridde believes that such a heteroplasia is probably always heterotopous, the tissue out of place is always that found normally in a part directly bordering upon the organ in which the misplaced tissue occurs. Orth has used the terms *alloplasia* and *dysplasia* in practically the same sense as Schridde's heteroplasia.

Metaplasia of connective tissue into epithelium or of epithelium into connective tissue can never occur—a change of type is not possible: *omnis cellula e cellula ejusdem generis*. The older conception of metaplasia, now and then revived, that epithelium may arise from connective tissue, leucocytes from connective-tissue cells, tissue cells of every kind from leucocytes, etc., receives scanty support at the present day. The accepted idea of metaplasia is that of a variation in cell forms due to changed conditions—not a change of type. The cell types of the body may be regarded as being of as fixed a nature as the species of the animal and vegetable worlds; variation occurs to a slight extent and only between closely related forms.

As examples of physiological metaplasia may be mentioned the formation of adipose and myxomatous tissues from fibrous tissue, the development of fatty marrow from lymphoid, or in old age the change of the former into a gelatinous or mucoid marrow, the old-age atrophy of lymphadenoid structures into fat and connective tissue, etc.

Pathological metaplasia is for the greater part of a retrogressive nature, as in the transformation of fibrous tissue, bone, and cartilage into myxomatous tissue. The process is also closely associated with progressive changes, inasmuch as it is a constant occurrence in certain forms of tumors. It is very difficult to draw a definite line of separation between the degenerative and the progressive features of the process; in many cases metaplasia may be regarded as standing between degeneration and growth. In so far as the metaplasia itself is concerned there is no new formation of cells, only a change of those already formed. In quickly growing tumors, however, metaplasia may occur so rapidly as to assume the character of a direct new formation. Moreover, developmental changes often follow as well as precede the metaplasia. On the other hand, the tissue resulting from the metaplasia is practically always of a lower type and not infrequently of a perishable nature as shown by its tendency to necrosis. The degree and rapidity of both progressive and degenerative processes depends largely upon the vascular supply; an abundant supply of blood favoring the former, a poor one the latter process.

The occurrence of pathological metaplasias may be explained by the assumption that the cells of closely related tissues possess common potentialities which, under normal conditions of growth, are latent or subordinated to their specific qualities. Under such pathological conditions as inflammation, disturbance of function, changed nutrition, etc., these latent qualities assert themselves even to such an extent as to result in the changing of the character of the tissue. Mechanical and chemical influences that change the function of a part give rise to metaplastic processes. Chronic inflammations and pressure can cause bone-formations in connective tissues; exposure to air and friction can produce a horny epithelium on the cervix of the uterus (prolapse, inversion) or mucosa of the bladder (ectopia); injection of Scharlach-oil into the mamma causes the development of squamous epithelium with a horny layer; traumatic injury of the stomach mucosa gives rise to epidermis-like epithelium; anastomosis of gall-bladder to intestine causes a development of mucous glands in the former, etc. The potentialities of the germ layers are distributed during the development of the body in an unequal degree among the cells arising from these layers, so that, with the exception of cells genetically widely separated, not only special but also like potentialities are represented in these cells in varying degree. The more closely related are the cells genetically, the greater the degree of common potentialities. Metaplasia in fetal tissues should therefore be much more possible than in later life, since in the former the individual cell forms are less differentiated and possess more qualities in common. This point is of great importance with reference to the origin of tumors. From indifferent cell material in the form of fetal "inclusions," "rests," etc., a great variety of tissues might arise in later life. The mixed sarcoma of the kidney some of the teratoid growths, the formation of cartilage and bone in connective tissues, etc., may be explained in this way.

Metaplasia may occur in two ways:

1. The transformation of the tissue occurs with a persistence of the original cells, and without a new formation of cells (myxomatous metaplasia of bone, cartilage, fat, connective tissue, fatty metaplasia of connective tissue). This *direct metaplasia* is usually retrogressive in character.

2. The transformation may occur in two phases; first a new formation of cells (neoplastic phase), followed by a differentiation in a new direction (metaplastic phase). Such an *indirect metaplasia* includes the great majority of the true metaplasias of connective tissue and epithelium. If the indirect metaplasia leads to the development of a higher tissue it is called a *prosoplastic* or *progressive metaplasia* (gland acini out of salivary duct epithelium, liver cells out of bile ducts, etc.); when a higher tissue becomes transformed into a less highly differentiated one it is termed *anaplastic* or *regressive metaplasia* (columnar cells into squamous, etc.).

The most common form of metaplasia is the transformation of fibrous connective tissue into adipose tissue. This is brought about by the taking-up of large amounts of fat into the connective-tissue cells, the latter becoming changed into the large round cells characteristic of adipose tissue. Fatty metaplasia is one of the most common physiological processes; it occurs pathologically in connective tissues which ordinarily do not contain fat, in cases of fatty infiltration. As a result of atrophy or of changed conditions of nutrition the fat tissue may be changed back into fibrous tissue. Not infrequently after disappearance of the fat there is a formation of myxomatous tissue,

a mucoid substance being formed in the intercellular substance. On the other hand, mucous tissue may become changed to fatty, the stellate cells taking up fat and becoming changed into round fat cells. Lymphadenoid tissue is also closely related to fatty, and there are evidences of frequent physiological variation between these two forms of tissue. In atrophic lymph glands and in the change of lymphoid to fatty marrow there is first a removal of the lymphoid cells and a change of the reticular cells to fat cells. In the development of lymphadenoid tissue from connective and adipose tissues the fat is removed from the cells in the case of the latter, the connective-tissue fibrillæ become loosely arranged, a portion of the cells becoming changed into reticular cells, while at the same time there is an infiltration of round cells in the reticular meshes.

Myxomatous metaplasia occurs physiologically in the adult body in the bursæ, synovial membranes, and tendon sheaths; pathologically in inflammatory conditions of these structures, and particularly in the connective tissue of certain neoplasms. Fibrous and adipose tissues, bone, and cartilage may become changed into myxomatous tissue; in the case of fibrous tissue the fibrillæ disappear, the basement substance undergoes a partial liquefaction with the formation of mucin, while the spindle cells become changed into stellate or irregularly branched cells.

In the case of bone or cartilage there is a liquefaction of the basement substance with mucin formation, the bone or cartilage cells becoming changed to stellate or anastomosing branched forms.

Cartilaginous and osseous metaplasias occur in the connective tissue of the large arteries and of the cardiac valves, in the subcutaneous and intermuscular connective tissue, also in newly formed connective tissue in the eyeball, and in the stroma of both the mature connective-tissue tumors and sarcoma, more rarely in that of carcinoma. Osseous metaplasia may occur also in the meninges, sclera, choroid, serous membranes, tonsils, lymph nodes, lung, thyroid, endocardium, myocardium, muscles, liver, kidneys, adrenals, ovaries, testis, epididymis, stomach, tubes, skin, and elsewhere. New-formed bone marrow may be found in such metaplastic bone. The basement substance loses its fibrillar character and becomes homogeneous in the change into hyaline cartilage, the connective-tissue cells assuming the appearance of cartilage cells. Fibrous cartilage may be formed by the development of fibrillæ of collagenous material in the hyaline matrix. With the deposit of lime salts in the hyaline intercellular substance and the change of the cartilage cells into bone cells, bone may be formed directly from the cartilage. Bone may also be formed directly from fibrous tissue by the change of the fibrillar intercellular substance into an osteoid substance which later becomes calcified; the connective-tissue cells lying in the spaces appear as bone cells. Cartilage may become changed into fibrous tissue, but there is no evidence that fully formed bone undergoes such a metaplasia.

A metaplasia of unstriped muscle into striped as well as the reverse process has been claimed by many observers to occur under various pathological conditions, particularly in the case of the mixed sarcomas of the kidney. It is very probable, however, that these neoplasms are due to congenital inclusions of the myotome, and are not to be regarded as examples of true metaplasia of adult tissues.

Myxomatous, cartilaginous, and osseous metaplasias are found very often in the mixed connective-tissue tumors and in certain forms of sarcoma, particularly those arising from periosteal or intermuscular connective tissue. Both myxomatous and cartilaginous metaplasias are very common in the mixed endothelial tumors arising from the salivary (parotid) and lacrymal glands, less common in those of the mammary gland and testicle. It should be remembered, however, that the presence of bone and cartilage in these growths may be explained also on the ground of inclusions of fetal tissue. The ossification of the costal, tracheal, and laryngeal cartilages is of such frequent occurrence as to fall within normal limits and is hardly to be regarded as a pathological metaplasia except under extraordinary conditions. The change occurs more rarely in the bronchial cartilages.

The metaplasia of lymphoid out of fatty marrow occurs in leukemia and the various forms of anemia. Very rarely marrow-like tissue is found in the spleen and lymph glands. Whether this is to be regarded as metaplasia or as metastasis is not settled. Metaplasia of adipose tissue into lymphoid or hemolymphoid occurs also after removal of regional lymph glands, splenectomy, etc. Such metaplasia is to be regarded as regenerative or compensatory in nature.

Metaplasia of epithelium is limited to the transformation of columnar into squamous epithelium or the reverse process. In inflammatory processes of the upper respiratory tract (ulceration, ozena, etc.), in the urethra following chronic gonorrhea, in the endometrium (chronic endometritis, inversion, ichthyosis uteri, uterine polypi projecting into the vagina or beyond the vulva, etc.), in chronic inflammations of urinary and gall-bladders, kidney pelvis and oviduct, and in chronic inflammation of ear polypi arising in the middle ear and perforating the tympanum, transitional or columnar epithelium may be replaced by squamous. In all these cases the chronic inflammatory process leads to frequent desquamation or necrosis of the epithelium, this being followed by regeneration, the newly formed epithelium being of the squamous type. On the other hand, the transitional epithelium of the bladder may be changed to columnar in the case of bladder papillomata. Recently a metaplasia of the surface cells of serous membranes into goblet cells has been described; also a transformation of the endothelium of the lymph sinuses of lymph nodes into ciliated columnar cells has been reported. Further study is needed of such findings. True epithelial metaplasias must be carefully distinguished from *pseudometaplasia* or histologic accommodation. Such as occurs in the case of columnar cells lining cysts, in which as the result of great intracystic pressure the lining epithelium becomes flattened. This flattened epithelium cannot be regarded as metaplastic unless it actually takes on the characters of squamous cells (prickle cells, cornification). Further, the replacement of columnar epithelium by the ingrowth of squamous cells from a neighboring part, as occurs from the external ear through a defective tympanum into the middle ear is not true metaplasia.

As a result of such epithelial metaplasia new growths of the nature of epidermal or squamous-celled carcinoma (cancroid) may arise in regions normally covered by transitional, columnar, or ciliated epithelium. The cases reported of cancroid of bladder, kidney pelvis, endometrium, and gall-bladder have been explained in this way, but the possibility must also be considered that these arise from congenital misplacement of squamous cells or from ingrowths or transplantations from neighboring squamous epithelium (in the case of the endometrium, from the epithelium of the cervix). Columnar-celled carcinoma or adenocarcinoma may arise from the columnar cells of bladder papillomata. The practical significance of metaplasia lies particularly in its relationship to such neoplastic development. It is also of interest that a neoplasm originally homoiotypic may as it develops show metaplastic differentiations (adenocancroid of endometrium, stomach, pancreas, and mamma).

ALDRED SCOTT WARTHIN.

Metaproteins.—See *Aliment*.

Metastasis.—The transportation of substances from one part of the body to another, the transportation of disease-producing agents, the production in one part of the body of a local disease from a primary focus of similar disease in some other part not immediately adjacent, are various meanings covered by the term metastasis. The word owes its technical origin to the old humoral pathology, and originally signified the beginning of new paroxysms of disease in other parts of the body due to acrimony of the humors, the diseased humors (acrimonia) taking their origin from the incomplete ripening or digestion (critical secretion, apostasis) of acrimonia at the primary seat of disease, the unripe humors being transferred (metastasis) to other parts of the body to complete their crisis. With the passing of the humoral theory the term lost its original meaning, and came to be applied to the transportation of any substance from one part of the body to another by way of the blood or lymph.

Traces of the original idea are still found in the occasional incorrect use of such expressions as dyscrasic, gouty, or rheumatic metastasis, the metastasis of dyscrasic substances in certain eruptive diseases and skin lesions, the metastasis of mumps to the mammary gland and testicles, etc. The older uses, such as *metastasis of secretions* (the explanation of milk leg and puerperal fever through cessation of milk secretion and lochial discharges), *metastasis of blood* (vicarious bleeding in suppressed menstruation), *metastasis ad nervos* (reflex nervous distnrbances), have completely disappeared before the modern conceptions of these conditions.

In a broad sense the term metastasis is at the present time applied to the trânsportation, within the body, of any substance from one part to another (bile and blood pigment, dust, lime salts, uric acid, silver, lead, extrinsic pigments, air, fat, parenchymatous cells, animal and vegetable parasites and cells of malignant tumors). With the exception of the last two classes such transportation is frequently discussed under the head of embolism or pathological deposits, the conception of metastasis being narrowed to the idea of the transportation of a definite agent of disease and the production of the specific disease at the point of deposit of said agent. By many writers metastasis is accordingly limited to two processes only: tumor metastasis and metastasis of bacteria. For this limitation of meaning there is no good reason beyond the fact that these two classes of metastatic processes outweigh in pathological importance all other forms. Moreover, the result of metastasis, that is *metastatic disease*, should not be confounded with the *process of metastasis*.

The most rational classification of metastasis is that given by Ziegler, which is based upon the character of the transported body. Six groups are distinguished:

1. Insoluble substances: dust, stone, coal, metal, pottery clays, tobacco, hair, tattoo pigments, etc.
2. Parenchymatous cells (liver, spleen, placental, and bone marrow), portions of tissues, thrombi, fat, etc.
3. Cells of malignant tumors.
4. Animal and vegetable parasites.
5. Soluble substances arising within the body or introduced from without and deposited in an insoluble form: blood and bile pigments, lime salts, silver, etc.
6. Air.

According to the method of transportation the following forms of metastasis may be distinguished: *lymphogenous*, through the lymph channels; *hematogenous*, through the blood stream; *implantation metastasis*, transportation upon a free surface; *transplantation metastasis*, from one tissue to another or from one animal to another. Transportation in the direction of the blood or lymph streams is known as *direct*, in the opposite direction as *retrograde* metastasis, while the passage of any substance from the venous to arterial circulation without passing through the lungs, as through a persistent foramen ovale or ductus Botalli, is styled *crossed* or *paradoxical* metastasis.

Hematogenous Metastasis.—This is the most common form of metastasis; any of the substances mentioned in the above six classes may gain entrance to the blood stream and be carried to other parts of the vascular system to be deposited in those vessels of such small lumen as not to admit of further passage of the transported substance. The point of lodgment and the results of such lodgment depend upon the size and nature of the transported body. Hematogenous metastasis is usually direct, but retrograde transportation may occur in the veins, rarely in the arteries. Paradoxical or crossed metastasis may result from persistent foramen ovale or ductus Botalli. Retrograde metastasis is explained by the occurrence of backward currents set up by abnormal waves of pressure proceeding from the heart, by sudden local disturbances of pressure due to muscular action, etc. As a chief factor in the dissemination of tumor cells and bacteria hematogenous metastasis is of the greatest pathological importance.

Lymphogenous Metastasis.—This form of metastasis is of particular importance in the spread of carcinoma cells throughout the body. It is usually direct, but is very frequently retrograde, the current in the lymph channels being much more snbject to disturbances of pressure from muscular action, etc.

Implantation Metastasis.—This is the transportation of bacteria or tumor cells and their implantation upon either the mucous or the serous surfaces. Such transportation may be brought about by the influence of gravity, by the movement of ciliated epithelium, by peristalsis, through the agency of flnids, secretions, air, etc. In the case of the respiratory tract tubercle bacilli may be carried from a lesion situated high in the respiratory passages into the smaller bronchioles and alveoli by the means of inspiration. Caseating and ulcerating tubercles in the upper portion of the digestive tract may set free bacilli, which, carried by the intestinal contents, may give rise to tuberculous lesions in the lower portion. Such implantations are most likely to occur at the ileocecal valve and in the rectum. Likewise tuberculosis of the kidney may give rise to tuberculous lesions of ureters and bladder. Peritoneal tuberculosis is often accompanied by tuberculosis of the Fallopian tubes and uterus, the downward current from the fimbriated openings of the tubes favoring the production of implantation metastases upon the mucosa of tubes and uterus.

Implantation metastasis plays a very important rôle in the pathology of the peritoneal cavity. The rupture of purulent or tuberculous processes into the cavity gives rise to implantations which are most abundant in the pelvis and lowest portions of the cavity, where the bacteria through the force of gravity are most likely to settle. Similarly, widespread implantation metastases of malignant growths may occur over the peritoneum; particularly in the case of malignant papilliferous cystadenoma and carcinoma of the ovary. The cystocarcinoma of the testicle often gives rise to peritoneal or subperitoneal metastases, which in turn become foci for extensive implantation metastases over the peritoneal surface. Similar processes occur in the pleural and other serous cavities. In the case of kidney carcinoma implantation metastases may occur along the ureter and in the bladder; in ovarian carcinoma, in the mucosa of the tubes and on the endometrium. It is also probable that similar implantations of carcinoma may occur in the intestinal tract. It is to be remembered that many metastases on free surfaces commonly regarded as implantation metastases are often due to retrograde transport in veins or lymphatics, as has been shown by Kaufmann to be the case in the so-called implantation metastases in the vaginal wall in cases of primary cancer of the cervix. It is possible that the same explanation holds good for the so-called implantation

of carcinoma from one labium to another at the point of approximation.

Transplantation Metastasis.—The transplantation of bacteria or tumor cells into previously unaffected tissues through the medium of a wound or abrasion of the surface. Such metastasis may follow surgical operations or such diagnostic procedures as the use of the trocar. Transplantation metastases of carcinoma have occurred in the abdominal wall after tapping in cases of malignant disease of the peritoneum, in the skin incisions after removal of mammary carcinoma, and in operations for carcinoma in other parts of the body. The transplantation of minute bits of carcinoma by operation accidentally or through intention has led to their growth and the formation of secondary nodules in the new situation. Transplantation of malignant tumors from one animal to another of the same species is also possible. Accidental operative transplantation of either sarcoma or carcinoma must be regarded as of very rare occurrence. On the other hand, such transportation of bacteria is an occurrence only too common. By many writers no distinction is made between implantation and transplantation metastases.

The results of metastasis depend upon the character and size of the transported body. The metastasis of small, bland, insoluble substances such as coal dust, etc., is of relatively slight importance, as the effect upon the tissues at the point of lodgment is slight; if the substance is soluble and chemically active, tissue changes may be produced; bacteria and animal parasites may multiply and set up their characteristic changes; while from the cells of malignant tumors metastatic or daughter tumors may arise. The last two classes are consequently of chief importance in the production of metastic disease.

Metastasis of Animal and Vegetable Parasites.—Various protozoa (malaria plasmodium, trypanosome, etc.) are disseminated through the blood stream. Transplantation of echinococcus and cysticercus cysts may follow the rupture or dislodgment of these into the blood stream. Metastasis of *Bilharzia hematobia*, and of the eggs and embryos of the filaria occur, the embryos of the trichina, tenia, and ankylostomum are scattered throughout the body by means of the blood and lymph, and the presence of amebæ in liver abscesses may be due to a portal-vein metastasis from the intestine.

The metastasis of bacteria plays a rôle of very great pathological importance, particularly in the case of the pyogenic organisms, spirochete of syphilis, and the tubercle bacillus. The entrance of pus-forming organisms may give rise to metastatic abscesses in any portion of the body. Multiplication of the bacteria does not usually take place to any great extent in the circulating blood, but at the places where they are deposited upon the endothelium of the blood-vessels, most often in the small capillaries of the lung, kidney, glomeruli, liver, spleen, brain, etc. At the point of growth the same degenerative and inflammatory changes are produced as in the primary focus: tissue necrosis, leucocyte infiltration, and abscess formation (metastatic abscess, pyemia). The metastases may be so numerous as to resemble those in miliary tuberculosis (miliary, pinhead abscess). When there is no evident primary focus the infection is spoken of as cryptogenic. The pneumococcus, gonococcus, typhoid bacillus, and colon bacillus may also give rise to important metastatic processes. Tuberculosis in its early stages is a local disease, but the process may become widely disseminated throughout the body by the rupture of caseating tubercles into blood or lymph vessels or through direct involvement of these. When great numbers of bacilli gain entrance to the blood, a general hematogenous miliary tuberculosis may be produced; if the number is small, the bacilli may be deposited in one organ only (metastatic local tuberculosis). Rupture of caseating tubercles into the thoracic duct or its afferent branches may also give rise to general miliary tuberculosis. Local metastatic tuberculosis is very common in the kidneys, testicles, bones, spleen, etc. In many cases there is no evident primary focus (cryptogenic tuberculosis). Inspiration metastasis of tubercle bacilli is not infrequent in the respiratory tract; implantation metastasis occurs frequently in the digestive, genital, and urinary tracts and peritoneal cavity. In the case of the higher forms of vegetable parasites metastasis has been observed in actinomycosis (pyemic actinomycosis), cladothrix infection, thrush, and in blastomycetic dermatitis. The metastasis of bacteria through the lymphatics is of very great importance in the case of the pyogenic cocci, tubercle bacillus, bacillus of bubonic plague, etc. As a result lymphangitis and lymphadenitis (bubo) are of frequent occurrence in such infections.

Tumor-cell Metastasis.—Through the entrance of living cells of sarcoma or carcinoma into the blood or lymph vessels secondary or daughter tumors may develop at the point of lodgment of such transported cells. It is to be emphasized in this case that tumor cells and not parasites are transported and that the new tumors arise directly from these transported cells. There is no true analogy between the metastasis of bacterial affections and that of malignant growths. The metastatic secondaries develop by cell division of the transported cells; as growth progresses the blood-vessels and connective tissue of the surrounding structures take part in building up the stroma of the tumor nodule. The changes produced in the surrounding tissue are of the same nature as those at the primary focus modified by the character of the part or organ in which the secondary is located. This action is of the nature of a mechanical destruction by the growing tumor rather than of a toxic nature.

The metastatic growth always bears a close resemblance to the primary, but occasionally the metastases may show more or less variation in character from the primary, as, for example, cornification may be present in the primary of a squamous-cell carcinoma, but absent in the secondaries; or the secondaries of a columnar-celled cancer may contain only flattened cells. As a general rule, however, it may be taken that the metastases resemble the primary in kind.

The number of metastases differs greatly in different cases, depending upon the location of the primary, the size and shape of its cells, the relation of these to the blood or lymph vessels, etc. In some cases the number of metastases may be so great that general miliary carcinomatosis or sarcomatosis may be produced. The size of the metastatic growth bears no relation to that of the primary; enormous secondaries may arise from minute primaries. In some cases the metastases completely overshadow the primary in clinical importance. This is not infrequently the case in carcinoma of the prostate, uterus, and pylorus.

As a rule, metastasis is more common in carcinoma than in sarcoma, owing to the fact that the carcinoma cells grow directly into the lymphatics. It is for this reason that the transportation of carcinoma cells occurs chiefly through the lymphatics, while, on the other hand, that of sarcoma is usually through the blood-vessels, the cells of the sarcoma lying in very close relation to or forming the walls of the blood-vessels contained in the growth. Carcinoma metastases are, therefore, usually found in the lymph glands and in the liver, more rarely in the lungs and spleen, while sarcoma metastases are of frequent occurrence in the latter organs. To this there are numerous exceptions: cancer cells may invade the walls of blood-vessels directly and give rise to hematogenous metastases; in the case of kidney carcinoma the renal veins and ascending vena cava are almost always invaded and metastases produced in the lungs. The general principle of lymphogenous metastases in cancer and hæmatogenous in sarcoma will hold good, however, for the majority of cases.

It may be taken as a general rule that tumor metastases are common in organs where primary growths are rare, as in the lungs, liver, and kidneys, and are rare in organs where primary new growths are of common occurrence, as in the stomach, uterus, eye, etc.

The same degenerative processes are found in metastatic growths as in the primary. The secondaries of a mucoid carcinoma usually show a mucoid change, and in the case of primary sarcomata showing cartilaginous or bony metaplasias the secondaries usually show the same changes.

The location of the metastases varies according to the seat of the primary as well as with its nature. Certain laws of probability are, however, shown in the distribution of the secondaries of tumors of certain organs.

The metastases of mammary cancer appear first in the lymph glands of the axilla; after these the supraclavicular and anterior mediastinal glands are involved. Of the viscera the liver, lungs, and brain are most frequently the seat of metastases. In some cases of mammary cancer bone metastases play an important rôle, in other cases they do not occur. Retrograde metastasis through the lymphatics of the skin may also take place.

Metastases of stomach carcinoma occur most frequently in the epigastric, portal, and retroperitoneal lymph glands, peritoneum and omentum, liver, lungs, ovaries, and bones. According to Osler metastases occur in primary stomach carcinoma in 86.6 per cent. of cases, according to Welch in 63.4 per cent., according to Ewald in 75 per cent. of cases. Retrograde metastasis may lead to multiple carcinomatous constrictions of the intestines. The metastases of intestinal carcinoma are usually hematogenous, through the portal vein into the liver. This is explained by the numerous large and thin-walled vessels in the intestinal coats.

Primary carcinoma of the uterus gives rise to metastases first in the iliac, sacral, and lumbar retroperitoneal glands, later in the liver, more rarely in distant organs. Primary sarcoma of the uterus does not often give rise to secondaries; they are usually found, when they do occur, in the lungs, liver, vagina, and ovaries. Primary carcinoma of the ovary gives rise to secondaries in the retroperitoneal glands and the liver, and more rarely in distant organs. Implantation metastases over the peritoneum are very common; they are more rare in the mucosa of the tubes and uterus.

Both primary carcinoma and sarcoma of the kidneys break into the renal veins and produce metastases in the lungs. The neighboring lymph glands, particularly those near the hilum, are usually quickly involved. In the case of cancer of the left kidney retrograde metastasis into the spermatic vein may occur. In carcinoma and sarcoma of the testis the regional lymph glands are usually affected; hematogenous metastasis into distant organs is not infrequent. Retrograde metastasis into the kidney through the renal vein may take place. In the case of the cystocarcinoma of this organ implantation metastases over the peritoneum are very common. They may form the chief clinical feature, the primary being of insignificant size. Likewise primary carcinoma of the prostate very often gives rise to metastases of great clinical importance, while the primary may be but a small nodule. The secondaries are often found in the bones, usually in the large ones. The metastasis is usually through the veins; statical and traumatic influences are potent in the location of the metastasis. In all cases in which carcinomatous growths are found in the bones without evident primary disease the prostate and thyroid should be carefully examined for the existence of a primary.

The secondaries of primary cancer of gall-bladder and pancreas are usually found first in the regional lymphatics and liver, later in the lungs and other organs. Primary carcinoma of the liver rarely gives rise to secondaries, but when they do occur these are hematogenous. The metastases of malignant hypernephroma arising either in the adrenals or in the kidneys are usually found in the lungs. Primary carcinoma of the thyroid very frequently gives rise to metastases in the bones, the skull, sternum, and ribs being most frequently involved. In primary sarcoma of the thyroid, bone metastases are less commonly found.

In the case of other organs of the body the general rule of lymphogenous metastasis for carcinoma, hematogenous for sarcoma will hold good. There are, however, all possible forms of combinations, the metastases in many cases being determined by various factors: relation of tumor cells to blood and lymph vessels, location of primary, etc.

Besides the metastasis of malignant tumors cases of metastases from apparently benign tumors have been reported. Thyroid adenoma and chondroma of the testis are the benign growths which most frequently give rise to secondaries. Metastases of osteoma and angioma have also been reported. The very fact of such metastasis should, however, exclude these growths from the benign category. In the case of the chondroma of the testis the primary growth is probably to be regarded as of the nature of a malignant teratoma. The so-called benign adenoma of the thyroid gives rise to bone metastases which resemble the original tumor. They may be multiple. As the secondary foci are not malignant in character they should be removed by local operation; amputation is not indicated.

ALDRED SCOTT WARTHIN.

Metastigmata.—A suborder of mites, Acarina, which includes the ticks. These arachnids have a hard integument and possess one pair of stigmata above and behind the fourth, fifth, or sixth pair of appendages. See *Arachnida*. A. S. P.

Metastrongylus.—A genus of round worms, Family *Strongylidæ*, in which the mouth has six papillæ. *M. apri* is not uncommonly found in the bronchial tubes of pigs in Germany (sixty per cent. in Berlin). It is an occasional parasite in man. Its usual habitat is the lung, where it may cause pneumonia or bronchitis. See *Nematoda*. A. S. P.

Metazoa.—The animal kingdom is divided into three groups: the Protozoa, including the one-celled animals; the Parazoa, with only one phylum, the Porifera or sponges; and the Metazoa, which includes all other animals. Metazoans are separated from parazoans because the latter have a peculiar development which makes it appear that they have originated independently from the Protozoa. All Metazoa pass through blastula and gastrula stages during development. A. S. PEARSE.

Methemoglobin is a transformation product of oxyhemoglobin found in transudates and cystic fluids containing blood, in the urine in hemoglobinuria and also in the blood and urine after poisoning with potassium chlorate, amyl nitrite, after hemolysis, etc. By the action of ozone, potassium permanganate, potassium chlorate, pyrogallol, pyrocatechin, acetanilide an abundant formation of methemoglobin occurs and by the spontaneous decomposition of blood some methemoglobin may be formed. According to some investigators methemoglobin differs from oxyhemoglobin by containing its oxygen in a more stable combination. A solution of methemoglobin has a dusky brown color. The absorption spectra of methemoglobin differ according to the reaction of the solution. See *Blood*. F. P. U.

Methyl Alcohol.—Methyl alcohol, $H.CH_2OH$ or CH_3OH, known to the chemist also as *carbinol* and *methanol*, is more popularly known under the several names of *pyroligneous spirit*, *pyroxylic spirit*, *wood spirit*, *wood alcohol*, and *wood naphtha*—names taking origin from the fact that methyl alcohol occurs as one of the ingredients of crude wood vinegar, the fluid product of the destructive distillation of wood. Methyl alcohol, when pure, is a thin, colorless fluid, much resembling common (ethyl) alcohol in taste and smell, but, obtained from wood vinegar and unpurified, has both a rank and an offensive flavor and odor. Methyl alcohol resembles ethyl alcohol also in being volatile, inflammable, and miscible in all proportions with water and ether. The two alcohols also mix freely with each other. *Physiologically*, the effects of methyl alcohol were at one time thought to be similar to those of common alcohol, but the substance is now known to be a rank poison, having a specially deleterious action on the optic nerve. Blindness has been caused by the drinking of a very moderate quantity of wood alcohol or even by its external application, and death has frequently followed a debauch on liquor made of flavored wood alcohol in imitation of whiskey. *Therapeutically*, this alcohol was formerly given, with no very obvious purpose, in a number of diseases. Methyl alcohol is useful in the arts as a solvent. Methylated spirit is ethyl alcohol containing one-ninth its volume of methyl alcohol.

Edward Curtis.
R. J. E. Scott.

Methyl Chloride (Monochlormethane) $CH_3.Cl$.—A colorless gas, analogous to ethyl chloride, obtained by the action of hydrochloric acid upon methyl alcohol. It becomes liquefied at a temperature of −11.4° F., or, under a pressure of five atmospheres. This liquid vaporizes at 5° to 8° F., the change producing an intense degree of cold amounting to 40° or 50,° F.

It was introduced as an analgesic and as a local anesthetic in minor operative procedures, but the intense and rapid freezing made it difficult to control its effects. The action of ethyl chloride (*q.v.*) is less marked and this milder preparation has replaced the more active methyl chloride.

Beaumont Small.

Methyl Iodide, *Moniodomethane*, CH_3I. Methylic iodide is a colorless, heavy, ethereal fluid, of specific gravity 2.199 at 0° C. (32° F.), and boiling-point 44° C. (111° F.). When pure its vapor is anesthetic after the manner of that of chloroform, but this iodide is easily decomposed, and so is apt to incite the irritant effects due to free iodine. In consequence of this disadvantage methyl iodide has never been given a place among accepted anesthetics. It was originally proposed by Dr. Richardson in 1868. Methyl iodide is a very powerful vesicant. Edward Curtis.
R. J. E. Scott.

Methyl Oxide.—Methyl oxide $(CH_3)_2O$, commonly called *methylic ether*, is the same compound of the radical *methyl* that common ether is of the radical *ethyl*. Methylic ether is a gaseous body at all ordinary temperatures (condensing only at a temperature of −21° C. [−5.8° F.]); is colorless, and of a not unpleasant ethereal odor. Methylic ether is a powerful and rapid anesthetic, and was experimented with by Dr. B. W. Richardson, in 1867, with a view to its possible employment as an anesthetic in surgery. Dr. Richardson used a saturated solution of methylic ether in absolute ethylic (common) ether, the solution being effected at the temperature of 0° C. (32° F.). The preparation, however, has never come into general use. Edward Curtis.
R. J. E. Scott.

Methyl Salicylate.—See *Salicylic Acid.*

Methyl Uracile.—See *Thymine.*

Methyl Violet.—See *Pyoktanin.*

Methylene Bichloride.—*Methylenic Chloride*, *Dichloromethane*, CH_2Cl_2. This body is closely related to chloroform chemically, and, accordingly, much resembles that body in physical characteristics and in physiological properties. Methylene bichloride is a heavy, colorless, ethereal fluid, of specific gravity 1.344, and boiling-point 40° C. (104° F.), and of neutral reaction. Its odor resembles that of chloroform. It mixes freely with chloroform, ether, and alcohol. The medicinal importance of methylene bichloride lies in the anesthetic powers of the vapor of the drug, which closely resemble those of chloroform both in kind and in degree. This anesthetic was one of Dr. B. W. Richardson's numerous proposed substitutes for chloroform, and was quite extensively used by many surgeons, notably by Mr. Spencer Wells. But owing to its dangerous quality it now has only an historic interest.

The name "methylene chloride" has been given also to certain anesthetic mixtures—to a mixture of the present body and ordinary ether, and to one of chloroform and methyl chloride, or chloroform and methyl alcohol.

Edward Curtis.
R. J. E. Scott.

Methylene Blue (Methyl Thionine Hydrochloride) $C_{16}H_{18}N_3SCl$.—Pure methylene blue occurs as a dark green crystalline powder, or crystals with a bronze-green tinge and dark green in transverse fracture. The methylene blue of commerce contains varying amounts of zinc and arsenic which render it unfit for medicinal purposes. The average dose is one to four grains, every four hours, or one-half to one grain hypodermically. It is readily soluble in water and is free from any toxic action. On account of its dissolving and staining properties it is best administered in capsules as furnished by all manufacturing chemists.

This aniline product was introduced into medicine in 1890, by Ehrlich and Lippmann (*Deut. med. Woch.*, June, 1890), as an analgesic of some value. Professor Ehrlich had investigated the action of the drug on nervous tissue as a staining reagent, and had demonstrated that it had a peculiar selective action on the axis cylinders of motor and sensory nerves. They claimed that when taken into the stomach, or introduced subcutaneously, it rapidly spread throughout the system and gave relief to all neurotic pains, and the pain in rheumatism of the muscles, joints, and tendons.

In the following year (1891) Ehrlich and Guttman announced that the drug was also a remedy for malarial troubles. They were led to experiment upon this disease from the fact that the plasmodia of malarial disease were readily stained by this body, not only in prepared specimens but also in fresh blood. They found that it had a decided curative power over the disease; the periodical attacks ceased within a few days, and at the end of eight days all plasmodia had disappeared from the blood. A dose of gr. iss. was given ten or twelve hours before the expected attack, and repeated every two hours until five doses had been taken. The treatment, they say, should be continued for seven or eight days after all malarial symptoms have subsided.

Dr. W. S. Thayer, in *Johns Hopkins Hospital Bulletin*, May, 1892, gives a detailed report of seven cases treated by this method. He concludes that: 1. Methylene blue has a definite action against malarial fever, accomplishing its end by destroying

the specific organism; but it is materially less efficacious than quinine, failing to accomplish its purpose in many cases in which quinine acts satisfactorily. 2. Reaction appears to be rapid, the chills disappearing and the temperature, in remittent cases, falling to normal during the first four or five days; later, however, if a sufficient number of organisms have resisted the drug, they appear to develop again directly under its influence, causing a return of the symptoms. 3. Methylene blue seems to have no advantages over quinine which would warrant its further use.

It is recognized as a useful remedy in the treatment of many forms of malaria, not replacing quinine, but of service in cases in which this drug has failed, and the two together often succeeding when both have failed when given separately.

It has been employed with benefit in cases of *Filaria sanguinis hominis*, in Malta fever, and other forms of blood infection.

Methylene blue has also been given in tuberculous conditions. In pulmonary phthisis a dose of gr. iss. was given the first day, increased on the second day to gr. iij., on the third day to gr. ivss., and so on until gr. xxiv. were given in the twenty-four hours. The usual improvement of symptoms is said to follow its use.

The latest use of methylene blue has been in the treatment of diseases of the genito-urinary organs, both by internal administration and locally as an injection. It has been shown that as much as sixty-eight per cent. of the amount given is excreted by the kidneys, and during its passage it is mildly diuretic and exerts an anodyne and germicidal action. Numerous cases of kidney disease have been reported in which it has proved beneficial, but it has been of most practical value in cystitis and urethritis, particularly when gonorrheal in character. The dose is gr. i. three times a day, and oil of santalwood, copaiba, etc., may be combined. The bladder and urethra may also be irrigated freely with a solution of the strength of from half a grain to one grain to the pint.

It is employed as a test for renal efficiency which has proved to be of some practical value, after its administration if there is a normal action of the kiney, it should appear in fifteen minutes and be totally excreted in thirty-six hours. With the aid of the cystoscope the relative action of the kidneys can readily be estimated. BEAUMONT SMALL.

Methysticum.—KAVA; KAVA-KAVA; AVA. The root of *Methysticum methysticum* (Forst.) Lyons, and of *M. excelsum* (Forst.) Lyons (fam. *Piperaceæ*). The first-named (generally known as *Piper Methysticum* Forst.) yields the bulk of the drug. It is a good-sized softly woody shrub, native and widely cultivated through the South Pacific Islands. The root has acquired a local reputation as a remedy for dropsy and painful affections of the bladder and the urinary tract, but it is chiefly prized as the source of a native beverage. The plant is reduced to a pulpy mass, sometimes, it is said, by mastication, and allowed to ferment until an intoxicating liquor is produced. The primary effect is as a stimulant, but ultimately it causes a peculiar form of intoxication in which the limbs and body are uncontrollable and helpless, while the mental faculties are clear or slightly dazed.

Authorities differ as to the resemblance of its effects to those of alcohol. It is not unlikely that by keeping, or by different methods of preparation, alcohol is yielded by the large amount of starch which is contained. Excessive use of it produces a chronic, troublesome scaly disease of the skin.

The root is soft and juicy when fresh, but becomes very light upon drying. It is light gray in color externally, and pale yellowish-white when cut. It comes in large, thick, clumpy pieces, often eight or ten centimeters across at the base of the stems, and divides quickly into several crooked, irregular branches. The texture is woody, but soft and light; the sawed surface is dusty or mealy. The odor is slight, the taste rather spicy and bitter, leaving the tongue slightly benumbed for a little while. A transverse section shows a thin bark, and a radiated, woody ring, in which the narrow wood edges are separated by broad, starch-bearing, medullary rays.

Half its weight consists of starch. It contains also an essential oil; two resins, alpha- and beta-resin kava; and a neutral crystalline principle called *kavahin*, or *methysticin*, which is closely allied to *pipirine*. The crystalline body exists to the extent of one per cent., but has been found inactive. The alpha resin, which is obtained by means of alcohol, and is insoluble in water, contains the medicinal properties of the plant, and is thought by Lewin to be the active ingredient. It has, however, been shown that the watery infusion also is useful, and this would indicate that the virtues of the plant are not limited to the resin itself. At present the resin and the fluid extract, not miscible with water, are the preparations employed for medicinal purposes.

Kava-kava has formed the subject of an exhaustive study by Dr. Cerna (*Therapeutic Gazette*, January, 1891) who arrives at the following conclusions regarding its physiological action: Moderate doses produce a stimulating effect, particularly on the central nervous ganglia; in larger quantities it produces general anesthesia, and diminishes and ultimately abolishes reflex action by influencing the spinal cord, and probably also the spinal centers. The great muscular weakness observed is not due to any action on the higher cerebral centers, as they maintain their normal functional activity. Very large quantities depress the circulatory and respiratory systems, and, in poisonous doses, death is produced by failure of the respiration or by cardiac paralysis. Placed on the tongue, it at first causes a burning sensation, which is followed by numbness and anesthesia, which continue for some time and are accompanied by a free flow of saliva. On the cornea and conjunctiva the same effect is produced. The local anesthetic action is said to be equal to that of cocaine, but its use is restricted by the insolubility of the preparations in water.

Kava is the best simple diuretic that we possess. It quickly produces an abundant flow of pale urine without irritation, but, on the contrary, with soothing effect, and is hence very useful in removing dropsical effusions. At other times its action is favored by the use of an abundance of water. Such use of it is recommended in cystitis, gonorrhea, and chronic inflammatory conditions of the mucous membrane of the urinary organs. The inflammatory action is rapidly moderated, and the purulent and catarrhal discharges diminish in amount.

The fluid extract is the most convenient preparation to use, and has been employed with decided success. It may be given in doses of ♏ xx.–lx. (1.2–2.4) three times a day, and has been combined with sweet spirit of nitre and glycerin when these are indicated. The alpha resin is given in doses of gr. i.–iss. (0.06–0.1) three times a day. A solid extract is prepared, the dose of which is gr. ij.–vi. (0.12–0.4). The principle, kavahin, is not employed, as its therapeutic action and dose are uncertain. HENRY H. RUSBY.

Metorchis.—A genus of flukes. These worms are slender, pointed anteriorly and truncated posteriorly. *M. truncatus* is common in the livers of cats and has probably occurred in man. See *Trematoda*. A. S. P.

Metritis.—In view of the confusion which has existed and to a large extent still exists regarding the

pathological and clinical classification of inflammatory diseases of the uterus, it is practically impossible to present a definition of metritis which shall fulfill the desired requirements. The terms metritis and endometritis have been employed interchangeably without any satisfactory attempt at separating them into the specific lesions to which they refer and in most conceptions of "endometritis" the accompanying changes in the myometrium have been regarded as a part of the process. In 1907 a committee of the American Medical Association considered that any classification based upon etiology was faulty and that one founded upon clinical symptoms was equally unreliable. The committee believed that the etiological factor in acute cases can usually be determined, whereas, in the chronic forms it ordinarily escapes detection. In the latter it was assumed that either the glands or the stroma were specially affected and that the so-called hypertrophies and atrophies were to be regarded as the final stages, or the results of chronic inflammations. Shortly after this a complete change in the conception of these conditions resulted from the studies of Hitschman and Adler on the structure of the normal endometrium, with particular reference to the process of menstruation. With slight modifications, the claim made by these authors, that the glandular forms of endometritis were nothing but normal premenstrual findings and that the interstitial type was the sole chronic inflammatory form, have been quite generally accepted. The view that in certain forms of hyperplasia an inflammatory origin may not be at fault has however been admitted. In view of the confusion of terms already referred to, it has been suggested that the word "endometritis" should be abandoned, as either a clinical or a pathological descriptive term. This revision of the views entertained with respect to inflammatory and other disturbances of the uterus, aside from neoplastic and similar conditions, will necessitate a change in the therapeutics of this condition. It would be simpler perhaps to regard every distinctly inflammatory or degenerative process in the uterus as a disease of the entire organ, rather than limited to the lining membrane, the myometrium, or the serous covering, recognizing that although an infectious process may be limited for a time to the endometrium, it quickly involves the entire structure to a greater or lesser extent. Whether we can immediately dispose of the term "endometritis" is a question difficult to decide in view of the long established custom. In this country insufficient attention has been extended to the subject by both clinician and pathologist, but there are evidences that the light which has been thrown on the problem will soon result in a more careful study of this topic.

In this article the term "endometritis" will be employed more or less synonymously with "metritis" as referring to the various types of acute and chronic inflammatory diseases of the uterus, considering in addition under the chronic type those forms depending on constitutional conditions in which the inflammatory factor may or may not be present.

Acute Metritis (Metritis Acuta).—Acute inflammations of the uterine wall are almost exclusively dependent on primary acute inflammations of the mucous membrane which lines the cavity. These inflammatory processes may not only penetrate the entire thickness of the uterine wall to the peritoneal covering but may extend through the same into the general abdominal cavity. A bacterial origin forms the basis of these infections in so many cases that practically it may be regarded as the chief etiological factor. Infection with pyogenic organisms following pregnancy at any stage, or the inoculation with the gonococcus, constitutes the most frequent source of acute infections of the endometrium and likewise of the muscular portion of the organ. The former occur most commonly during labor or in the puerperium, but a gonorrheal infection may result at any time by direct extension from a cervical gonorrhea. Septic infections occurring aside from pregnancy are comparatively rare but may result from trauma, the introduction of unclean instruments, or curettage without sufficient aseptic precautions.

An acute septic infection of the uterus may possibly remain localized in the endometrium but the myometrium is very frequently involved and shows characteristic histological changes. The invasion by septic organisms usually occurs through the lymphatic channels and the capillaries and the connective tissue between the muscle bundles may be found full of the same. They may likewise find their way into the surrounding tissues by a process of infiltration. The smaller blood-vessels, particularly in the neighborhood of the placental site, are frequently the seat of minute infected thrombi. The infective organisms may invade the entire thickness of the uterine wall and after reaching the peritoneal covering penetrate the same and enter the abdominal cavity. Under these circumstances they will bring about the development of a general peritonitis or lead to localized pelvic inflammations which result in the production of adhesions between the uterus, the intestines, and the adnexæ. In severe cases of acute metritis purulent foci may be developed within the uterine wall which as a rule are discharged into the cavity. Mural abscesses, however, may if sufficiently large extend into the parametrial tissues and result in the production of extensive exudates or cavities. The latter may rupture into the general peritoneal cavity or point into the vagina, usually in the neighborhood of Douglas' cul-de-sac. If the patient does not succumb to the infection it is possible that the same is gradually eliminated and the infective organisms killed. Infiltration of a very extensive character may be gradually absorbed and even where foci of pus are present these may in the course of time become comparatively harmless. In a large number of cases, however, such a favorable healing process does not take place and although the acute phenomena subside, absorption of the inflammatory exudates is not complete and a chronic irritation follows which results in the formation of cicatricial tissue in the connective tissue of the uterine wall. This means the conversion of an acute into a chronic inflammatory process similar to what may take place in other parts of the body.

If the infection in a case of acute metritis results from the gonococcus the effect is somewhat different from that in the purely septic processes. In most instances the gonococcus remains localized in the mucous membrane and prefers to extend from the cavity along the course of the Fallopian tubes than through the medium of the muscular wall of the uterus. Histological researches have shown, however, that the gonococcus can penetrate into the vascular system and result in the production of metastatic foci in other parts of the body. In some cases therefore the connective tissues of the musculature of the uterus are invaded so that abscesses in the same may be produced. This is particularly the case after pregnancy, as the tissues of the uterus are much more relaxed at this time and more favorable to the invasion of bacterial organisms. An acute gonorrheal infection of the wall of the uterus is not as serious as that by septic organisms, and a complete restoration to normal conditions may take place. It is quite common, however, that the acute gonorrheal form becomes converted into a chronic process and it will be referred to again in this connection.

Symptoms.—The most prominent symptoms of acute metritis are pain and rise of temperature. The pain is usually localized in the lower abdomen and in the lumbar region and accompanied by a feeling of distress referable to the bladder and the rectum.

The rise of temperature is usually preceded by a chill. During the puerperium a metritis is ushered in by the usual evidences of puerperal sepsis; headache, coated tongue, malaise, and a change in the character of the lochia. The latter, however, is not essential and the lochia may be perfectly normal and free from odor notwithstanding the presence of a serious infection of the uterus itself. As the condition frequently follows a sapremia, the evidences of the latter may be first to appear and must be carefully distinguished from the same. Thus foul lochia with a rise of temperature and some abdominal tenderness may point merely to a disintegration of retained blood clots or secundines in the uterine cavity. The fact must be borne in mind, however, that such a process of decay may constitute a favorable ground for the invasion of the body of the uterus itself by the pyogenic organisms which are frequently present. It is difficult to distinguish by clinical means whether the process has invaded the uterus or still remains localized in the endometrium and in view of what has been said above of the probable extension of these infectious processes, such a distinction is of comparatively little moment. If a woman is examined at this time it will usually be found that the uterus is tender to the touch and in a more or less fixed position due to the spasm of the surrounding muscular structures. This may be compared to the spasm of the abdominal wall associated with acute inflammatory infections of the appendix, gall-bladder, or other abdominal organs. The subsequent symptoms in these cases of acute metritis depend on the extent of the invasion of the process in each particular case. If the peritoneum is involved the usual evidences of pelvic or general peritonitis supervene and if the parametrial tissues become involved in the process the local evidences of the same can usually be elicited. Moreover, in the severe cases where general septicemia has resulted the evidences of the local process in the uterus may be overshadowed by the systemic condition.

Diagnosis.—The diagnosis of an acute metritis depends on the variety under consideration. If this supervenes during the puerperium, the tenderness and rigidity already referred to may be the only characteristic physical signs, as the discharge from the uterus may have no bearing whatever in making a diagnosis. In other cases where the metritis results from an infection due to instrumentation the symptoms usually come on within twenty-four or thirty-six hours after the invasion of the uterine cavity has occurred and the diagnosis here may be based on the history and the tenderness on bimanual examination. In gonorrheal cases we usually have the evidences of a gonorrhea in some other portion of the genital tract, the invasion of the uterus itself being marked by localized tenderness and an increased purulent discharge from the cervix. In the latter case there will likewise be backache, malaise, a slight or moderate rise of temperature, but usually no chills. The uterus on bimanual examination will be found somewhat enlarged and probably tender.

Prognosis in acute metritis depends entirely on the manner in which the infection took place and the virulence of the organisms. As a rule, the prognosis must be carefully guarded as we never know in the individual case whether the process will remain limited in the uterus or become general. A patient must, therefore, be kept under very careful observation until all the possibilities of an extension of the process are exhausted. As we have already seen, metastasis may occur in remote portions of the body and if an acute pain is complained of in one of the joints or other structures accompanied by an exacerbation of temperature, we must always bear this in mind as a probable extension of the original process in the uterus. The formation of abscesses is not common except in puerperal cases. Small foci of a septic infection may remain localized in the uterus for considerable periods only to be lightened up sometimes months afterward in case a new pregnancy supervenes or trauma to the uterus occurs.

Treatment is both local and general and in considering the same, attention must be called to the very great importance of prophylaxis, especially during labor. This need not be referred to in greater detail at this point, but attention directed to the article on the *Puerperium* for further information on this subject. As instrumentation has been noted as a cause for metritis, attention may be directed to the necessity for invariably exercising the most careful aseptic precautions when invading the uterus for any purpose whatsoever, whether for exploration or operation. As regards treatment in general, attention is strongly directed to the necessity for maintaining a very conservative attitude in the presence of any septic infection of the uterus. The patient should be put to bed and kept absolutely quiet. In every case the application of an ice-bag to the lower abdomen will relieve the pain and frequently the use of a prolonged hot vaginal douche with plain water or mildly antiseptic, will do much to relieve the congestion present in the parts. In puerperal cases if drainage is provided for by a patent cervix, no intrauterine manipulations should be resorted to unless a careful exploration with the finger shows the presence of retained placental remnants. The tendency at the present time is to permit even these to remain until they are naturally extruded. In view of the fact that the infectious process is disseminated through the lymphatics and possibly the blood-vessels, it is advisable to provide for thorough contraction of the uterus. This is partly gained by the application of the ice-bag and hot douches, and may also be furthered by the administration of ergot in moderate doses, from one-half to one dram of the fluid extract three times a day. By elevating the head of the bed or placing the patient in the Fowler position, drainage is likewise favored and it is possible that by this means a puerperal infection may be restricted to the pelvis. It is inadvisable in the majority of cases to resort to any local measures. The constitutional treatment of the condition will be found more fully described in the section on puerperal fever.

In cases of gonorrheal metritis a complete extirpation of the uterus and adnexæ must be considered in the severe cases, but otherwise supportive measures will usually suffice until the acute condition has subsided into a more or less chronic one. Intrauterine applications of silver salts and other materials in acute gonorrheal infection are best avoided.

Chronic Metritis.—In most instances a chronic metritis follows upon an acute puerperal or other infection of the uterus but a number of constitutional conditions must also be considered in discussing the etiology of this process. In many cases it is a difficult matter to trace the relationship between the chronic and the previous acute disease. A large number of puerperal infections, especially after abortion, are so mild in character that they are scarcely noted and have practically been forgotten by the patient or her attendant. An acute gonorrheal infection if not severe may likewise have escaped observation. A bacterial cause for chronic metritis may be assumed in all women in whom labor or abortion has taken place or in whom there are other evidences of inflammatory disease in the genital tract such as salpingitis or a chronic cellulitis. It has usually been assumed that a chronic metritis occurs from a previous infection of the mucous membrane, although a number of investigators claim that a primary involvement of the myometrium may occur, marked principally by a hyperplasia of the connective tissue and more or less atrophy of the muscular

structures. This interference with the muscular contractions of the uterus results in a venous congestion with the production of frequent hemorrhages. It is possible that a similar chronic passive congestion condition may result from retrodisplacements or any other interference with the venous circulation. Whether this may occur independently of any bacterial participation is still a questionable matter, but undoubtedly cases are found in which chronic metritis is diagnosed, as in virgins and a large number of nulliparæ, in whom no evidences of any previous acute infection can be found. Chronic constipation, masturbation, cardiac disease, improper mode of life, insufficient exercise have likewise been regarded as etiological factors in the production of a chronic metritis. It is evident therefore that we are by no means entirely cognizant of the definite factors that underlie the production of a chronic metritis in certain cases in which no previous acute bacterial infection can be determined. The pathology of the condition is pretty well cleared up, however, and no differences can be determined between the cases that have had previous infections and those which are apparently of a non-infectious character. As a general thing the uterus is more or less enlarged either in its entirety or in the cervical portion. Its consistency is hard and tough as compared with the normal organ and a greater resistance is encountered in cutting through the same. On section the openings of the sclerotic vessels are well marked and the mass of the uterus seems to be made up of connective tissue rather than muscular structures. A microscopical examination shows that intermuscular connective tissue is very prominent and the muscular elements diminished. Hyaline degeneration of the vessels is usually present and occasionally calcareous degeneration can be found. There may be small cell infiltration of the interstitial tissues, especially around the vessels. Microorganisms in chronic cases are practically never found. The endometrium undergoes well-marked changes and this should be considered in connection with the changes in the myometrium. In many cases the lower segment of the uterus and the cervix seem to be involved in these changes rather than the body of the uterus. This is usually the case where cervical tears are present and have offered the possibility of an inflammatory process from direct infection. It is often found that the localization of the chronic inflammatory process in either the body or the cervical portion of the uterus may be sharply differentiated.

Symptoms of chronic metritis usually develop in a very gradual manner. If it supervenes upon disturbed involution of the uterus the patient fails to be restored to her usual condition after getting up and presents constitutional evidences marked by irregular pains, malaise, possibly slight rise of temperature, and a feeling of pelvic distress. Every exertion is accompanied by backache and the discharge from the uterus may continue in the form of a brownish serum. Occasionally there may be a disposition to empty the bladder frequently and constipation is common. Menstruation appears early and is abundant and bleeding between the periods is frequent. The course of the disease is irregular and a period of improvement lasting over several months may be succeeded by others in which a return of the symptoms takes place.

Sterility is a frequent accompaniment of chronic metritis but it is less dependent on the development of changes in the uterine parenchyma than in the complicating involvement of the mucous membrane of the uterine canal and the tubes. However, when conception does occur abortions are frequent and it is not until the local conditions have been cured that normal pregnancy again results. The effect of pregnancy on chronic metritis varies. In cases where the complicating adnexal disease has been done away with the chronic metritis may subside but this is a result that cannot always be hoped for.

Diagnosis.—In view of the uncertainty of certain of the symptoms which attend the presence of a chronic metritis the differential diagnosis between this and other conditions may be difficult. Among those which require the exercise of good diagnostic judgment is early pregnancy, because in both we are dealing with an increase in the size and a softening of the mass of the uterus, accompanied by increased vaginal secretion. Moreover, patients afflicted with an endometrial lesion may continue to menstruate once or twice after conception has taken place. It is only after the lapse of sufficient time for the production of other and more definite signs of pregnancy that the diagnosis of the latter can be made. The development of fibroids may simulate this condition but a uniform enlargement of the uterus is usually not present.

Prognosis.—The prognosis in chronic metritis depends on the original cause. If due to a septic puerperal infection a cure is often possible with appropriate treatment. In connection with this, however, we must bear in mind the complicating lesions in the endometrium, the adnexal and the perimetrial tissues. During the climacteric chronic metritic processes may undergo complete resolution but in a great many instances the patient has become so run down by her long illness that the final natural cure is not accompanied by any prolonged extension of life.

Treatment.—In discussing the treatment of this common illness the etiological factor which forms the basis of each particular case must be carefully considered. Prophylaxis is of the greatest importance and the careful conduct of labor and puerperium with proper asepsis and complete removal of every part of the ovum is a most necessary requirement. Keeping the puerperal woman in bed until her symptoms warrant her getting up is much more efficient than following a rule of letting her get up on a certain day. Proper involution is the essential prophylactic measure and this may be secured by the administration of oxytocics, hot douches, tonic baths, and attention to the bowels. Proper hygienic care of the growing girl, particularly during the time of her periods, will do much to reduce the susceptibility to this condition. Anemic and neurasthenic girls are particularly liable and it is important that such systemic disorders be done away with in every instance. In the treatment of puerperal sepsis the accepted methods described elsewhere must be followed and if patients are carefully watched for three months after delivery until involution is complete a smaller number of cases of metritis would undoubtedly result.

In all cases of chronic metritis the treatment resolves itself into both general and local measures. Among the former attention is directed to the necessity of making a careful examination of the circulatory, muscular, and digestive apparatus. In the presence of any cardiac disturbance this must be taken care of in addition to any measures directed to the uterus itself. Valvular and myocardial disease must be eliminated or improved before any amelioration of the uterine conditions can be hoped for. A flabby muscular system must be restored to normal condition by appropriate measures. Other constitutional disturbances, including gout, rheumatism, malaria, anemia, chlorosis, tuberculous infections, anomalies of internal secretions, etc., require careful diagnosis and treatment. The digestive tract also demands consideration especially as regards a proper elimination through the bowels. Constipation is a contributing cause of uterine inflammatory conditions in many cases by increasing the pelvic congestion and so reflecting directly on the uterus as referred to above. In correcting constipation under these circumstances attention must be directed to insisting on proper emptying of the bowels at a definite time of the day, aided by diet, an abundance of water, and

usually the vegetable cathartics, including cascara, podophyllin, and aloes, the latter of course to be given in very small doses to avoid any increase in the congestion already present. The use of the heavy mineral oils is also of great value in such cases. Until regular evacuation of the bowels is established the use of a soapsuds enema every morning, or the injection of olive oil into the rectum in the evening will be of great value. Having carefully examined and noted the constitutional abnormalities in each patient and having extended to them proper attention, local measures may be considered. If a pelvic examination shows the presence of a uterine displacement this must be corrected by palliative or operative means before a successful outcome of the myometrial disturbances can be hoped for. Wearing a pessary in the earlier stages of the treatment is preferable to immediate operative interference to correct uterine displacement. When the local conditions have subsided and the general health is improved then operative results are less distressing to the patient and a cure more certain. If adnexal disease is present its treatment is likewise essential and the use of glycerin tampons combined with other medicaments is always of value in depleting the congested areas and thus reducing the pain and discomfort. These tampon treatments may be advantageously combined with hot douches, but unless such a method is consistently carried out it is of no value. Depending on the individual case, glycerin combined with ichthyol (ten per cent.), or glyceride of tannin should be applied on a tampon at intervals of from one to five days. The best form of application is by means of a fourfold gauze strip an inch wide and a yard long, one end of which is provided with a piece of tape that facilitates its removal. One end of this strip is impregnated with a half ounce of the desired medicament and inserted through a bivalve speculum into the posterior vaginal fornix, the remainder of the dry strip being packed in front of it. This impregnated gauze is allowed to remain in place for about twenty-four hours and on its removal a vaginal douche is taken by the patient while lying on her back, using for the purpose not less than one gallon of water at a temperature of 110° F. The insertion of the ordinary cotton tampon does not accomplish the desired result, for as soon as the same becomes saturated with the vaginal discharges it sinks toward the vaginal outlet and fails to accomplish any good result. The ordinary vaginal douche of one or two quarts of warm water is likewise of no value as a means for combating the uterine congestion present in these cases. As an endometritis usually complicates and is part of the lesion in these cases, local applications to the interior of the uterine cavity may be of value but they should not be carried to excess. An application to the interior of the uterus of the official tincture of iodine, either full strength or half strength, provided the cervix is sufficiently patent, will facilitate a resolution of the process, but as a general thing it is best to avoid intrauterine applications in those cases where the entire organ is involved, as the reaction may be severe enough to make the woman's condition worse rather than better. In many instances the local treatment as described and the improvement of the general health will do much to overcome a chronic metritis but in most instances it will be found necessary to resort to more radical measures before the hope of a cure is possible. Where indicated the diseased endometrium may be removed by curettage, this being preceded by a thorough dilatation of the cervix and followed by the application of iodine to the interior of the cavity. In cases where retrodisplacement or procidentia of the uterus is present, the appropriate corrective operative procedures should be employed and if adnexal disease is present this must likewise be eliminated.

Where the cervix is extensively hypertrophied and the seat of erosions, a high amputation of this portion of the uterus will do a great deal to overcome the chronic inflammatory changes in the latter.

Massage for the purpose of overcoming chronic inflammatory conditions in the uterus has been recommended and may be of value in cases where there is no likelihood of bringing about an exacerbation of the inflammatory process in the perimetric tissues or the endometrium. Training and skill are necessary in this procedure but many women would naturally object to the same for personal reasons. It has never found extensive employment in this country. The application of the electric current in various forms has been employed with success. The application should be made, however, only by one who has thoroughly studied the effects of the various currents in specific cases, otherwise the patient's condition will be rendered worse rather than improved. The employment of baths of various kinds has been largely resorted to abroad but has found little favor in this country for the reason that the facilities are not at hand or have not been developed.

George W. Kosmak.

Metrorrhagia.—The ordinary or customary discharge of blood from the womb at the menstrual period is the point of departure, so to speak, from which this term originates. Just where to draw the line is difficult because the term is a relative one. What is ordinary and not excessive for one woman may be extraordinary and excessive for another. Any hemorrhage from the womb, be the quantity large or small, which depletes the woman's vital force may be regarded as metrorrhagia. The term menorrhagia is often used when this excessive loss occurs in connection with the monthly flow.

Metrorrhagia may therefore be regarded as a hemorrhage from the womb, excessive in quantity, occurring at no definite time, of no definite duration, and due to a variety of causes.

Conditions which favor or cause such a hemorrhage are relaxation of the uterine structures, hypertrophy of the uterine mucosa, malignant degeneration of the uterus, repeated congestion of the pelvic circulation, especially if the blood tension is high or the vascular walls are weak or friable.

1. *Relaxation of the Uterine Structures.*—Such a condition may signify merely a relaxed state of the uterine muscle, or relaxation of the mucosa as well. After a prolonged and severe parturition—especially if there has been uterine inertia during parturition, or if the patient has been kept under the influence of an anesthetic for an unusually long time—the uterus frequently remains relaxed, the great uterine sinuses remain unclosed, and the blood may pour forth in a mighty current. This is commonly termed postpartum hemorrhage. It is a true metrorrhagia. The relaxed and flabby condition is often present in weak and anemic women or in those who are suffering with serious disease, such as Bright's disease of the kidneys or tuberculosis. In such cases the hemorrhages are frequently profuse and of long duration. They may occur with the monthly period or during the interval and should be regarded with great seriousness, for such women cannot well sustain such losses of the vital fluid.

The treatment which I have found most effective for the first class of cases is the tamponade of the uterus in the presence of the hemorrhage. Other measures need not be discussed, for with me, at least, they have proved distinctly inferior to the tampon. My plan is to draw the uterus down to the vulva with a volsella firmly fixed in the anterior lip of the cervix, and then to carry successive portions of a long strip of aseptic gauze, two inches wide, quite to the fundus, with long narrow dressing forceps, until the cavity is fairly well filled, at the same time compressing the

uterus with the left hand through the abdominal wall. In my hands this has several times proved efficient after other measures had failed. The same treatment is equally suitable for the profuse hemorrhage which often follows abortion. For the second class of cases one must first improve the general condition with iron, strychnine, and an abundance of food. In the intervals between the bleedings one may apply Churchill's tincture of iodine, or the nitrate of silver, four drams to the ounce of water, to the endometrium every other day, and should such treatment be ineffective after a few weeks of trial, one may dilate the uterus and curette the endometrium. It may not be possible or desirable to scrape away much of the uterine mucosa, but the effect of the operation will be to stimulate the organ to contraction. The operation should be repeated if a single scraping proves insufficient. Some of the cases of profuse hemorrhage during the menopause are successfully treated by this method. The uterus is then tamponed, but not too firmly, the tampon being retained for two days.

2. *Hypertrophy of the Uterine Mucosa.*—The metrorrhagia which results from this cause may consist either of a continual dripping which requires the constant use of a napkin, or of a more or less profuse flowing which ceases only when the patient is exhausted or when the uterus is filled with a clot. The hypertrophied tissue is usually of rapid growth, contains an abundance of vessels, and breaks down readily. After it has broken down it is quickly renewed only to break down again and be accompanied by another hemorrhage. Such a condition frequently follows parturition at term, or abortion, especially if the entire product of conception were not expelled or removed. It also results from gonorrhea which may have invaded the endometrium, from the presence of fibromyomata within the uterine muscle, especially when their development is toward the endometrium rather than toward the peritoneum, and it not infrequently is one of the phenomena which accompany the menopause. The treatment in all these conditions is the same, for the pathological significance is the same in all. To attempt to relieve the hemorrhage by the internal use of drugs is futile and an unreasonable waste of time. Even the use of astringent or caustic applications to the endometrium is of doubtful value, and in most cases will only prove disappointing and unsuccessful. The only excuse for such treatment would be the unwillingness of the patient to submit at once to the operative method. This consists in the careful and sufficient dilatation of the uterine canal and the removal, with a sharp curette, of the entire hypertrophied mucous membrane. The uterine cavity is then tamponed with aseptic gauze which may usually be retained for two days. In almost all cases the result of this operation will be the immediate cessation of the hemorrhage, and very frequently the cure will be a permanent one. If, however, the cause of the bleeding is a fibromyoma the bleeding will probably recur, and it may be necessary to remove the tumor to produce a permanent result. A repetition of the operation is also frequently required in connection with the menopause.

3. *Malignant Degeneration of the Uterus.*—Any form of malignant degeneration of the uterus is likely to be accompanied by metrorrhagia. In the case of sarcoma the bleeding is not so frequent and may not be so profuse as in that of carcinoma. Whether carcinoma be limited to the cervix or to the corpus, or involve both parts of the organ, hemorrhage will invariably occur. It may occur as a result of great emotion or excitement; it often occurs after coitus. The slightest disturbance of the friable tissue of the cancerous uterus causes bleeding which may be very difficult to arrest. If the diseased tissue is not disturbed in any way there will be a periodical disintegration and breaking down of such tissue, accompanied by profuse hemorrhage. The hemorrhage usually comes with a gush and continues until the patient is exhausted, until a sufficiently large clot is formed, or until it is arrested by mechanical means. The treatment of such hemorrhages is of course only palliative, in so far as the disease which causes them is concerned. For the immediate arrest of the bleeding, pledgets of cotton wool saturated with a solution of alum or of persulphate of iron should be carefully introduced, one after the other, into the vagina, until that cavity is firmly packed. This packing may be left undisturbed for twenty-four hours, and then, if the bleeding recurs when it is removed, the same procedure should be repeated. As soon as possible it is desirable that the diseased tissue should all be scraped away with the sharp curette and a tampon introduced like that which has been described. Such an operation is usually followed by relief from hemorrhage, perhaps for weeks or even months.

4. *Repeated Congestion of the Pelvic Circulation.*—Hemorrhage from this cause is of frequent occurrence, and there may or may not be any apparent hypertrophy of the uterine mucosa. It may be the result of excessive sexual indulgence, of great emotion or excitement, of sudden removal to a great altitude where the atmospheric pressure is decidedly lower than the pressure within the blood-vessels, or of unusual blood tension from a variety of causes at the time of the monthly flow. I have frequently seen this variety of metrorrhagia in prostitutes and I believe that it is very common with them, especially if they are also suffering with disease of the tubes and ovaries, to which they are very susceptible. Hysterical women or women who experience great calamities or catastrophes are sometimes sufferers from this form of hemorrhage. Women who remove their residence from the sea-level to an altitude of 6,000 feet or more are frequently troubled with metrorrhagia until they become accustomed to their new surroundings, even though they may be in ordinary health in all other respects. Those who suffer from this cause at the time of the monthly flow may not present any lesion which is discoverable as a cause. Metrorrhagia sometimes occurs upon the approach of the menopause. The condition will usually yield quite readily to treatment. It is hardly necessary to say that if the cause is excessive coitus such excess should cease. Those who reside in high altitudes should change their residence if the bleeding does not cease after a few months. The hysterical and emotional must learn self-control, and if the blood tension is excessive a course of treatment with the bromides must be entered upon. In some cases it may be desirable to make applications of iodine or carbolic acid or persulphate of iron to the endometrium, and if this does not avail it will be necessary to dilate the uterine canal and curette the endometrium. For the immediate treatment of the hemorrhage the tamponade of the vagina after the manner which has been described will usually prove effective. ANDREW F. CURRIER.

Mexico.—This great southern portion of North America, extending over seventeen degrees of latitude and thirty of longitude, is comprehended between the United States and Central America on the north and south, and the Pacific Ocean and the Gulf of Mexico on the east and west. It is 1,950 miles long and 750 wide in the widest part, and 140 in the narrowest. It has an area of 767,005 square miles, and almost equals Great Britain and Ireland, France, Germany, and Austria-Hungary together. Mexico is a republic at least in name (largely modelled on that of the United States) containing twenty-seven states and one federal district. Its population is 15,063,207 of which about twenty per cent. are white, thirty-seven per cent. Indian, and forty-three per cent. mixed blood. It consists principally of an immense tableland or plateau, averaging 8,000 feet in height at the southern

portion in the states of Mexico and Puebla, and thence northward it falls in height to 3,600 feet at El Paso Del Norte. The boundaries of this plateau are formed by the Sierra Madre—an almost unbroken chain—on the west; and on the east, parallel to the Gulf Coast and from ten to one hundred miles from it, by the Sierras of the east, forming more a series of groups than a connected range. There are also short cross ridges which break up the surface, the principal one being the Cordillera de Anahuac. Outside of these mountain boundaries the land slopes to the Gulf and to the Pacific, quite gradually on the east, while on the Pacific side the Cordillera runs on the whole very near the coast, leaving a very narrow strip of land between the same and the sea. "All climates," as Hann remarks, "are represented in Mexico—the hot, damp climate of the tropics, as well as the hot dry desert climate of the lowlands. The temperate climate of the medium elevations, and the climate of the region of eternal snows on the highest mountain peaks." This relief of the land—its varying elevation—rather than the latitude, determines the diversity of the climate.

Three different climatic zones are distinguished. *First*, the *warm—Tierra Caliente*—up to about 3,000 feet. This is considered a hot, damp, unwholesome region as a whole, especially the low marshy Gulf coast, where various diseases are prevalent—malaria, yellow fever, dysentery, and others. The temperature varies from 77° to 82° F.; it seldom falls below 60° and often rises to 100° or more. In the coast valleys, however, at an altitude of from 500 to 3,000 feet, the climatic conditions are improved, and malaria is much less prevalent. These valleys "blossom" throughout the year and are well sheltered by the mountains, so that neither extreme heat nor uncomfortable cold prevails. *Second*, the temperate zone—*Tierra Templada*—embracing territory from 3,000 to 5,000 or 6,000 feet in altitude. The climate in this region is that of continual spring, the mean annual temperature being 62° to 70° F., varying but a few degrees during the season. This zone embraces all the higher terraces and portions of the central plateau. "The zone of temperate lands, oceanic slopes," says Romero ("Geographical and Statistical Notes on Mexico," M. Romero, 1898), "enjoys an everlasting spring, being exposed neither to severe winter nor to intolerable summer heats; in every glen flows a rippling stream; every human abode is embowered in leafy vegetation, and here the native plants are intermingled with those of Europe and Africa. Each traveller in his turn describes the valley in which he has tarried longest as the loveliest in the world; nowhere else do the snowy crests or smoking volcanic cones rise in more imposing grandeur above the surrounding sea of verdure all carpeted with the brightest flowers." Chihuahua, elevation about 4,500 feet, may be taken as a type of the climate of the central plateau lying in this zone. The coldest months are from November to February, and the hottest from May to August. The summer climate is very agreeable and the air cool and bracing. *Third*, the *cold* zone—*Tierra Fria*—embracing territory of an elevation of from 5,000 or 6,000 to 8,000 and 9,000 feet. This zone includes all the higher regions of the central plateau, and Zacatecas is the gateway to it from the north. In this zone (cold) are situated some of the most important cities of Mexico, such as Aguas Calientes, San Luis Potosí, Leon, Lagos, Silio, Querétaro, Guadalajara, and Mexico City. The mean average annual temperature is from 59° to 63° F., and the rainfall is about five times less than in the temperate zone. It is in this cold zone that the most favorable climatic conditions exist for the open-air treatment of tuberculosis, if one were sure of obtaining good accommodations, good food, and efficient medical service. "In this higher plateau, the climate," says Squires (*Medical Record*, 1897, vol. lii., p. 782), "is an ideal one both winter and summer, and is rendered even and temperate by the shelter afforded by the mountains from the winds and storms. December and January are the coldest months, but the thermometer rarely reaches freezing. The days are delightful, and every day is clear and bright, and flowers are in bloom." "If possible," continues Squires, "the summer climate on this plateau is superior to that of winter; rain begins in June and continues until October. (South of latitude 28° N. there are but two seasons, the rainy and dry.) It rarely rains, however, more than two or three hours a day, in the afternoon. At this season the vegetation is luxuriant. The nights are always cool." Squires thus describes a day during the rainy season:

"One is awakened in the morning by the sunshine pouring into his room. The birds in the patio of the hotel as well as those in the gardens are singing. The fragrance of the moist ground and flowers comes into the open window with the sunshine, and aside from the clear moist air one would not realize that it had rained the day before and that it was a morning in the height of the rainy season. It seems too beautiful to remain longer in the house, and one is soon up and out into the bright sunlight. The sky is cloudless except for a little bunch of clouds near the horizon, and as the day wears on this grows larger, until by

Meteorological Observations (Annual Averages). (Taken in Various Cities of Mexico During Several Years.)
From M. Romero, prepared by the Meteorological Observatory of the City of Mexico.

Localities.	North latitude.	Height above sea level. Feet.	Temperature.			Relative humidity. Per cent.	Average clouds.	Wind.		Rainfall. Inches.
			Maximum.	Minimum.	Mean.			Prevailing direction.	Velocity.	
Mexico	19.26	7,472	88.8 F.	29.0	60.0 F.	60	5.0	N. W.	0.8	23.9
Zacatecas	22.46	8,174	71.2	43.0	55.7	48	3.2	S. E.	2.6	32.0
Guadalajara	20.41	5,131	95.9	23.9	67.4	53	No. of cloudy days, 124.	N. E.	2.4	33.6
Monterey	25.4	1,610	91.7	53.0	69.8	60	Days of rain, 94	S. E.	.....	24.5
Saltillo	25.25	5,307	93.2	27.0	62.2	61	4.4	N.	1.4	20.5
Durango	24.2	6,500	88.0	20.0	62.0	.....	.....	.....	.....	21.5
Aguas Calientes	21.53	6,086	84.3	37.0	65.4	53	.....	N.	.....	21.1
San Luis Potosi	22.9	6,190	93.0	28.8	63.3	60	4.4	E.	1.3	15.1
Silao	20.56	6,053	90.0	39.2	67.1	.....	Days of rain, 99	W.	.....	13.5
Puebla	19.03	7,106	89.4	30.0	60.2	63	4.7	N. E.	1.9	36.1
Queretaro	20.45	6,060	91.5	33.8	64.5	59	4.1	E.	0.6	23.5
Jalapa*	19.32	4,712	92.3	42.9	65.3	.....	Days of rain,202	.....	.....	.....
Oaxaca	16.57	5,092	91.2	43.2	69.0	80	.....	.....	.....	.....

*Within the belt of one hundred inches annual rainfall.

three or four o'clock in the afternoon the sun is hidden and the rain commences. Shower follows shower for two or three hours, and then the clouds disappear, and by seven in the evening the streets are dry, the moon shines out, and then the population of the town comes to take a walk and sit on the plaza, and listen to the music. One can stay there until midnight if he chooses without fear of cold or catarrh."

The foregoing table gives some of the principal climatic data of various points in this region as well as of Monterey in the warm zone, and of Jalapa and Oaxaca in the temperate:

The whole of the great central tableland—the great plateau of Anahuac—possesses an unsurpassed all-the-year-round climate; it has elevation, abundant sunshine, low humidity, small precipitation, and an equable, mild temperature with comparatively small variation throughout the year. There are also absence of snow, and protection from wind and dust. Naturally, then, such a climate should be well adapted for the open-air treatment of suitable cases of pulmonary tuberculosis, if one were sure of proper accommodations and food and efficient medical service, and —the most important of all—the assurance of a stable government for the protection of life and property. When these are assured, this region would seem destined to become a great and popular health resort. Perhaps, however, its greatest value will be in offering a permanent residence to those who are phthisically inclined, or who for any reason cannot comfortably endure the rigorous climate of the North with its indoor life.

According to Squires asthmatics find relief in this climate, and those affected with Bright's disease, without cardiac complications, experience some relief from the disease. It is favorable also for neurasthenia and insomnia. Those suffering from organic heart disease should not visit this or any other elevated region. The invalid should exercise here the precaution necessary in approaching all elevated regions, namely, to make the ascent gradually and refrain from violent exercise for some days until the circulation recovers its equilibrium.

The vegetation of Mexico is extraordinary as regards both its variety and its luxuriance. Tropical, semi-tropical, and the temperate-zone products are found at the varying elevations. In the so-called "paradise" of Mexico, the temperate-zone region, especially on the terrace facing the gulf, "a wealth of semi-tropical vegetation" is found. "No country in the world shows so many variations in the aspect of plant life as Mexico" ("The Universal Encyclopedia"). "The tropical flora invades many parts of the terrace lands and even of the plateaus to heights of 4,000 and 5,000 feet." To enumerate some of the plants and fruits—there are the orange, lemon, olive, mango, pomegranate, pineapple, banana, ginger, coffee plant, cotton, sugar cane, india-rubber tree, cocoa, almond, rice, vine, maize, wheat, tobacco, yucca, an endless variety of the cactus family, the palm, the maguey from which pulque is made, the cypress, oak, pine, fir, and cedar, and an infinite variety of plants and flowers. There are 114 different species of timber and cabinet wood, and fifty-nine classified species of medicinal plants.

A short description will now be given of some of the more important places of resort in the plateau.

City of Mexico (elevation 7,472 feet; population 470,659), situated upon the Anahuac Plateau, in the western portion of a great valley, surrounded on all sides by high mountains, with the two snow-capped volcanoes—Popocatapetl and Ixtachihuatl—rising up like watch towers over the valley, wrapped about with an extraordinarily clear atmosphere, and enroofed with a marvellously blue sky, stands the capital of the great republic of Mexico amidst imposing scenery, full of historic interest and suggestion. If the traveller has never done so before, he should not leave this memorable city without reading Prescott's fascinating and graphic description of that wellnigh incredible feat, the conquest of Mexico by Cortez, of which the capture of this city was the culmination. Round about the city are six lakes, two of which are sweet waters and the others salt. The near presence of these bodies of water is not particularly favorable from a health point of view, and has made the problem of adequate drainage difficult. The city itself is imposing in its extent and regularity; in its public buildings, churches, and cathedral, its public squares and avenues, and in its scientific and literary establishments. Water is brought into the city by two stone aqueducts leading to a great number of fountains from which the water is distributed in earthen jars by water carriers. There are also many artesian wells. The whole valley in which the city is situated is now drained by a tunnel (six miles long, extending through the mountains) and a canal, the total length of the two combined being nearly thirty-seven miles. With this canal and tunnel the city is connected by a new and complete sewerage system. The climate is temperate and delightful. The mean annual temperature is 60° F., the maximum 88.8° F., and the minimum 29° F.

The temperature of Mexico City for July is as follows:

Monthly mean in shade	62.96° F.
Monthly mean in sun	63.14
Maximum in shade	77.18
Maximum in sun	88.34
Minimum in shade	53.60
Minimum in open air	46.40
Total range in shade	23.58
Total range in open air	41.94

The nights and mornings are cool and agreeable the year through, although occasionally in January and February the thermometer sinks to the freezing-point in the mornings. The warmest months are April and May, and the coldest December and January. The rainy season lasts from May to October; there are 139 rainy days, and the annual precipitation is 23.9 inches. The mean annual relative humidity is sixty per cent.; it is the least in spring, forty-nine per cent., and the greatest in September, seventy-two per cent. Heretofore Mexico has not been a healthy city owing to the lack of proper drainage and the habits of the poor classes. Intestinal diseases are the most common and fatal; typhus fever, rheumatic fever, tuberculosis, and smallpox among the Indians, are also prevalent. Malaria is common, and, in the higher elevations in general, pneumonia is a much dreaded disease, and a very large per cent. of the cases are quickly fatal. According to Galloway, nasal catarrh is very prevalent among the Americans ("Experience of an American Physician in Mexico," D. H. Galloway, *Journal American Medical Association*, 1895, vol. xxiv., p. 119).

From Mexico City many attractive excursions can be made to the Castle of Chapultepec, Guadalupe, Hidalgo, Toluca, and other points of interest. There are a number of good hotels and restaurants in the city, and an extensive system of tramcars. French, English, and Spanish are spoken in the hotels and shops.

Guadalajara, 5,131 feet above the level of the sea, has a population of 118,799 inhabitants. It is called the "Pearl of the Occident," and is said to be one of the best lighted and cleanest cities of Mexico. Here is a fine cathedral, the largest theater in the republic, a famous hospicio, and many fine parks and gardens. According to Solly ("Medical Climatology") Guadalajara is well supplied with restaurants and hotels, and the drainage and sanitary conditions are superior to those of most Mexican towns.

The climate is fine, partaking of the characteristics of all this plateau. The mean annual temperature

is 67° F. with a maximum of 95.9° F. and a minimum of 23.9° F. In winter there is an average of twenty-five cloudy days. Forty miles south of Guadalajara is Lake Chapala, 6,000 feet above the sea. It is fifty miles long and eighteen wide, and is the largest lake in the republic. Fifteen miles east of the city are the Falls of Juanacatlan, called the "Mexican Niagara." The excursion to San Pedro, a favorite and wealthy suburb of the city, is very attractive, as are many other excursions round about the city.

Querétaro—elevation 6,060 feet—contains 35,011 inhabitants and is beautifully situated in a fertile valley with the mountains in the distant background. It is said to be one of the most beautiful cities in Mexico. The streets are narrow and crooked but generally neat and clean. There are many attractive old churches, numerous public fountains, and handsome plazas. A stone aqueduct, five miles long and of attractive architecture, brings water into the city. Two miles out of the city is the spot where the Archduke Maximilian was shot in 1867. The climate of Querétaro is much like that of Guadalajara, the annual average temperature being 64.5° F.; the maximum 91.5°, and minimum 33.8°. In 1894 the seasonal temperature was as follows: winter, 59° F.; spring, 69°; summer, 68°; autumn, 62°. The monthly mean for January was 60°, and for May (the warmest month), 72°; for July, 67° (Solly).

San Luis Potosí.—elevation 6,190 feet, population 82,976—an enterprising business city called "the Chicago of Mexico." It is situated in a fertile region surrounded by mountains. The climate is very much like that of Querétaro, the mean annual temperature being 63.3° F. San Luis Potosí is in a region of rich silver mines, and has the largest smelting plant in Mexico. The drainage is said to be poor, but the streets are clean. There are a government palace, a cathedral, plazas, and an attractive alameda.

Saltillo—elevation 5,307 feet, population 35,063. This city possesses an excellent all-the-year-round climate. The mean annual temperature is from 62° to 64° F.; the maximum 93.2° F., and the minimum 27° F. The number of rainy days is sixty-six yearly. There is a good water supply from the mountains. In the parks flourish, throughout the year, the lemon and orange trees, the oleander, rose, violet, geranium, and other plants of a semi-tropical nature. The climate of this place is said to be favorable for persons suffering from malaria, or from nervous maladies, and for weakly individuals. Saltillo possesses warm sulphur springs, and there are two hotels.

Durango—elevation 6,500 feet, population 37,085—is situated in the plain of San Antonio, and possesses a mild, dry climate, with a mean winter temperature of about 50° F., and an annual mean temperature of 62° F. There is an abundant supply of pure water, but no good system of drainage. The streets are well shaded, and the plazas are attractive, with flowers in bloom the whole year. According to Hinsdale ("A System of Physiological Therapeutics," vol. iv., book ii., Climatology, p. 322) it is an excellent place for the *tuberculous*, but there is but one hotel in the town and the prices there are excessive.

Zacatecas—elevation 8,174 feet; population 25,905. This is a mining town of ancient date, picturesquely situated in a mountain ravine, and is one of the highest points in Mexico. On account of its great elevation the climate is cool, very dry, and stimulating. The mean annual temperature is 55.7° F.; the maximum 71.2° F., and the minimum 43° F.; the average relative humidity is 48 per cent. Tuberculosis is said to be very rare there.

Aguas Calientes—6,086 feet above sea level, a city of 77,800 inhabitants—has a fine climate the year round, and, according to Squires, the hotels are exceptionally good. The hot baths are a great attraction, and there are well-appointed bathhouses with arrangements for shower baths, and large swimming tanks. These baths are much frequented and are serviceable for rheumatism, skin, and nervous diseases. There are many fine gardens and several plazas here. In the month of April is held the annual fair (the Feast of San Marcos), which attracts people from all over the republic. This city is on the line of the Mexican Central Railway, and is also connected with Tampico by rail.

Silao—elevation 6,053 feet; population, 15,000. This is an attractive town with handsome gardens and some fine churches, possessing a climate very similar to that of Guadalajara. The mean annual temperature is 67.1° F.; the maximum 90° F., and the minimum 39.2° F. According to Hinsdale (*loc. cit.*) there is a sanatorium here under good medical direction.

Puebla—elevation 7,106 feet; population 101,214. This large city, 115 miles southeast from the city of Mexico, is beautifully situated in the midst of a well-wooded and fertile district, near the snow-capped mountains, and is said to be one of the cleanest and best-drained cities in Mexico. The streets are broad; there are several plazas, and the cathedral vies in richness and beauty with that in the city of Mexico (Solly). The climatic data are similar to those for the city of Mexico, except that its greater nearness to the snow-covered mountain peaks renders the nights cooler. Seven miles from Puebla is the great and famous pyramid of Cholula.

Many other cities might be mentioned, such as Guanajuato, Leon, Morelia, Patzcuaro, Chihuahua, Monterey, and others, but it would be, in a measure, but a repetition, as the general characteristics of all these Mexican towns are quite similar, and in their climate they differ one from another principally in the difference of the climate of the so-called "temperate" and "cold" zones.

There are also many mineral springs of value in various portions of the country. Some have already been mentioned, others are at Santa Rosalia, a town of about 8,000 inhabitants, where there are sulphur springs with accommodations which are said to be good. Near Mexico City, at Guadalupe, are the Penon baths and wells, which are said to compare favorably with Kissingen, Wiesbaden, Wildbad, and Ems; there is a hotel with modern conveniences and bathhouses "complete in every particular." Four miles distant from Monterey are the Topo Chico hot springs with an excellent bathhouse conducted by an American. At Comaujilla, near Monterey, are others.

The Mexican Central Railway traverses the great central plateau from El Paso in New Mexico to Mexico City, and to Tampico on the Gulf Coast, thus affording easy access to most of the large cities in this region. Other places are reached by the Mexican International, National, and other railways. Excellent excursions with first-class accommodations afford opportunities, during the winter and spring, for making the Mexican tour. One can also reach Mexico by water to Tampico and Vera Cruz, and thence by rail to Mexico City.

Edward O. Otis.

Meyer, Hans Wilhelm.—Born in Fredericia, on the eastern coast of the peninsular part of Denmark, October 25, 1824. He pursued his medical studies at the University of Copenhagen, and passed the State examinations in 1847. He then spent several years in visiting the hospitals and clinics of Prague, Paris, London, Montpellier, etc. In 1853 he began the practice of his profession in Copenhagen, and in 1865 he established a Clinic for Diseases of the Ear, Larynx and Nasal Cavities. From this time onward he contributed to current medical literature a number of

articles on topics related to this specialty—articles which marked a new epoch in nasopharyngeal surgery. Meyer was the first to call attention to the existence of adenoid vegetations in the vault of the pharynx, to emphasize their causative relationship to affections of the middle ear as well as to other abnormal bodily conditions, and to formulate a rational and effective method of treating them. Three articles, all bearing the same title ("Ueber adenoide Vegetationen in der Nasenrachenhöhle"), appeared in succession—the first one in *Hospitalstidende* (1868), the second in the *Medico-Chirurgical Transactions* (liii., 1869), and the third in the *Archiv für Ohrenheilkunde* (vii., viii., 1873–1874). Then again, in the Proceedings of the International Medical Congress (London, 1881), Meyer published a new paper on this same subject. He also wrote papers on other otological topics—as, for example, "Ueber das Wesen der Chronischen Trommelhöhlenеiterung," 1884; and "Zur Behandlung der Ohrblutgeschwulst," in Archiv f. Ohrenk., xvi., 1880. He died June 3, 1895. A. H. B.

Meynert, Theodor.—A prominent psychiatrist of Vienna, Austria. Born at Dresden, Saxony, June 15, 1833. He received his doctor's degree from the University of Vienna in 1861, and four years later he was appointed an instructor in the anatomy and functions of the brain in the same institution. Then, step by step, he was promoted to the following positions: Prosector of the Vienna Insane Asylum in 1866; Chief of the Psychiatric Clinic and Professor Extraordinary of Psychiatry in 1870; Professor-in-Ordinary of Diseases of the Nervous System in 1873; and Hofrat in 1885. He died May 31, 1892.

The following represent some of the more important of Meynert's published writings: "Anatomie der Hirnrinde als Träger des Vorstellungslebens und ihrer Verbindungsbahnen mit der empfindenden Oberflächen und den bewegenden Massen," In *Leidesdorf's Lehrb. d. Psych.*, 1865; "Der Bau der Grosshirnrinde und seine örtliche Verschiedenh.," Neuwied, 1868; "Ueber den doppelten Rückenmarkssursprang im Gehirne," in *Wien. Akad. d. Wissensch.*, 1869; and "Psychiatrie, Klinik der Erkrankungen des Vorderhirns," I. Hälfte, Vienna, 1884. A. H. B.

Mezereum.—Mezereon. The barks of several species of *Daphne* are collected and sold under the above names; thus the United States Pharmacopœia admits "*D. mezereum* L. and other European species;" the British Pharmacopœia "*D. mezereum*, *D. laureola*, and *D. gnidium* L." The French Codex restricts the name properly to the first-named species, but also recognizes *D. gnidium* L. as *Garou ou Sainbois*. The genus is essentially of European and Asiatic origin, and comprises about forty species of trees and shrubs, with tough, irritating, and acrid bark, and generally evergreen leaves, and pretty, usually fragrant, flowers. Several species are cultivated as ornamental shrubs.

Mezereon bark is collected in winter, and imported in rolls or bundles; often it is pressed irregularly into bales. It is prepared for the market in the form of long, very tough strips which curl inward on drying. Externally, it is smooth, grayish, or reddish brown with transverse scars and minute blackish dots. Underneath the corky layer it is bright green. Internally, it is whitish and silky. The corky and bast layers are easily separable; odor slight (when dry), taste very acrid. The fresh bark is actively irritant to the skin, and may be used as a vesicant. The dried bark moistened, or a decoction made from it, has the same qualities. Owing to this irritating quality it is made abroad into liniments and ointments.

Composition.—*Mezereum resin*, a yellowish-brown, shining, non-crystalline substance of sharp, burning taste, and very irritating action upon the nasal mucous membranes and skin, is the irritating constituent. *Daphnin* is a crystalline, bitter glucoside, not important.

Action and Use.—Of the irritating character of the bark, due to the above-named resin, and its application in blistering fomentations, liniments, etc., perhaps enough has been said. It is not so desirable for use, in this country at least, as several better known and more reliable rubefacients—ginger, for instance, or cantharides. Internally it has been given in chronic rheumatism, in syphilis, "scrofula," etc., with no definite reason and no advantage. In overdoses it is a gastrointestinal irritant poison.

Administration.—Pieces of the bark soaked in vinegar are sometimes used as slow blisters. For internal use the dose of the bark is, say gr. iij. (0.5) or a little more; it is very seldom given alone. Our official preparations are: Compound Decoction, and Compound Extract of Sarsaparilla, and the Fluid Extract of Mezereon. An extract also was formerly official, but was dropped because its use became obsolete in this country. H. H. Rusby.

Miana Bug.—A tick, *Argas persicus*, which is widely distributed through Europe, Asia, Africa, North America and Australia. It is preëminently a parasite of fowls, but readily attacks man and causes a very painful bite. The adults of this species may live for more than a year without food. See *Arachnida*.

A. S. P.

Microfilaria.—A generic term that has been used to designate larval forms of various round worms of the genus Filaria. See *Nematoda*. A. S. P.

Microscope and its Accessories.—The microscope is an optical apparatus by means of which a clear, enlarged image of a near object is obtained. The name microscope was invented by Giovanni Faber, a member of the Academy of the Lincei, in 1625. There are two forms of microscopes, simple and compound. A simple microscope consists of one or more converging lenses or lens systems. A compound microscope is more complex consisting of an objective, that forms

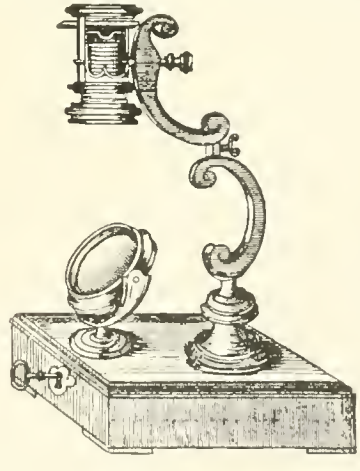
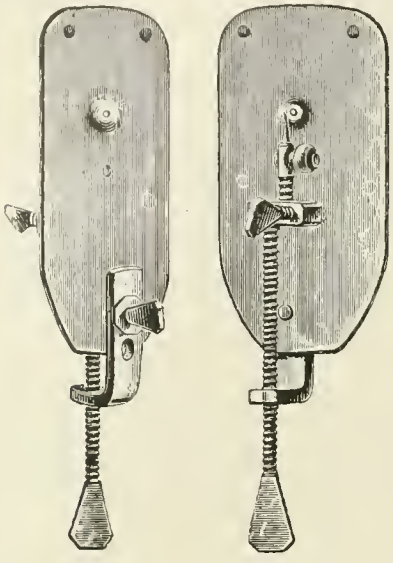


Fig. 3977.—Wilson's Simple Microscope, Made by Adams (1746). (Carpenter.)

an enlarged image of the object, and an ocular, that magnifies the real image. Before going into the description of these forms, it will be of interest to consider the history of the instrument.

The discovery of a simple microscope is accredited to a Franciscan monk, Roger Bacon, who, in 1276, described "Crystal lenses that show things larger." The earliest simple microscope illustrated is that of Descartes, which Lieberkuhn's microscope resembles closely. Between these stand the simple instruments of Leeuwenhoek.



A B

Fig. 3978.—Leeuwenkoek's Microscope (1673). *A*, front view; *B*, back view. (Carpenter.)

The compound microscope is distinctly a modern instrument, the first having been made during the seventeenth century. Although there are several who are accredited with the discovery of the instrument, it is stated by Govi that Galileo was the inventor. He obtained from the Dutch telescope the first compound microscope, in 1610, and this instrument he called an *occhialino*. It is this instrument to which Faber first applied the name microscope. In 1621 Drebbel reduced the Keplerian telescope to a microscope. According to Galileo the instrument "magnified 50,000 times, so that one sees a fly as large as a hen." In reality the linear amplification is equal to about thirty-six times.

Fig. 3979.—Campani's Microscope (1660). (Carpenter.)

Perhaps the earliest microscopes existing to-day are two of unknown origin that closely resemble that of Campani. These are in the Museo di Fisica and belonged to the Accademia del Cimento. The first practical microscope with a field lens is described by M. de Monconys in 1665, but was made for him in 1660.

One of the earliest microscopists was Robert Hooke of London. In his "Micrographia" published in 1665 he gives an illustration of his microscope. This contained a field lens and Hooke perfectly understood its usage. This microscope had no mirror, but a very powerful illuminating apparatus took its place. Although a seemingly crude affair, the results obtained by Hooke were very good and gave an impetus to the subject of microscopy in England. Until 1716 very little progress was made in the development of the microscope. In this year Hertel not only produced a better mounting, but also introduced the mirror for

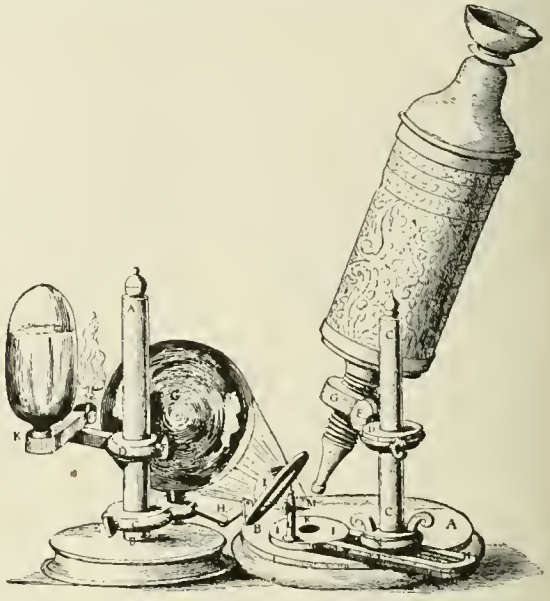


Fig. 3980.—Hooke's Compound Microscope (1665). (Carpenter.)

reflecting the light, and a movable stage above the level of the base of the instrument. Somewhat later Martin added great improvement in the way of arrangement of lenses and the mechanism. He was the first to use a rack and pinion adjustment and the incline movements of the pillar. One of the best of his instruments was made in 1780 and stood two feet high. The lenses were twenty-four in number and varied in focal length from four inches to one-tenth inch.

Fig. 3981.—Linen Tester.

Fig. 3982.—Tripod Magnifier.

Probably the first microscope approaching those of recent date in form is that of Lister (1826). Through his able writings a powerful influence was exerted upon the advancement of the microscope, both from a mechanical and an optical standpoint. Powel's microscope (1835) was an excellent piece of workmanship and represented the acme of perfection of that time. The fine adjustment was slow, but one of the steadiest ever devised. The substage condenser was adjustable and the stage an advance over preceding forms.

Fig. 3983.—Watchmaker's Glass.

From this time on rapid strides were made in the matter of lenses, adjustment, illumination, stages, and other refinements until the beautiful, highly accurate, and mechanically perfect instrument of to-day was

evolved. The instruments of to-day come under the general types American, English, and Continental.

Simple Microscopes.—These consist of one or more converging lenses or lens-systems and comprise the hand magnifiers and most of the simpler dissecting microscopes; the latter are mounted forms.

The simple forms are represented by reading glasses, tripod magnifiers and triplets and are used when only moderate magnification is desired and for the examination of opaque objects. They are necessary adjuncts for study and dissection in botany and biology, and in the arts they play an especial rôle in the examination of linens, in engraving, watch-making, etc. They are usually small and conveniently carried in the pocket.

Reading glasses give low magnification, but cover a large field. They vary in diameter from two to six inches.

Linen testers are small and also give low magnification, but the field is restricted. They have the advantage of being folded and the lens protected.

Tripod magnifiers give a large field and have the advantage of an adjustable focus.

A *watchmaker's glass* is used by jewelers and engravers and gives a magnification of from four to ten times.

Other pocket magnifiers are made as single lenses, doublets, and triplets. The doublets give three different focal lengths, hence three different magnifications; the triplets six different focal lengths and six different magnifications. The doublets and triplets in which all lenses are fixed, and hence give but one magnification for each mount, may be purchased, and these magnify from six to twenty-four times.

A *B*

Fig. 3984.—Triplet Magnifiers. *A*, Adjustable; *B*, non-adjustable.

For more careful and detailed work of dissection, these lenses are mounted and then form *dissecting microscopes*. The simple microscope of Wilson (1746) resembles somewhat the dissecting microscope of to-day.

A late type of dissecting microscope is shown in Fig. 9. This consists of a horseshoe-shaped base, from which extends the pillar to which are attached

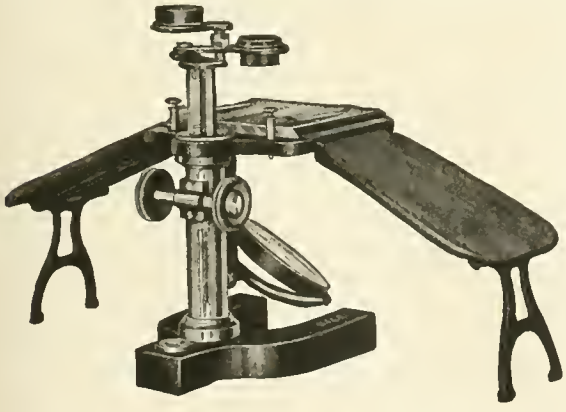


Fig. 3985.—Dissecting Microscope.

the rack and pinion adjustment and the stage. The rack and pinion moves the column up and down in focusing. To the column is attached a jointed lens-arm carrying two lenses (doublets or triplets). By means of the jointed arm the lenses may be carried over any area of the stage. The stage is chiefly glass and possesses two clips for holding slides in place. A metal plate, black and white, may be inserted beneath the stage to give an opaque background. Beneath the stage is a mirror, plane and concave, attached to an adjustable arm. At the sides of the stage are attached the removable hand rests.

The Compound Microscope.—In order to understand the use and manipulation of this instrument, a knowledge of its parts is essential. It consists of two main portions, the stand and optical parts. The stand comprises a base, *B*, that varies in the different makes, but should be heavy so as to give stability. From

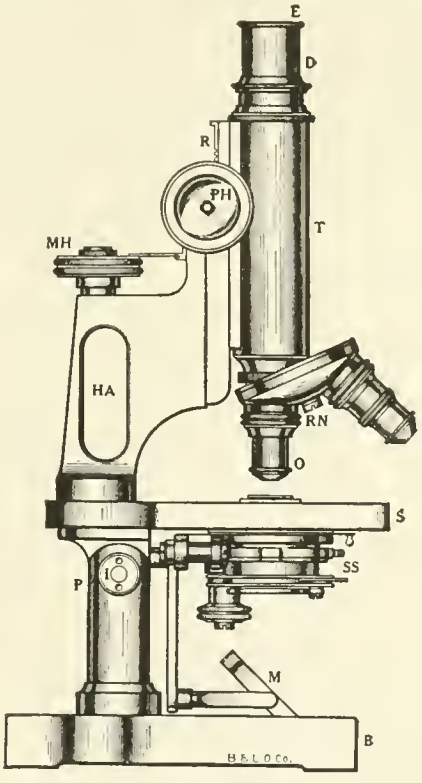


Fig. 3986.—Parts of the Microscope: E, Eyepiece; D, draw-tube; T, body-tube; RN, revolving nose-piece; O, objective; PH, pinion head; MH, micrometer head; HA, handle arm; S, stage; SS, substage; M, mirror; B, base; R, rack; P, pillar; I, inclination joint.

the base arises column *P*, called the pillar. The parts above are joined to the pillar at *I*, so that they may be inclined at various angles. Above the pillar is the handle, *HA*, upon the top of which is the micrometer screw, *MH*, or fine adjustment. To the front of the handle is attached the tube, *T*, which is worked up and down by means of the rack and pinion adjustment, *PH*; at the upper end of the tube is the ocular, *E*, that fits into the draw tube, *D*, mounted in the main tube. At the lower end of the tube is attached the revolving nose-piece, *RN*, which may accommodate two, three, or four objectives. Extending at right angles from the base of the handle is the stage, *S*, upon which the objects for examination are placed and held in place by spring clips. Beneath the stage is the substage, *SS*, which may be simply an iris diaphragm, or may consist of Abbé condenser and iris diaphragm as the cut shows. This substage may be lowered and swung out of line. Suspended from the stage by a movable arm is the mirror, one side of which is concave and the other plane.

The *ocular* is in reality a simple microscope as it enlarges the image made by the objective. It consists of an upper ocular lens and a lower objective, or field lens; these are plano-convex. The ordinary achromatic or Huyghenian eyepieces magnify from five to fifteen times according to the focus of its lenses. This ocular was designed by Huyghens for the telescope and later adapted to the microscope. All oculars are usually identified by a number that indicates its magnifying powers.

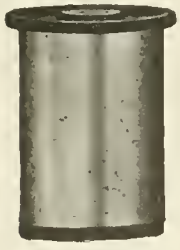


Fig. 3987. — The Huyghenian Ocular.

The *compensating ocular* is used only with apochromatic lenses. This form of eyepiece corrects the color fringe at the marginal parts of the image and gives a larger field than the preceding.

The *modern objective* consists of one or more converging lens systems; the image formed is enlarged, inverted and real. Each combination comprises a convex and concave lens; that nearest the object is called the front combination and that nearest the ocular, the back combination. Between these may be one or more sets of lenses. This combining of lenses is done to avoid spherical distortion of the image and to free it from color as two colors of the spectrum are brought to the same focus producing white light. These lenses are now made of new Jena glass, whereas formerly the convex lens was made of crown glass and the concave of flint glass.

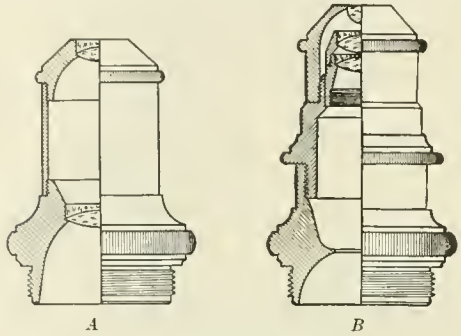


Fig. 3988.—The Objective, Sectional View. *A*, 16 mm. objective; *B*, 4 mm. objective.

The *achromatic objectives* are the usual or ordinary ones. These are corrected for one color, the central part of the spectrum, and their defining powers are limited as is also the magnification eyepiece used with it. They are undercorrected spherically for red rays and overcorrected for blue rays.

Apochromatic objectives are superior to the preceding and more costly. The lenses are made of a new kind of glass combined with a natural mineral as calcium fluorid (fluorite, or fluorspar). They bring three colors of the spectrum to a focus, practically doing away with the secondary spectrum so that all images formed are nearly equally sharp for all colors of the spectrum. This color correction is obtained in all zones of the objective, while in the achromatic objectives the best correction is one, the central zone. The image is much more perfect and brighter making the lenses of greater value in photography. Higher oculars are more readily used as they are capable of using a greater amount of light than the achromatic objectives. Compensating oculars only can be used with these objectives.

Most objectives are unadjustable, that is, the lens systems are all fixed in position. Adjustable objectives are those in which the position of the front or back systems may be regulated so as to compensate for the displacement of light by the mounting medium and coverglass after the light has left the object.

Parachromatic or *semi-apochromatic objectives* are just between the two preceding forms and are better than the achromatic, but not so good as the apochromatic objectives.

Objectives are usually designated by their equivalent focal length either in millimeters or inches and fractions of an inch. An objective designated as $\frac{1}{12}$ inch or 2 millimeters indicates that the image it produces is the same size as that of a simple lens of $\frac{1}{12}$ inch or 2 millimeters in focal length. They vary then from 2 inches to $\frac{1}{16}$ inch, or 50 millimeters to 1.5 millimeters equivalent focus; the shorter the focus the greater the magnifying power. With low and medium (2 inches to $\frac{1}{8}$ inch) power objective, nothing intervenes between the object and objective but air and these are called *dry objectives*. When some liquid is placed upon the object so that the objective stands therein, they are termed *immersion objectives* and the liquid called an immersion fluid. With the $\frac{1}{8}$-inch objective, *water* is used; with higher power objectives, some other liquid the refractive and dispersive power of which is the same as that of the front lens of the objective. Such fluids are called homogeneous and comprise thickened cedar-wood oil, or glycerin with stannous chloride in solution. As cedar-wood oil is most commonly used, these objectives are termed oil-immersion objectives. By the use of immersion fluids the rays of light are not refracted from the time that they leave the balsam,

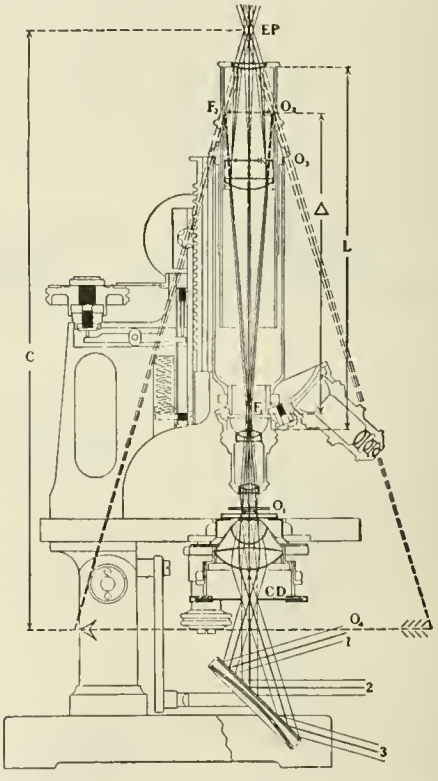


Fig. 3989 —Diagram Showing the Course of Light Rays through the Microscope. F_1, Upper focal plane of objective; F_2, lower focal plane of eyepiece; Δ, optical tube length = distance between F_1 and F_2; O_1, object; O_2, real image in F_2, transposed by the collective lens to O_3, real image in eyepiece diaphragm; O_4, virtual image formed at the projection distance C, 250 mm. from EP, eyepoint; CD, condenser diaphragm; L, mechanical tube length (160 mm.); 1, 2, 3, three pencils of parallel light coming from different points of a distant illuminant, for instance, a white cloud, which illuminate three different points of the object.

in which the object is mounted, until they enter the objective as shown in Fig. 3990.

MAGNIFICATION OF ACHROMATIC OBJECTIVES.
Tube length 160, distance of image 250 millimeters.

	Objective.	Huygbenian eyepieces. 3 ×	4 ×	6 ×	8 ×	9 ×	Objective.
Dry objectives	32 mm.	18	25	35	47	54	32 mm.
	16 mm.	42	60	80	118	132	16 mm.
	8 mm.	93	126	190	250	283	8 mm.
	4 mm. long working distance	200	260	400	530	600	4 mm. long working distance.
Water imm. millimeters	4 mm.	200	260	400	530	600	4 mm.
	3 mm.	275	375	550	750	825	3 mm.
	3 mm.	275	375	550	750	825	3 mm.
	2 mm.	400	510	800	1,000	1,200	2 mm.
	1.5 mm.	533	670	1,066	1,330	1,600	1.5 mm.

MAGNIFICATION OF APOCHROMATIC OBJECTIVES.
In combination with compensating eyepieces. Tube length 160 millimeters, distance of image 250 millimeters.

Objectives.	Compensating eyepiece. 1 ×	3 ×	6 ×	9 ×	12 ×	Objectives.
16 mm.	15.6	47	94	141	187	16 mm.
8 mm.	31.2	94	187	287	375	8 mm.
4 mm.	62.5	187	375	562	750	4 mm.
3 mm.	83.3	250	500	750	1,000	3 mm.
2 mm.	125.0	375	750	1,125	1,500	2 mm.
1.5 mm.	166.7	500	1,000	1,500	2,000	1.5 mm.

The *tube* is that portion to which the optical parts are attached. The upper portion which receives the ocular is double, so that it can be drawn out, and is marked in millimeters. This is due to the fact that objectives are corrected for certain distances, most of them for 160 millimeters. To get the best results, the draw-tube should be set at that mark. To the lower end of the tube is attached the revolving nose-piece that may be double, triple, or quadruple. By this device one lens can replace another by merely revolving the nose-piece to the next stop. The tube is the part of the mechanism that moves up and down in focusing. It should be fitted so that its position is not altered by ordinary jars.

The *rack and pinion adjustment* moves the tube up and down a considerable distance at each turn. By this means a near focus is obtained. It should be of such a nature, however, that a high-power objective can be brought to an exact focus.

The *micrometer screw*, or fine adjustment, moves the tube a minute fraction of the distance that the rack and pinion does and is used after the latter to bring the image into exact focus. It should not be necessary to turn the screw a full turn either way.

A *pneumatic focusing attachment* has been devised by Dr. M. J. Greenman. By means of compressed air, a larger wheel is moved either way. This motion is transferred and reduced, by small gears, to the micrometer screw and the microscope is thus focused. The amount of air is easily regulated by means of a lever that admits the air into the tube by means of a three-way valve. This apparatus is of especial importance in photomicrography where the operator must be at some distance from the microscope.

The *substage* is beneath the stage and for ordinary work up to 500 diameters consists of an iris diaphragm and the mirror. The iris diaphragm can be regulated so that its opening is of any size. The object of the diaphragm is to cut off all extra light rays, so that those that enter the objective come from the object or its immediate neighborhood. The opening should be about that of the front lens of the objective. It should be mounted as close to the object as possible.

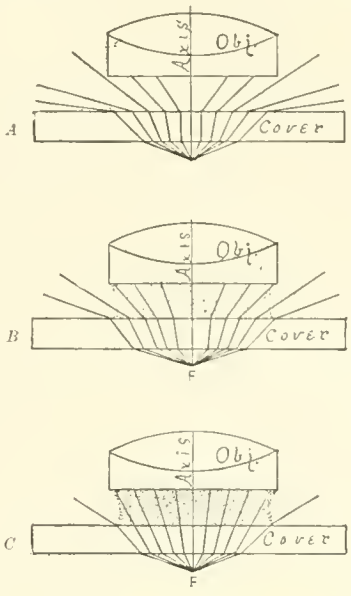


FIG. 3990.—Diagram Showing the Current of Light Utilized by Dry, Water-immersion, and Oil-immersion Objectives. *A*, dry; *B*, water; *C*, oil. (Gage.)

The *mirror* should be freely movable, but remain firmly in any position. One side should be plane and the other concave. The plane side is used when parallel rays of light are desired or when only a moderate amount of light is required; the concave mirror gives a greater amount of light.

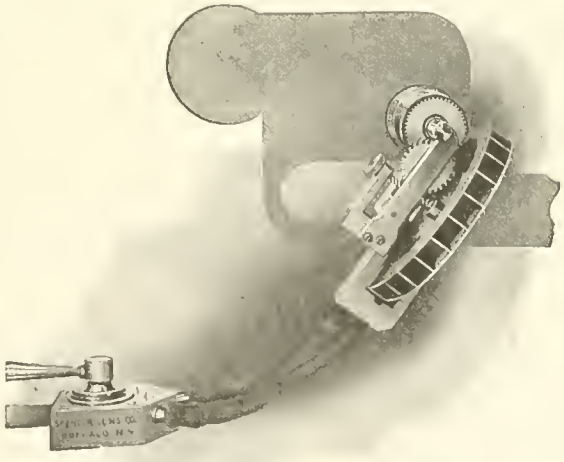


FIG. 3991.—Pneumatic Focusing Device.

Condenser.—The higher the power of the objective, the more light is required as in bacteriology and ultramicroscopy. As ordinary mirrors do not suffice, this difficulty is overcome by the use of a condenser, or

illuminator. The best is the achromatic form, but the one most used is the non-achromatic or Abbé condenser. This consists of two plano-convex lenses, or two plano-convex with an intermediate concavo-convex lens. The condenser should be mounted so that it may be readily moved up and down and also easily swung out of the field when not desired.

In order to examine an object with a simple or compound microscope it must reflect light (opaque objects), or transmit light (transparent objects). In the study of whole objects, as in botany and zoology, rays of light (usually daylight) fall upon the object and are reflected through the lens to the eye. This is called reflected or direct light. When high-power lenses are used, the light must be strengthened by means of a bull's eye lens, or special illuminating objectives.

In the study of transparent objects, as prepared slides and minute animal and plant forms, the light rays pass through the object from a mirror or condenser and constitute transmitted light. This may be either central (axial) or oblique. In the former instance, the light rays are either parallel to or coincident with the optical axis of the microscope, and the object is symmetrically illuminated. In the latter, the rays of light are reflected at an angle to the optical axis.

Light and Illumination.—For most work daylight (not direct sunlight) is the best, though not absolutely necessary. Artificial light may be obtained from an ordinary lamp, a Wellsbach, or an incandescent lamp with a frosted globe, or an especial electric arc light. When the mirror is so set that the rays of light pass into the microscope parallel to its optical axis, the method is called central or axial lighting. If the mirror be tilted so that the light rays are very oblique to the optical axis, it is termed oblique illumination. Some objects are studied better by this method. Again some objects under proper lighting conditions appear self-luminous on a dark field. This condition is obtained by the use of a central stop diaphragm.

Binocular Microscope.—As early as 1677 Cherubin D'Orleans constructed a binocular microscope which gave inverted images. The first practical erecting binocular microscope was devised by Professor J. L. Riddell of New Orleans, in 1851, and constructed in 1852. Only one objective was utilized and the inverted image was erected by means of prisms. The best type to-day is the Greenough type of binocular. This consists of two separate ocular parts mounted on one stage. Below the ocular of each tube is placed a

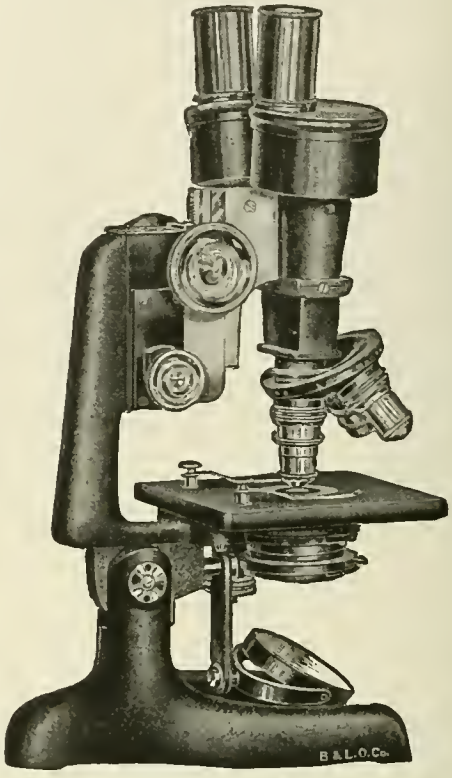


Fig. 3993.—Binocular Microscope.

Porro prism for erecting the image. Each tube may be used without the other and they may be moved apart or closer together to suit the position of the eyes of the different individuals. These microscopes are of great value to the zoologist, botanist, and embryologist for dissection.

Although formerly the microscope was a necessary part of the equipment of laboratories of Histology, Pathology, Embryology, and Clinical Medicine, it plays an important rôle in Petrology, Mineralogy, Crystallography, Metallography, and Metallurgy. For these purposes they are of especial design. For details the reader is referred to special works.

Portable Microscope.—Owing to the extensive and varied use to which the microscope has been put, it has been necessary to take it far from the laboratory. Its use by engineers, explorers, army surgeons, etc., has necessitated a modification of the usual form for the convenience of carrying. This has resulted in the manufacture of a compact instrument of the folding type without sacrifice of its efficiency. This result is obtained by the use of a V-shaped, hinged, folding base and by mounting the stage on a joint with a

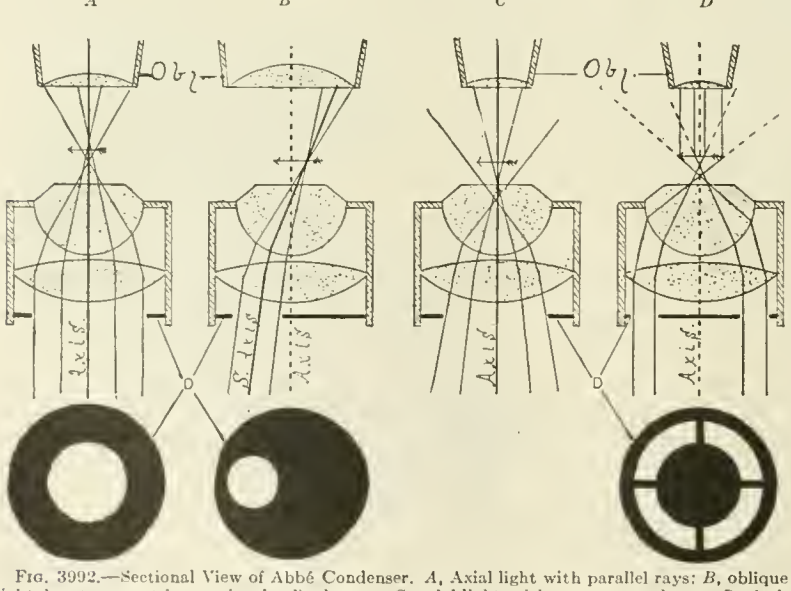


Fig. 3992.—Sectional View of Abbé Condenser. *A*, Axial light with parallel rays; *B*, oblique light due to eccentric opening in diaphragm; *C*, axial light with convergent beam; *D*, dark ground illumination with central stop diaphragm. (Gage.)

clamp so that the stage may be turned into a vertical position when the instrument is packed, reducing thereby the transverse dimension by one-half.

Accessories.—The accessories comprise mechanical stage, micrometers, preparation marker, and camera lucida, etc.

Mechanical Stage.—The stage of an ordinary microscope is a fixed part of the stand and the slides are held in place by means of two clips. In studying the various fields of the object the slide is manipulated by the hands of the observer. Without a marker, or other suitable device, given areas are difficult to find upon subsequent examinations. To overcome this and to give greater convenience of manipulation, especially with high-power objectives, the mechanical stage has been devised. This may be either of an attachable form or may be incorporated in the instrument as a revolving mechanical stage.

The ordinary, or attachable, mechanical stage may be put on or taken off of the microscope stage at will. It is either clamped or screwed to the stage so as to give firmness and stability. It is provided with two rack and pinion screws which move the object slide, one from side to side and the other forward and backward. In one of the latest models the backward and forward movement amounts to 38 millimeters and the lateral movement to 60 millimeters, permitting thus the study of serial sections on two- by three-inch slides. The movements are at equal speed in both directions. The verniers are graduated to read 0.1 millimeter and if a record of position is kept, the same area may be quickly found by placing slide in the recorded position.

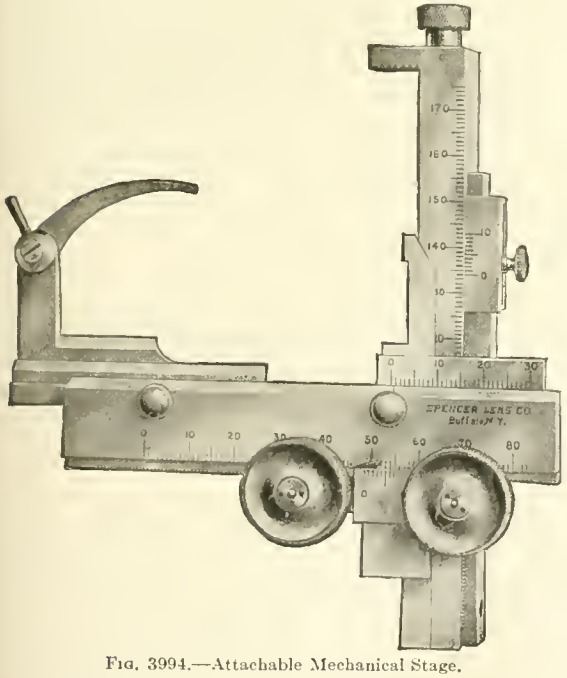


Fig. 3994.—Attachable Mechanical Stage.

The revolving mechanical stage is circular in form and is adapted only to those microscopes with circular, self-centering stages. In addition to the movements of the preceding form this stage has also a circular movement. Its circumference is divided into 360 degrees and has a vernier reading to 0.1 of a degree. The whole stage may be centered to the optical axis by means of two centering screws.

Double Demonstrating Eyepiece.—In order that the same object may be examined in the same microscope by two simultaneously, student and teacher, say, a double demonstrating eyepiece is used. This instrument fits into the microscope like an ordinary ocular. In this part, prisms are so arranged, above the eyepiece stop, so the same image is seen through the laterally placed ocular. This lateral ocular is independently adjusted so as to compensate for differences in the sight of two observers. A movable

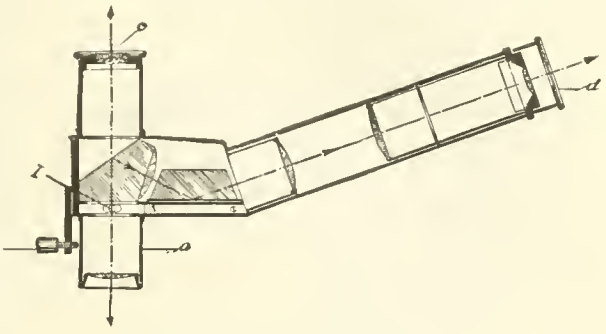


Fig. 3995.—Demonstration Eyepiece.

pointer is fitted into the eyepiece and this can be manipulated so as to point to any part of the field. This instrument is used in class teaching and also in photography of living bacteria illuminated with the dark ground condenser, as the photographer can watch for the best pose of the organisms, so to speak.

Micrometer.—In order to obtain the size of objects with the microscope, various forms of micrometers are used. As a unit of measure, Hartung (1859) proposed the use of one one-thousandth of a millimeter. Listing (1869) favored this unit and used the term mikron which is now written micron and indicated by the Greek letter Mu (μ).

The easiest way to obtain the size of an object is to trace its outline with the aid of a camera lucida and then to place a stage micrometer upon the stage and compare the drawing with the lines on the scale.

The stage micrometer consists of a glass slide 25 × 75 millimeters upon which a scale is ruled. The scales vary and may be 0.1 millimeter, 0.01 millimeter, 0.1 inch or 0.01 inch. The micrometer discs are discs of glass made to fit in the eyepiece of the microscope. These are designed in various rulings, as (1) lines 0.1 millimeter apart and each tenth line numbered; (2) in 0.5 squares; (3) in 1.0-millimeter squares; (4) one large square divided into four, one of which is subdivided into twenty-five squares of which one is still further subdivided into twenty-five. The last disc is used in counting bacteria.

Fig. 3996.—Micrometer Eyepiece with Fixed Scale.

Micrometer eyepieces are of two forms, one with a *fixed scale* and the other with a *movable scale*. In each the rulings are 0.1 millimeter with each fifth and tenth line longer than the others. The better type is the one with the movable scale.

As the *valuation of an ocular micrometer* depends upon the magnification used, the value must be determined for each objective that is used. The tube length should always be the same in measuring an object as when obtaining the value of the micrometer. To obtain the value of micrometer with fixed scale, place the stage micrometer upon the microscope stage and focus the instrument thereon. Place the disc in the eyepiece. Then make any two lines of the ocular micrometer coincide with two upon the stage micrometer by varying the length of the tube (pulling out or pushing in the draw-tube). Note how many spaces of the eyepiece micrometer are included be-

tween two successive lines of the stage micrometer. If, for instance, ten spaces on the ocular micrometer are included in one space on the stage micrometer, each space on the ocular micrometer has a value of one-tenth. If each stage micrometer space is equal to 0.1 millimeter, then each ocular micrometer space is

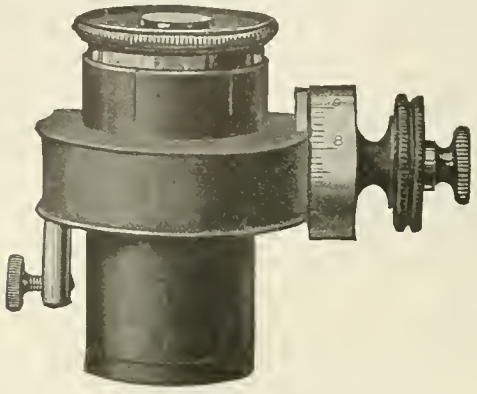


Fig. 3997.—Micrometer Eyepiece with Adjustable Scale. (Spencer Lens Co.)

equal to only 0.01 millimeter or 10μ for that objective and tube length.

To measure an object, replace the stage micrometer by the object slide and note the number of spaces covered by the object. Multiply this number by the value of each space and this will give the size of the object, as nine spaces equal 90μ.

Movable Scale Micrometer.—This is the most accurate form of micrometer. The scale is five millimeters long and is divided into twenty spaces. Each millimeter is marked by a long line. At the side is a screw of $\frac{1}{4}$-millimeter pitch that moves the scale, so that one revolution of the wheel moves the scale one space or $\frac{1}{4}$ millimeter. Upon the axis of the screw is mounted an adjustable drum graduated into 100 divisions, so that each division is equal to $\frac{1}{100}$ of a space on the scale. An index pointer is mounted in relation with this drum.

The *valuation of the spaces* of a movable scale micrometer eyepiece is obtained in the same way as for the fixed scale. The advantage of the micrometer, however, is that fractional spaces may be measured by means of the rotation of the drum. Manipulate the eyepiece and stage micrometer so that two lines coincide and then count the number of spaces of the eyepiece micrometer included between the two or more lines of the stage micrometer. If a fractional space exists, then note the reading of the drum and then rotate until the fractional space is covered and the boundary lines coincide; then note the number of divisions that the drum was rotated. If, for instance, the stage micrometer used is divided into 0.01 millimeter and seven and fraction spaces of the eyepiece micrometer were included between three-stage micrometer spaces, then the fractional space must first be determined. Move the drum as above, and if, say, one-half revolution (or fifty divisions) complete the space, then 7.5 spaces of the eyepiece micrometer equal three spaces of the stage micrometer. As each of the latter spaces equals 10μ, then 7.5 eyepiece spaces equal 30μ or one equals 4μ.

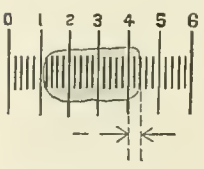


Fig. 3998.—Sketch of Scale. (Spencer Lens Co.)

This is fixed for that objective and tube length. To measure an object, place it upon the stage, and note the number of spaces covered. If there is no fractional space, multiply the number of spaces by 4μ and the answer is the measurement in microns. If a fractional space exists, note the drum reading and rotate the drum until the space is covered. Find the number of divisions and add to the full spaces and multiply them by 4μ. If nine full spaces, one-fourth space (twenty-five divisions of drum), are required, the object measures 37μ.

Preparation Marker.—When a given field of a slide is of especial note, the area may be recorded by noting the readings of a mechanical stage or by marking the slide if no stage is being used. A marker is an attachment like an objective that can be screwed into the nose-piece of a microscope. At its lower end it bears a brush, the position of which is eccentric, and this eccentricity can be varied so that the circles made are of various diameters. This brush-

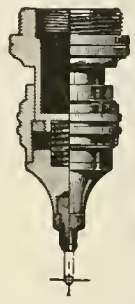


Fig. 3999.—Slide Marker.

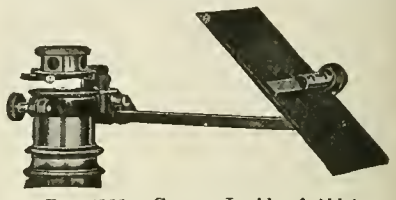


Fig. 4000.—Camera Lucida of Abbé.

bearing portion revolves upon the part that is screwed into the nose-piece. To mark a slide, find the desired area and place it in the center of the field. Dip the brush into some colored shellac or cement and place on the nose-piece and revolve it into the position of the objective. Then gently lower it until the brush just touches the coverglass and revolve the marker. This makes a circle about the area, so that it is more readily found upon subsequent examination. The brush should be cleaned with alcohol when the marking is competed. The one shown is used for liquid colors.

Camera Lucida.—A camera lucida is an optical device for superimposing or combining two fields in the same eye. When used with a microscope, it seems to project the magnified vertical image as a

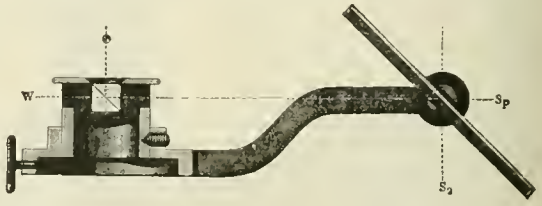


Fig. 4001.—Sectional View of Abbé Camera Lucida. (Carpenter.)

picture upon the drawing board where it is visible and can be drawn and measured. In the better type, the rays of light from the paper are twice reflected and the image is not inverted. For some forms the microscope must be horizontal, but the more convenient form permits the microscope to be used in a vertical position.

Wollaston's camera lucida was the first devised and required the microscope to be horizontal and gave an inverted picture. Of those cameras that do not invert the picture, that devised by Professor Abbé is the best. The principle involved, however, was that suggested by G. Burch in 1878. The Abbé camera lucida is shown in position in Fig. 4000. It is clamped to the tube over the ocular of the microscope. The images of the paper and pencil are reflected by the inclined (forty-five degrees) mirror, at the right, into the cube of glass in the closed case at the top. This cube has a diagonally silvered plane that

reflects the image to the eye. The silvered plane has a small hole in the visual point of the eyepiece, through which hole the image of the object is seen, while the images of the paper and pencil are seen in the silvered plane. By this means the image of the object and pencil are seen coincidently.

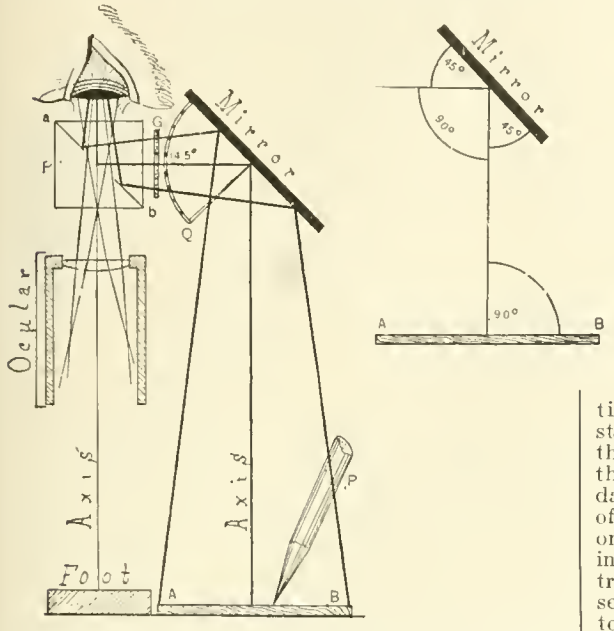


Fig. 4002.—Abbé Camera Lucida, Diagrammatic View. (Gage)

With the mirror at forty-five degrees, the paper must be horizontal. The mirror may be tilted to forty-five degrees or thirty-five degrees to get rid of the image of the stage of the microscope. If the mirror be tilted, the drawing board must also be tilted to overcome distortion that would result, and the usual rule is to tilt the board twice the number of degrees as the mirror has been changed from forty-five degrees. Special tilting drawing boards are made for this purpose.

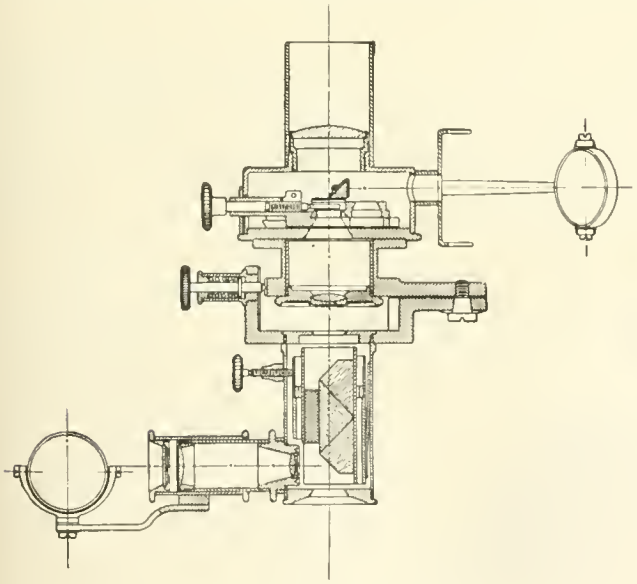
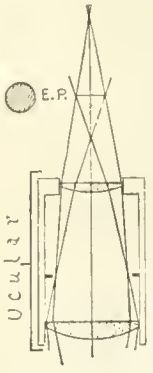


Fig. 4003.—Microspectroscope.

In order to determine the *magnification* of the microscope and the size of the drawing with camera lucida, place the stage micrometer (0.01 millimeter) upon the microscope and mark down five or ten consecutive lines. Then measure five with a millimeter rule and divide this by the number of space values and the result gives the magnification; *i.e.* suppose five spaces ($\frac{5}{100}$ millimeter) measure 10 millimeters with the ruler, then 10 millimeters divided by $\frac{5}{100}$ equals 200. The image was drawn at a magnification of 200 diameter.



Microspectroscope.—A *spectrum* is a succession of colors (rainbow) from red to blue fading insensibly into one another, caused by daylight, or good artificial light, passing through a prism. Certain substances when heated give colored flames and when the rays of light from such colored flames are passed through a properly mounted prism (in conjunction with daylight), certain lines or bands are seen in certain parts of the ordinary spectrum. The substance must not only be vaporized (gaseous) but must be rendered incandescent. Such an examination is called spectrum analysis, and the instrument is called a spectroscope. It is very accurate, of the greatest importance to the chemist and pharmacist, as exceedingly small quantities of a substance, either by itself or in combination, can be detected. Solids and liquids cannot be analyzed by this instrument and as a result the microspectroscope was devised. This is a modified eyepiece originally devised by Dr. Sorby and worked out by Mr. Browning. The arrangement of the prisms and other parts is seen in Fig. 4003. By means of the instrument coloring matter in solution (as blood, chlorophyl, etc.) is readily detected. On the other hand, insoluble substance in minute grains may likewise be examined. As a result of this discovery the microspectroscope plays an important part in the study of animal and vegetable pigments and of colored minerals and chemicals such as cannot be brought to an incandescent gaseous state for the ordinary spectroscope.

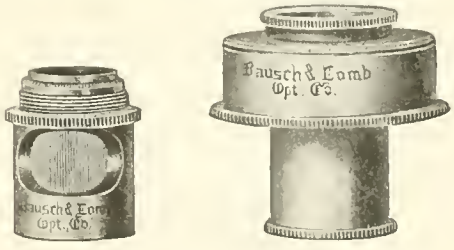


Fig. 4004.—*A*, Analyzer; *B*, Polarizer.

Micropolariscope.—When a beam of light is passed through two rhombs of Iceland spar it is made to divaricate into two rays of light, producing two images. If the upper rhomb be rotated on a vertical axis, four images will appear and will be equally intense at 45 degrees. At 90 degrees only two images are seen. On continuing the rotation to 180 degrees four images appear and then are reduced to two at 180 degrees. This is called polarization. Nicol devised a prism

of Iceland spar in which only one of the two rays is utilized. An instrument for producing and testing polarized light is called a polariscope.

The micropolariscope, for use with the microscope, consists of two Nicol prisms, one suitably mounted and placed beneath the object to be examined, so that the object is illuminated by polarized light; this

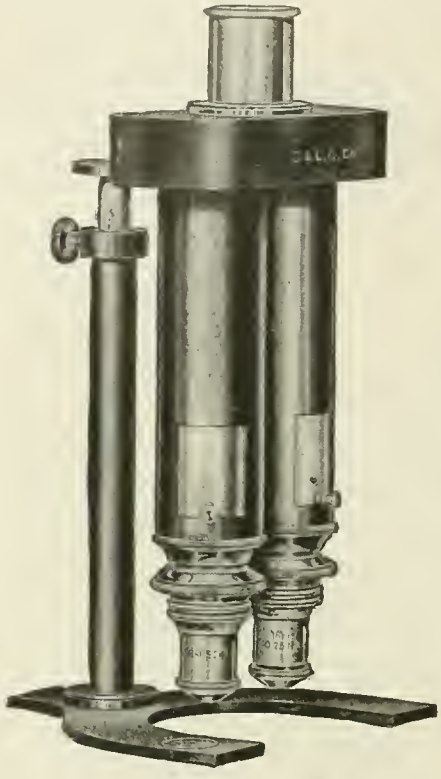


Fig. 4005.—Color Comparison Microscope.

part is called the polarizer. The analyzer is another Nicol prism, placed usually above the eyepiece of the microscope.

This instrument is of especial value in Petrology and Mineralogy and the study of sugar, starches and many other organic and inorganic substances.

Color Comparison Microscope.—This instrument consists of two tubes, two objectives and a single

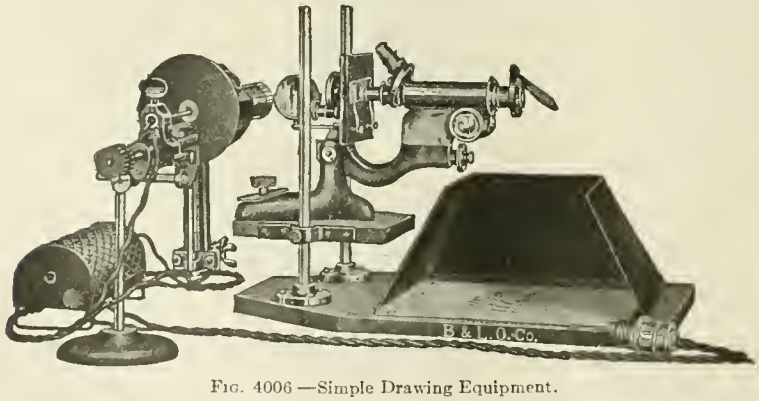


Fig. 4006 —Simple Drawing Equipment.

ocular. Beneath the ocular is mounted a double prism by means of which half of one field appears adjacent to the other in the ocular. The lower end of each tube is provided with a slot and shutter for insertion of Lovibond tint glasses for color comparison. By this means the exact color of a substance under examination can be obtained in terms of a standard tint glass series.

Simple Drawing Equipment.—The microscope is placed upon a support that can be adjusted vertically, thus allowing a range of projection distance and permitting of an increase in magnification without changing the objective. The support is attached to a drawing board provided with a light shield made of metal and, if necessary, a hood can be adjusted about the head of the operator and the drawing board so as to exclude all light. A special mirror is clamped to the eyepiece; by means of the mirror, when inclined forty-five degrees, the image is reflected to the drawing board and may then be outlined. The illumination is provided by an arc lamp and bull's-eye condenser. This instrument is of especial use in reconstruction work.

Fig. 4007.—Simple Erecting Body.

Compound Erecting Body.—The ordinary microscope and lenses form an inverted image. This is often of a disadvantage, especially in dissections. To overcome this, the compound erecting body was devised. By installing two double erecting prisms between the objective and the ocular, the inverted image from the objective is itself inverted or erected, that is, the various parts of the object and image are in identical positions. This instrument is not only of value to the botanist and zoologist, but has been adopted in mechanical and industrial work, for engraving and the examination of small mechanical works as watch movements, tools, dies, jewels, fabrics, etc.

H. E. Radasch.

Bibliography.

Carpenter: The Microscope and Its Revelations.
Gage: The Microscope.
Locy: Biology and Its Makers.

Micturition, Disorders of.—Given normal urine and a normal genitourinary tract, micturition is accompanied and followed by no other sensation than one of relief, and is performed normally from four to twelve times in twenty-four hours, depending upon the temperature and humidity of the air, the amount of exercise taken, the intensity of the mental occupation and the degree of anxiety which it entails, the volume of water drunk, and upon the kind of food ingested.

For convenience in reference, the disorders of micturition are given alphabetically, but the several possible causes of each disorder are arranged as nearly as possible according to the frequency of their occurrence.

Diminished Stream.—This disorder may be either (1) temporary or (2) constant until relieved by surgical intervention.

1. When temporary or of short duration a diminution in the size of the stream points to a transient obstruction, *e.g.* congestion at some point or zone in the urethra or a urethral spasm.

As a result of inflammation, any part of the urethral canal may become swollen to the extent of obstructing the urinary stream to a greater or less exent. Thus we may have a diminished stream due to a severe acute urethritis affecting the anterior urethra, with or without involve-

ment of the posterior urethra. It may also be observed in connection with an acute prostatitis.

Any lesion of the urethra—*e.g.* organic stricture, especially if irritable, or a granular patch—is capable of exciting urethral spasm, especially in neurotic individuals. The diagnosis must be made partly by exclusion, but chiefly by exploration of the urethra with a bougie-à-boule, sound, and endoscope.

After urination has been postponed unduly, the stream will be diminished until the vesical sphincter shall have become fully relaxed.

2. A diminished stream which either shows no tendency to grow larger or undergoes a progressive further diminution in size points to an organic obstruction. In all cases of this nature of long standing the resulting atony of the bladder plays an important though secondary part in the character of the stream.

Organic stricture, when neglected, gives a stream which tends constantly but slowly to diminish in size. If the stricture be situated at or near the meatus the stream will be small and scattering, but forcible; if it be situated deeper within the canal, the forcible projection will be lacking. When the stricture becomes inflamed from any cause, the diminution progresses rapidly and may persist until complete retention results.

Prostatic enlargement has among its early symptoms a diminution of the urinary stream. As micturition begins, the stream is small and feeble, sometimes dribbling; it then becomes larger and, except in the later stages of enlargement of the prostate, attains a fair volume and force, only to become again small and feeble and usually dribbling as the act is completed.

Chronic contraction of the prostatic fibers surrounding the neck of the bladder gives the same symptoms as does commencing enlargement of the prostate. In the differential diagnosis the chief point is the age of the patient, though the amount of residual urine and the cystoscopic findings furnish important data. In many cases the diagnosis cannot be made without an exploratory perineal section.

Periurethral abscess may cause a narrowing of the urethra and thus diminish the stream; when situated in the bulbous portion the abscess may cause acute retention.

A partial plugging of the urethra by a small calculus arrested on its way from the bladder produces a diminution of the stream that becomes more marked as inflammatory congestion advances. If the calculus is rough there will follow an oozing of blood from the meatus, unless the urethral mucous membrane happens to be deeply cicatricial at the point of arrest. Palpation along the course of the urethra—per rectum for the posterior portion—rarely fails to detect the calculus. Instrumental exploration usually is conclusive.

A partial plugging of the outlet of the bladder by a pedunculate tumor or a small movable calculus will give rise to a diminished stream accompanied by symptoms more or less pathognomonic of the lesion present. The diagnosis is materially aided by the fact that immediate relief is obtained by dorsal decubitus or by the dislodgement of the obstruction by means of a sound or searcher.

Urethral polypi diminish the stream in proportion to their size. When they are very small there may be no symptom except hemorrhage.

Dribbling.—In addition to the dribbling that characterizes the first and second forms of incontinence, as described in subsequent paragraphs, there are other types of dribbling to be recognized. Thus we have:

1. The involuntary, painless escape of a few drops of urine at the end of micturition.

2. The voluntary, not always painless, escape of a few drops of urine at the beginning of micturition.

3. The urine is voided in drops throughout micturition.

(1) In prostatic enlargement the dribbling of a few drops of urine at the end of micturition is a common and early symptom. It is independent of the degree of vesical atony which may be present; in fact, it may exist without the presence of any vesical atony whatever.

In chronic urethritis (anterior or posterior or both) the dribbling, when present, is constant until the muscular tone of the urethra has been restored.

In stricture of the urethra of large caliber the final drops of urine are caught behind the stricture and dribble out into the clothing.

In chronic contraction of the prostatic fibers surrounding the neck of the bladder the dribbling at first is an intermittent symptom; later, it is constant.

(2) In prostatic enlargement the voluntary and not always painless escape of a few drops of urine occurs at the beginning of micturition. It is preceded by hesitancy and gradually gives way to the full stream, which in turn dies away and ends with dribbling.

(3) In filiform stricture of the urethra, if it has existed for a relatively short period of time and consequently is associated with only slight atony of the bladder, the stream is of a dribbling character, and is produced with more or less effort.

In acute prostatitis (including prostatic abscess) and in acute seminal vesiculitis the urine is voided in drops when retention threatens, either from mechanical obstruction or as the result of reflex irritation.

Frequency and Urgency; Pain and Tenesmus.—Frequency of urination may be normal, or physiologic, within wide limits. It is abnormal, or pathologic, when accompanied by urgency, pain or tenesmus, or when due to a tangible, pathologic condition or to that obscure pathologic state called a neurosis. Frequency rarely occurs without at least a trace of urgency; frequency and urgency are practically never without a degree of initial or terminal pain and tenesmus. Frequency due to quantity alone is not included, it being dependent, strictly speaking, upon a disorder of elimination or of metabolism.

In acute posterior urethritis, when this is severe, frequency and urgency are marked; a lesser grade gives only frequency; the mildest grade of all does not occasion any disorder of micturition. In every case of acute posterior urethritis a digital rectal examination should be made to ascertain whether acute prostatitis and acute seminal vesiculitis are present.

In chronic posterior urethritis there is, in most cases, a very trifling frequency which shows a tendency to increase and may become complicated by urgency, as well as occasionally by pain and tenesmus, during an exacerbation of the local congestion. In a few cases frequency is constant, and is accompanied by more or less urgency and slight initial and terminal pain, with very moderate tenesmus.

In organic urethral stricture the frequency is due to the maintenance of a chronic posterior urethritis. Usually it is diurnal only. Later on, chronic partial retention is added, and, the symptoms becoming exaggerated by the congestion due to this retention, urgency and possibly pain and tenesmus develop. If infection either of the posterior urethra or of the bladder occur, the severity of the symptoms will be increased proportionately.

In acute prostatitis and acute seminal vesiculitis (including prostatic abscess) there may be, in the early stage, simply increased frequency, but usually both this symptom and urgency coexist from the outset, and with them are associated more or less pain and tenesmus. Very rarely there is no disorder of micturition. Digital rectal examination affords the only means of establishing the diagnosis.

In chronic prostatitis and chronic seminal vesiculitis a slight, uncomplicated, diurnal increase in frequency is a characteristic of the disease. It tends to increase and urgency develops during the occasional mild exacerbations to which the coincident posterior urethritis is liable.

In prostatic enlargement, an uncomplicated increase in frequency, especially if nocturnal and not due to volume, in a man forty-five years of age or older, who gives no history of a previous increase in frequency, is pathognomonic of the early stages of this affection. The frequency increases with the enlargement, and sooner or later becomes diurnal as well. Still later it becomes complicated by urgency and pain, and then by tenesmus, all of these depending upon the degree of prostatitis and urethrocystitis that have developed, and in some cases (especially those of an advanced type) upon the presence or absence of a calculus and the grade of infection present.

All varieties of acute cystitis cause increased frequency of micturition. If the inflammation be severe, or if it center about the neck of the bladder, as it commonly does, there will be extreme frequency with urgency, which latter symptom may amount to a slight incontinence on occasions. There will also be pain and tenesmus, the latter sometimes amounting to strangury. As a rule, however, temporary relief quickly follows the terminal pain and tenesmus.

In chronic cystitis frequency of micturition may be absent during the quiescent periods and during mild exacerbations. Urgency is rare. Unusual frequency with urgency, pain and tenesmus denotes a sharp exacerbation. Oft-recurring exacerbations in cases with little or no prostatic enlargement furnish strong presumptive proof of a colon bacillus infection, of the presence of a calculus in the bladder; and when such exacerbations occur in cases in which the prostate is enlarged, they indicate either that a fresh infection has taken place or that there is a calculus in the bladder, or both. When a sharp hematuria accompanies the exacerbations a differential diagnosis will be required between ulceration—simple, gonorrheal, or tuberculous—a calculus, and a neoplasm.

When a calculus is present in the bladder, diurnal rather than nocturnal increase of frequency is a characteristic of the condition. Micturition then is usually accompanied by pain, sometimes also by tenesmus, depending upon the size of the calculus, the character of its surface, and the degree of cystitis. Thus the increased frequency may become practically incontinence. The terminal pain is referred usually to a point about an inch back from the meatus. When the calculus is small and mobile, and therefore capable of rolling against the vesical outlet, there occur sudden attacks of increased frequency, urgency, pain and tenesmus, with a minimum of cystitis. Recumbency lessens the suffering; occasionally it gives complete relief. Exercise, especially that which jolts the pelvis, aggravates the symptoms.

In pyelitis, when acute and of high grade, the frequency, urgency, pain, and tenesmus referred to the neck of the bladder may simulate vesical calculus. Chronic pyelitis gives at most a slight increase in frequency of micturition.

The presence of a small tumor in the bladder, if it be seated at a point remote from the outlet, may not affect micturition. In a case of this character an uncomplicated hematuria is the only symptom that would point to the presence of the tumor. Larger tumors produce increased frequency which is in direct proportion to their size; they also produce urgency, pain, and tenesmus, all of which symptoms depend for their severity upon the location and mobility of the tumors. This applies also to polypi in the prostatic urethra.

In ulcer of the bladder, simple, gonorrheal or tuberculous, urgency depends upon the proximity of the ulcer to the vesical neck. If it be situated within the neck, there will be more or less pain and tenesmus, sometimes initial as well as terminal, with more or less hematuria.

In vesical tuberculosis an otherwise unaccountable increase in frequency, diurnal and nocturnal, is an early symptom. Cystoscopy often aids in the diagnosis. Later, the presence of urgency, pain, and tenesmus, and their severity depend upon the proximity of the lesion to the vesical neck and upon the extent of the lesion independently of its location. In advanced cases the pain and tenesmus usually are very severe and may be accompanied by hematuria. A negative examination for tubercle bacilli in the urine is not conclusive.

In renal tuberculosis, renal calculus, and ureteral calculus, also in the presence of a colon bacillus infection of the kidney, there is usually an uncomplicated diurnal increase in frequency, even though a secondary cystitis has not yet developed. Renal colic, due to any one of the above causes or to movable kidney, may be accompanied by reflex increase in frequency, urgency, pain, and tenesmus.

Among the acute symptoms associated with intermittent hydronephrosis there is usually more or less increase in frequency of micturition, often accompanied by urgency, pain, and tenesmus, the severity of these symptoms depending upon the cause of the hydronephrosis. As the attack subsides and the pent-up urine is liberated, there is likely to be a slight, uncomplicated, transient increase in frequency due to the sudden increase in the quantity of the urine discharged into the bladder.

In primary tuberculous prostatitis the incipient stage and occasionally a more advanced stage give, as a rule, no urinary symptoms. When the disease is well advanced it causes increased frequency and more or less urgency, accompanied by terminal pain and tenesmus so sharp as to simulate vesical calculus. The diagnosis is established by exclusion and by the discovery of nodules in the prostate on digital rectal examination. A negative examination for tubercle bacilli in the urine is not conclusive.

Increase in frequency of micturition occurs sometimes as a neurosis in neurotic individuals independently of age and sex. The increased frequency is diurnal and may become exaggerated by the large quantity of urine which these patients sometimes excrete. In some cases any attempt to postpone the act of micturition causes severe pain. The differential diagnosis between this neurosis and incipient vesical tuberculosis is sometimes difficult without the aid of cystoscopy.

In hernia of the bladder, before cystitis has developed, increase in frequency is the only urinary symptom. The pathognomonic signs are: a more or less tense, fluctuating tumor in the usual site of an inguinal hernia; its disappearance under gentle manipulation while the patient is recumbent; his ability to rise and void another volume of urine, although he emptied his bladder immediately before the reduction; and, finally, the reappearance of the inguinal tumor when the bladder is distended with fluid.

In contracted bladder the increase in frequency is as pronounced during the night as it is during the daytime. When the contraction is due to interstitial changes following long-standing chronic cystitis from any cause, or when it is due to advanced tuberculosis, progressive or stationary, there are increased frequency, some urgency, and more or less terminal pain and tenesmus.

Congenital diverticulum of the bladder gives no positive symptom, as a rule, until infection of the retained urine has taken place. Thereupon the symptoms are those of cystitis, commensurate with the severity of the infection, and a vague sense of pelvic weight or discomfort, The amount of residual urine will depend upon the size and number of the diverticulæ. Cystoscopy will be necessary to establish the diagnosis.

Two very rare conditions—a congenitally small bladder and an undeveloped bladder due to a long-neglected incontinence in childhood that has resulted in the habit of frequent micturition—give equal

diurnal and nocturnal increase in frequency as the only symptoms so long as there are no complications.

In chronic lesions of the spinal cord, a degree of increased frequency, which may well be described as an irritability of the bladder, is common in the earliest stages. Later on, there occurs an increase in frequency which is dependent upon overdistention of the bladder.

Hesitancy or Slowness in Starting the Stream.—As a pure neurosis hesitancy is very common; it is seen in the difficulty which certain patients experience when they attempt to urinate in a hurry or in the presence of others.

In prostatic enlargement hesitancy is an early and practically constant symptom. In chronic contraction of the prostatic fibers surrounding the neck of the bladder it is equally common.

In acute inflammatory conditions of the urethra hesitancy is due either to urethral spasm, as such, or to an inhibitory effect through fear of the *ardor urinæ*.

Chronic lesions of the urethra—*e.g.* granulations or an irritable stricture—sometimes produce a momentary urethral spasm.

In acute and chronic inflammatory affections of the prostate and seminal vesicles hesitancy may result either from the slight mechanical obstruction offered or from a slight urethral spasm.

Painful lesions of the rectum—*e.g.* ulcer, fissure, or inflamed hemorrhoids—not infrequently produce a momentary urethral spasm.

Incontinence.—Three forms are recognized: 1. A constant, passive, more or less continuous flowing away of the urine. 2. An involuntary escape of a few drops of urine on occasions. 3. An inability to retain sufficient urine in the bladder to constitute an act of micturition, or the constant voluntary—sometimes involuntary—emptying of the bladder by the expulsion of a few drops very frequently. (The nocturnal enuresis of children is not included, as it does not come properly under the title of this article. See *Enuresis.*)

1. This first form is true incontinence. Ordinarily it occurs under only two conditions: (*a*) overdistention of an atrophic bladder; (*b*) atony of the vesical sphincters, with or without atrophy.

Prostatic enlargement is the most classic cause of overdistention with atrophy, and therefore of true incontinence, in a man past the age of fifty-five. The incontinence is chiefly, if not wholly, nocturnal. Filiform stricture of the urethra, if of long standing and associated with marked atony of the bladder, bears the same relation to true incontinence in younger men. Here the incontinence is chiefly diurnal, and often alternates with acute retention.

Among the diseases of the spinal cord locomotor ataxia (tabes dorsalis) and other scleroses often cause atony of the bladder, thus permitting overdistention and true incontinence. Spastic contraction of the vesical sphincters will foster the overdistention; sensory disturbances causing anesthesia of the region will augment the incontinence. On the other hand, the reverse—viz., atony of the sphincters and hyperesthesia—may obtain.

2. The form of incontinence presents many grades and is a symptom of several different lesions. The occasions on which it occurs are: exacerbations in the causative lesions, and any sudden unusual pressure upon the bladder, such as takes place in coughing, sneezing, jumping, or lifting a weight. The causative lesions are: chronic posterior urethritis; ulcers near the neck of the bladder, simple, gonorrheal, or tuberculous; vesical calculi; vesical tuberculosis, especially when affecting the neck, whether with or without ulceration; renal tuberculosis ("slight incontinence with frequency, in the absence of other lesions, is strongly indicative of renal tuberculosis"); contracted bladder due to antecedent extreme pericystitis or interstitial cystitis; chronic prostatitis; slight atony, or "relaxation," of the vesical sphincters without atony of the bladder.

3. This is the least characteristic form of incontinence. It is merely an extreme frequency with uncontrollable urgency, and is therefore complicated by more or less pain and tenesmus. The lesions that cause it are: severe acute posterior urethritis; acute cystitis; a large, rough, movable calculus, or a collection of facetted calculi, occupying the cavity of the bladder and partially distending it; a small, rough calculus, lodged in the prostatic urethra; renal calculi, causing attacks of severe colic.

Interrupted Stream.—This is also known as the "stammering stream."

The causes of this disorder operate either (1) mechanically, by intermittent obstruction, or (2) reflexly, by intermittent excitation of the vesical sphincter. Under the first class are: prostatic enlargement; chronic contraction of the prostatic fibers surrounding the neck of the bladder; a small, rounded, mobile calculus; a pedunculate tumor; a blood clot. Under the second class are: acute, subacute, and chronic urethritis; stricture of the urethra, both of large and of small caliber; neurasthenia and neurotic tendencies.

Retention.—Confusion arises from the use of the word retention when suppression is meant. Retention of urine applies only to its discharge from the bladder, while suppression of urine applies only to its excretion by the kidneys.

Retention is due either to a mechanical obstruction, which prevents the escape of urine from the bladder, or to a diminished expulsive power on the part of this organ, this latter condition being due in turn to impaired innervation of the muscle coat, or possibly to some actual lesion of the muscle (atrophy, or rupture). In obstructions of long standing the retention is due to a combination of both these factors, for the hypertrophy which developed in the wall of the bladder as a result of its early efforts to overcome the obstruction finally gives way to an atrophy, the degree of which is in direct ratio to the chronicity of the obstruction.

I. Acute Retention.—The cause may be (*a*) organic obstruction; (*b*) spasmodic obstruction; (*c*) a combination of both; (*d*) a sudden impairment of the bladder function, with or without spasm of the sphincter.

(*a*) The following are among the more usual organic obstructions: a stricture of small caliber, when inflamed by sexual and alcoholic excesses, by excessive coffee drinking, or by exposure to cold and wet; a prostatic enlargement, when acutely congested or inflamed—a condition to which it is peculiarly liable after any excesses in venery, eating, and drinking, and as a result of constipation; acute prostatitis, simple or gonorrheal, especially when resulting in an abscess that is pointing toward the bladder; a rupture of the urethra, complete or partial; plugging of the internal meatus, *e.g.* by a small, movable calculus, a pedunculate vesical tumor, or a blood clot; and, finally, periurethral abscess, especially when located in the bulbous portion. Among the rare organic obstructions should be mentioned: acute posterior urethritis, severe acute seminal vesiculitis, tuberculous prostatitis, and papilloma of the urethra.

(*b*) Spasmodic obstruction—*i.e.* obstruction caused by spasm of the sphincter—occurs under the following circumstances: in acute anterior urethritis, occurring either independently or in connection with an existing urethral lesion (*e.g.* a stricture or a granular patch); when the urethra is the seat of a comparatively slight trauma, inflicted by a blow, by rough instrumentation, or by irritating injections; when there are rectal lesions, including fecal impaction and even constipation of only two or three days' standing; after operations, minor as well as major, on the urethra or

on the rectum or some contiguous region, whether performed under local, spinal, or general anesthesia; in the presence of shock, postoperative or traumatic; as a result of enforced postponement of micturition, especially if there is present any lesion of the urethra, prostate, or seminal vesicles;* in exhausting diseases, such as typhoid fever, pneumonia, peritonitis, and meningitis; in vesical tuberculosis; in pyelitis, simple, gonorrheal, tuberculous, or due to a calculus (the last-named occasionally causes acute retention instead of the more usual frequency and urgency of micturition); in hernia of the bladder—a rare occurrence; and, finally, in neuroses and neurotic conditions in general.

(*c*) A combination of organic and spasmodic obstructions is observed in severe acute posterior urethritis, when the swelling is extreme and when spasm is excited. It is also observed in severe acute prostatitis and in seminal vesiculitis.

(*d*) Sudden impairment of the bladder function, with or without spasm of the sphincter, may be observed in rupture of the bladder, whether intra- or extraperitoneal, and also in those injuries or diseases of the central nervous system which result in the production of a sudden hemiplegia or paraplegia, with or without coma.

II. Chronic Retention.—This is either partial or complete. Chronic partial retention is present when only a portion of the urine is spontaneously voided, the rest remaining in the bladder as "residual urine." Chronic complete retention exists when all spontaneous micturition has been lost and all the urine has to be drawn by catheter.

In prostatic enlargement there is at first only partial retention. This advances to complete retention if, the true conditions not being recognized, the bladder is allowed to become atonic through insidiously increasing overdistention. Thus arise the cases of chronic complete retention which have apparently assumed this character from the outset. An intercurrent acute retention is often the first symptom for which the patient seeks advice, he having diregarded the symptoms of the partial retention, or the "overflow" incontinence of the chronic total retention.

The remarks made in reference to prostatic enlargement in a preceding paragraph apply with equal appropriateness to chronic contraction of the fibers surrounding the neck of the bladder. This chronic contraction, however, is less frequent than prostatic enlargement, and consequently gives rise less frequently to chronic complete retention.

In filiform stricture of the urethra the chronic retention is only partial; it will disappear after appropriate treatment of the stricture unless the latter has been neglected for many years.

In chronic prostatitis, in tuberculosis of the prostate, and in vesical tubereulosis a small quantity of residual urine is an almost constant objective symptom.

As further causes of chronic retention may be mentioned: habitual failure to empty the bladder completely by reason of hurry or indifference; and frequently repeated prolonged postponement of micturition, thus causing frequent overdistention.

While the retention which originates in some chronic lesion of the spinal cord is only partial, it is nevertheless characterized by a large volume of residual urine—from five to twenty ounces. In the mild cases the amount of the residual urine will fluctuate even under the best conditions, often falling to two ounces. On the other hand, the amount is fairly constant in the more advanced eases, and the retention is associated with frequency, or with incontinence, or with both. JAMES PEDERSEN.

*In these cases the spasm is usually of short duration, and it is rarely found necessary to resort to the use of the catheter in order to secure relief for the patient.

Middeldorpf, Albrecht Theodor.—Born at Breslau, Germany, July 3, 1824. He pursued his medical studies first in his native city, and afterward in Berlin. In this way he became somewhat intimately aequainted with Purkinje (at Breslau), and with Johannes Mueller and Dieffenbach (in Berlin). He received his doctor's degree in 1846. In 1849 he was appointed an assistant to Remer in the surgical division of the Allerheiligen Hospital in Breslau. Already at this early period of his career he began to experiment with what he termed "Akidopeirastik," and before long he was able to publish a paper on the subject, under the title: "Ueberblick über die Akidopeirastik, eine neue Untersuchungs-methode mit Hülfe spitziger Werkzeuge" (in *Guensburg's Zeitschrift*, viii.). Another subject in which, for a long time past, he had taken great interest, was that of the employment of the galvanocautery. In 1853 he had already brought the apparatus to such a stage of completeness that he was able to apply it in the case of a living human being. His discovery is described by him in an article entitled "Die Galvanokaustik, ein Beitrag zur Operativen Medicin," Breslau, 1854 (with four plates). (In 1864 he published an "Abrégé de la galvanocaustic.") On the occasion of a trip which he made to Paris in 1856 he was given many opportunities to demonstrate the actual use of the appliance; and, as a further result of this visit, the Académie des Sciences bestowed upon him a Monthyon prize. He was also awarded the Napoleonic electricity medal. In 1859 he was made a "Medizinal Rat." He died July 29, 1868, from perforation of the intestine, after a somewhat prolonged period of poor health.

In the judgment of Pagel, Middeldorpf is entitled to the credit, not of having invented the galvanocautery, but of being the scientific and technical founder of the practice of employing that contrivance as a therapeutic agent of considerable value. In his further estimate of Middeldorpf's character and accomplishments, Pagel states that as a teacher he was distinguished by the masterful and very clear manner in which he drew his pictures of the different diseases and advocated the best manner of treating them, and that as a surgeon he was remarkable for the very careful and scrupulously conscientious manner in which he made his preparations for the operation, and for the technical completeness with which he terminated the work. A. H. B.

Midges.—*Chironomidæ*. The flies of this family, commonly known as midges, resemble mosquitos in form and size but are usually more delicate and the wing veins are not fringed with scales. The larvæ are worm-like and usually aquatic. There are 800 species in the family. Most of these are innocuous, but in the subfamily *Ceratopogoninæ* are the sand flies or punkies which suck blood. See *Insects, parasitic.*

A. S. P.

Migraine.—See *Headache.*

Mihalkovics, Victor Geza.—Born in Budapest, Hungary, January 29, 1844. He received his doctor's degree from the University of his native city in 1869. In 1871 he began the study of embryology and histology in Vienna, under Schenk and Toldt. In 1873 he went to Leipzig, and continued his histological researches under Ludwig and Schwalbe. Afterward he was, for a short time, one of Waldeyer's assistants in Strassburg. Then, in 1874, he returned to Budapest and was given the position of Privatdozent of descriptive anatomy in the university. In the following year he was made Professor Extraordinary of Embryology and Practieal Anatomy, and in 1881 full Professor, in the same institution. He died July 11, 1899.

Of the numerous contributions of this great anatomist to medical literature the following deserve to receive special mention: "Beiträge zur Anat. und Histol. des Hodens," Leipzig, 1873; "Ein Beitrag zur ersten Anlage der Augenlinse," 1875; "Entwicklungsgeschichte des Gehirns," Leipzig, 1877; and "Untersuchungen über die Entwicklung des Harn- und Geschlechtsapparates der Amnioten," 1885. Mihalkovics also published several works in the Hungarian language, and among the number a Treatise on the Descriptive Anatomy of the Human Being.

A. H. B.

von Mikulicz-Radecki, Johann.—Born at Czernowitz, Austria, May 16, 1850. He received his doctor's degree from the University of Vienna in 1875. During the following three years he was at first one of Billroth's pupils and then his assistant. In 1882 he accepted a call from the University of Krakau to be full Professor of Surgery and Director of the Surgical Clinic in that institution. In 1887 he was transferred to the same position in the University of Königsberg, and in 1890 he was called to Breslau. Up to this period of his career Mikulicz was actively engaged in the development of antiseptic surgical methods and made frequent contributions to periodical medical literature on the subject. In the following eight or ten years he was equally active in developing aseptic surgical methods. He may properly be recognized as the founder of the practice of œsophagoscopy and gastroscopy; he wrote several important articles on abdominal surgery, and particularly on surgery of the stomach; he interested himself a great deal in the subject of thyroid enlargement and Basedow's disease; and he contributed not a little to our knowledge of diseases of the mouth. Finally, he was associated with von Bergmann and Brunn in the publication of the "Handbuch der praktischen Chirurgie." He died in 1905.

Of Mikulicz's published writings the following deserve to receive special mention: "Die antiseptische Wundbehandlung und ihre Technik;" "Die Verwendung des Iodoforms in der Chirurgie," 1882; "Ueber Versuche die aseptische Wundbehandlung zu einer wirklich keimfreien Methode zu vervollkommnen," 1897; "Ueber Gastroskopie und Oesophagoskopie;" "Zur operativen Behandlung des stenosirenden Magengeschwürs," in *Archiv für klin. Chir.*, xxxvii.; "Beiträge zur plastischen Chirurgie der Nase," *ibidem*, xxx.; and "Die Krankheiten des Mundes," Jena, 1898 (expanded from an earlier article on the same subject in the "Twentieth Century Practice of Medicine," New York, 1896). A. H. B.

Miliaria.—*Synonyms:* Lichen tropicus; Prickly heat; Eczema solare; Red gum; Heat-rash; Strophulus.

Definition.—An acute inflammatory disease of the sweat glands, characterized by a large number of pin-point- to pin-head-sized vesicles, on an inflammatory base.

Symptoms.—While miliaria is frequently divided into miliaria papulosa and miliaria vesiculosa, the large majority of the cases are composed of an admixture of both types of lesions. The usual clinical case presents an innumerable number of small acuminate papules of a bright red color, frequently topped with a round, pin-point-sized, clear vesicle. They are frequently aggregated, and in severe cases, form large areas of eruption. At times the contents of the vesicles become infected, and assume an opaque appearance. Occasionally, the disease is transformed into a true eczema, but this happens rather infrequently, and only after a number of repeated attacks which have been indifferently treated. In long-continued and neglected cases, furuncles and abscesses may develop, particularly in infants and young children. Much discomfort usually accompanies the eruption, the patient complaining of a burning and pricking sensation, which at times becomes very intense. Sweating is usually excessive just before and during the eruption.

Etiology and Pathology.—The disease is brought on by exposure of the skin to excessive heat, which causes an overstimulation of the sweat glands and their ducts, with resulting hyperemia and inflammation. Overheating may be caused by climatic conditions, excessive amount of clothing, alcoholic excesses, or working in rooms at high temperature; stokers and boiler-room men are particularly prone to the disease. The obese are frequently affected. Infants often have the disease, particularly those whose mothers wrap them up in yards upon yards of swaddling clothes. It is not definitely known whether the disease is restricted to the epiderm, is a dilatation of the sweat duct, or is caused by irritation of the surface of the skin by excessive perspiration.

Diagnosis.—The rapid outbreak of the bright red acuminate papules, vesicles, and vesicopapules, with associate excessive perspiration and marked burning and pricking sensations, is characteristic. Sudamen occasionally resembles it, but in sudamen the vesicles are transparent, resembling dew-drops and presenting none of the signs of inflammation. Vesicular eczema rarely presents the uniformity and symmetry of the lesions that miliaria does.

Treatment.—Lotions and powders are preferable to ointments. The calamine and zinc lotion, containing one to two per cent. phenol, is very soothing. The following formula frequently allays the distressing burning and itching sensation:

Ichthyolis	℥ss.–℥i.
Magnesii carbonatis,	
Zinci oxidi	āā ℥i.
Aquæ rosæ	q.s. ad. ℥iv.
M.	

A dusting powder composed of equal parts of zinc oxide or stearate of zinc, with talc, starch, and boric acid, is very efficient. In stout persons, frequently subject to the disease, who perspire freely, a powder composed of one part of salicylic acid to thirty to fifty parts of boric acid, freely dusted on once daily, often proves preventive. Overclothing and active exercise should be avoided in summer, in those predisposed to the disease. Paul E. Bechet.

Miliaria Rubra.—See *Lichen*.

Milium.—*Synonyms:* Acne albida; Grutum; Strophulus albidus.

Symptoms.—Milia are most frequently found on the face, particularly around the eyes, and especially on the malar region. Occasionally they occur on the genitalia of both sexes. The lesions consist of millet-seed- to pin-head-sized, yellowish to pearly white, rounded masses, which usually project above the surface, assuming a more or less translucent appearance. The lesions are without aperture, and somewhat resemble portions of grains of rice buried in the skin. There are no subjective symptoms, the lesions giving rise to no disturbance. They never undergo ulceration, and when left alone are, in the course of years, exfoliated by the natural processes of physiological desquamation. Occasionally, the contents of the lesions, particularly old and large ones, undergo calcareous change from the deposit of salts of lime, forming the so-called cutaneous calculi.

Etiology and Pathology.—Milia most frequently occur in infancy and early adult life, but may be seen at any age. They are of common occurrence in cases

of acne and comedo. They occasionally follow any condition which causes partial destruction of the sebaceous glands, with resulting cicatricial formation, and consequent sealing up of the contents of the gland. They are therefore occasionally met with on the edges of scars, resulting either from wounds or from ulcerative dermatoses. In the majority of cases, however, no cause can be found. The lesion occurs in the upper part of the corium, just beneath the epidermis, and is due to the retention of sebaceous matter in one or more acini of the sebaceous glands. The contents of a milium consist of closely packed sebaceous matter, which occasionally becomes inspissated and calcareous.

Diagnosis.—Comedo has a duct orifice and blackish point, and is easily distinguishable from milium. Large, flattened milia may slightly resemble xanthoma, but this disease is so entirely different that a mistake in diagnosis is not probable.

Treatment.—Relief of this condition is rarely demanded, because of the small number of lesions usually present and of the complete lack of subjective symptoms. Electrolysis is a very convenient method for their removal; the operation is bloodless and very efficient, the resulting scar being almost imperceptible. The lesions may be incised, and their contents expressed with a comedo extractor. In the case of larger lesions, the interior should be touched with a five per cent. solution of phenol, or fifty per cent. solution of chromic acid. In children, if the lesions are quite numerous, the use of the so-called peeling pastes will cause them to be exfoliated. Occasionally, milder applications, such as sulphur twenty to forty grains to the ounce, will suffice in ridding the patient of them. Paul E. Bechet.

Milk, Composition of.—Milk may be regarded as an almost perfect foodstuff inasmuch as it contains the three principal classes of nutrients, proteins, carbohydrates and fats, together with a variety of inorganic salts and it contains these nutrients in a proper relationship. Milk is a specific product of the mammary glands, its characteristic constituents being found nowhere else in the body. From this fact it follows that the substances must be looked upon as true secretory products of the mammary glands. The secretion of the mammary glands during the first few days postpartum differs essentially from that elaborated after mammary gland secretion has been well established. To this first secretion the name colostrum (which see) has been given.

As human milk and the milk of animals are essentially of the same constitution, it seems best to consider first the one most thoroughly studied, namely, cow's milk, and then to discuss the essential properties of the remaining kinds of milk of importance in the feeding of children.

Cow's Milk.—Cow's milk, like every other kind, consists of an emulsion of very finely divided fat suspended in a solution containing proteins, carbohydrates, and inorganic salts. It has a non-transparent white or whitish-yellow color, which may be of a bluish shade in their layers and it possesses a sweetish taste and a faint, insipid odor. The specific gravity is variable, ranging usually from 1.028 to 1.034 at 15° C. The freezing-point is approximately − 0.56° and the molecular concentration 0.298.

Perfectly fresh milk is generally amphoteric to litmus. It has been demonstrated that the extent of the acid and alkaline part of this amphoteric reaction varies with the indicators employed, with the milk of different individual animals and also with the same animal at different times during the lactation period. It has been shown that as an average for the first and last portions of the milking of twenty cows, 100 c.c. of milk had the same alkaline reaction to blue lacmoid as 41 c.c. N/10 sodium hydroxide, and the same acid reaction to phenolphthalein as 19.5 c.c. N/10 sulphuric acid. From physicochemical measurements it has been determined that the real reaction of cow's milk is neutral or nearly so which corresponds with the reaction of animal fluids and tissues in general.

When exposed to the air milk undergoes a change whereby its reaction becomes more and more acid. This increasing acidity is induced by the action of microorganisms upon lactose whereby the latter is transformed into lactic acid, or finally butyric acid.

Fresh amphoteric milk does not coagulate on boiling but on the surface is formed a film consisting of coagulated casein and lime salts. On removal of this film, thus allowing a fresh surface to come in contact with the air, a new film will form indefinitely upon continued heating. The formation of the film is facilitated by surface evaporation and by the presence of fat, although these factors are not essential to the process. A similar film will form on heating any protein solution containing fat or paraffin. In the presence of real acidity, due to formation of lactic acid fermentation, or from any other cause, heat will fail to produce a film but instead a real coagulation will occur. When milk is boiled it is changed chemically and has a different odor and taste. These changes are due in part at least to a decomposition of the milk proteins and are accompanied by the liberation of hydrogen sulphide.

In the spontaneous souring of milk it is generally considered that lactic acid formation is the essential step, but succinic acid may also be present. In certain instances succinic acid may be formed without lactic acid being present. Other volatile fatty acids, such as acetic, butyric, etc., may also be formed in the bacterial decomposition of milk. It is assumed that these acids have their origin in lactose. A peculiar kind of coagulation (thick milk) sometimes occurs in milk during which it is converted into a thick, ropy, slimy mass. This action is due to microorgauisms acting upon milk sugar causing it to undergo a peculiar transformation. By sterilization with heat and prevention of bacterial contamination lactic acid formation may be entirely prevented or inhibited. The same thing may be accomplished for a short period by antiseptics such as formalin, salicylic acid, boric acid, etc. Fresh amphoteric milk treated with rennin coagulates rapidly to a solid mass (curd) from which a yellowish liquid (whey) is gradually pressed out. During this process no change occurs in the reaction of the milk and the process therefore is quite distinct from acid coagulation.

Milk contains as its principal solids, proteins, as casein, lactoalbumin, lactoglobulin; fats, as triolein, tripalmitin, tristearin, tributyrin; carbohydrate, as lactose; inorganic salts, as calcium phosphate, besides traces of such bodies as lecithin, cholesterol, urea, creatine, creatinine, citric acid, and the triglycerides of caproic, lauric, and myristic acids and a yellow coloring matter.

Fat occurs as fat globules which consist of extremely small drops of fat suspended in the milk plasma. It is a disputed question whether the fat globules consist entirely of fat or whether they also contain protein. By some investigators the existence of a special substance of a protein nature forming a membrane or a stroma is strenuously denied although very recently it has been shown by Abderhalden and Voltz that the acid hydrolysis of the fat globules yields glycocoll. Since neither casein or lactalbumin is capable of furnishing glycocoll on hydrolysis it is probable that the fat globules contain a special protein substance. It is still a question, however, whether casein and lactalbumin may not also be included in the fat globule envelope or membrane.

Casein belongs to the group of phosphoproteins

and has the following elementary composition, C = 53.0, H = 7.0, N = 15.7, O = 22.6, S = 0.8, P = 0.85. Like most proteins it exhibits a negative rotation which is rather variable. In neutral solution this equals $(\alpha)_D = -80°$ but in an alkaline reaction it is $(\alpha)_D = -97.8$ to $-111.8°$ in solutions of N/10 and N/5 NAOH respectively. The question whether the caseins obtained from the milk of different animals are identical has not been determined positively. It has been asserted, however, that mare's and ass's casein is higher in nitrogen but poorer in sulphur and carbon than that of the ruminants.

Dry casein is a fine white powder which is practically insoluble in distilled water and it is only slightly soluble in neutral salt solutions. It is readily soluble in dilute solutions of alkalis and alkali earths, but it is insoluble in dilute acids. Casein solutions containing lime are opalescent and it is probable that this opalescence is responsible in large measure for the white color of milk. Casein forms compounds with calcium of the nature of salts in which there are undoubtedly combinations of the type of di- and tri-calcium caseinates. Caseinates may be formed with other alkalis and alkali earths also, as sodium, potassium, and magnesium.

Upon boiling casein solutions do not coagulate but form thin pellicles when calcium is present. They are precipitated by weak acids in excess. From neutral solutions casein may be precipitated by sodium chloride, alum, zinc sulphate, and copper sulphate.

The most characteristic property of casein is its coagulation by rennin when calcium salts are present. Rennin, however, has an action upon casein even in the absence of calcium salts for if a calcium-free casein solution is treated with rennin the casein is changed and yields a coagulation if lime salts are subsequently added. From this it may be seen that milk coagulation by rennin is a two-fold process—first, the action of rennin upon casein taking place without visible change, second, the precipitation of the curd by the lime salts. Casein coagulation with rennin may be looked upon as a cleavage process in which most of the casein is split off as paracasein, a substance closely related to casein, which precipitates, whereas a proteose-like body remains in solution. Lactalbumin and lactoglobulin are not radically different so far as one may judge from the corresponding proteins occurring in the blood, hence they need no specific discussion.

Lactose or milk sugar belongs to the group of carbohydrates called disaccharides and upon hydrolysis yields a molecule of dextrose and one of galactose. It occurs as a rule only in milk, but is at times present in the urine of pregnant women and also after the ingestion of large quantities of lactose. Lactose occurs as colorless rhombic crystals containing one molecule of water. Milk sugar is soluble in six parts of cold water or in two and one-half parts boiling water and has a faint sweet taste. It is insoluble in ether or absolute alcohol, turns the plane of polarized light to the right, $(\alpha)d = +52.5°$, reduces metallic oxides, such as bismuth and copper, forms a characteristic osazone, and is not directly fermentable with pure yeast. By the influence of lactase, existing in ordinary yeast it may undergo alcoholic fermentation, dextrose and galactose first being produced.

Inorganic salts of milk consist chiefly of sodium, potassium, calcium, and magnesium in combination with chlorides and phosphates. Iron is present only in small quantities. Of the gases of milk, carbon dioxide is present in the largest quantity. Traces of nitrogen and oxygen may also be present. Numerous enzymes and other substances are present which will be discussed under human milk.

The quantitative composition of cow's milk is very variable. An average composition is the following compiled by König. The figures are percentages:

Water.	Solids.	Casein.	Albumin.	Fats.	Sugar.	Salts.
87.1	12.8	3.0	0.5	3.7	4.9	0.71
For skimmed milk		Proteins				
90.7	.....	3.1	.....	0.74	4.8	0.74
For cream						
65.5	.....	3.6	.....	26.7	3.5	0.61
For buttermilk						
90.3	.....	4.0	.....	0.9	3.7	0.67
For whey						
93.2	.....	0.85	.....	0.2	4.7	0.65

Milk of Other Animals.—Except from the quantitative standpoint little that is specific is definitely known concerning the milk of other animals. Goat's milk has a more yellowish color and a different odor than cow's milk. Mare's milk is alkaline and its casein is only incompletely precipitated by rennin. Like the casein of human milk it is not precipitated by acids in lumps or solid masses but in fine flocks. Ass's milk is quite similar to human except that it is poorer in fat.

The following table illustrates the comparative composition of milk of different species:

Species.	Water.	Solids.	Proteins.	Fats.	Sugar.	Salts.
Dog	75.4	24.5	9.9	9.6	3.2	0.73
Cat	81.6	18.4	9.1	3.3	4.9	0.58
Goat	86.9	13.0	3.7	4.1	4.4	0.86
Sheep	83.5	16.5	5.7	6.1	3.9	0.66
Cow	87.1	12.8	3.5	3.7	4.9	0.71
Horse	90.0	9.9	1.9	1.1	6.6	0.31
Ass	90.0	10.0	2.1	1.3	6.3	0.30
Pig	82.4	16.7	6.1	6.4	4.0	1.10
Elephant	67.8	32.1	3.1	19.6	8.8	0.65
Dolphin	48.6	51.3	.....	43.7	.....	0.46
Whale	69.8	30.2	9.4	19.4	traces	1.0

In the following table are given data showing the quantitative distribution of the ash of the milk of various species of animals. The figures are percentages:

Species.	Mare.	Cow.	Goat.	Sheep.	Ass.
K_2O	0.104	0.17	0.13	0.09	0.084
Na_2O	0.014	0.05	0.06	0.08	0.033
CaO	0.123	0.17–0.20	0.19	0.24	0.106
MgO	0.012	0.02	0.015	0.015	0.013
Fe_2O_3	0.001	0.001	0.003	0.004	0.001
P_2O_5	0.131	0.24–0.28	0.28–0.78	0.3–0.8	0.135
Cl	0.030	0.10	0.1	0.13	0.031

The composition and yield of milk of cows vary as the result of several factors, such as the season of the year, the character of the food, the condition of the animal, and also whether it is fatigued, at work or at rest. There is also a diurnal variation and the presence in the food of certain stimulants and nitrogenous substances may cause a variation. The composition of milk may vary also during the course of lactation and also during stages of the same milking. It has been shown that the per cent. of proteins and fat in milk varies with the season, being greater in the autumn and winter than in the spring or summer. The percentage of lactose remains constant throughout the year.

The influence of food upon the composition of milk has been a subject for controversy, some investigators claiming that this influence is slight, others

maintaining that the character of the food plays an important rôle in affecting milk composition. Albert and Maerker have shown that rations rich in fat produce a milk rich in fat. If fat feeding is continued for long periods, however, the fat in the milk decreases to the level maintained on poorer rations. Rhodin upon feeding emulsified oils found at first an increase of fat in the milk followed by a return to the normal amount. Upon feeding linseed oil to sheep Gogitidse found that the fat of milk could be made to contain as much as thirty-three per cent. of linseed fat. Hills found that the addition of cotton seed, maize, or linseed oils to the food of cattle causes an increase in the yield of milk per unit of dry matter fed. As the result of studies extending over many years Morgan, Beger, and Fingerling conclude that of all foods, fat alone exerts a specific action in causing increased milk fat production, proteins and carbohydrates having no such influence. When stimulants are added to foods originally free from such substances the effect of the stimulant is to increase the consumption of food and the yield of milk. No such increase is observed, however, when stimulants are added to foods already containing such compounds. Such stimulants as fenugreek, anise, caraway seed are recommended. The addition of lecithin to the diet tends to increase the yield of milk and also the live weight of the animal. Asparagin when substituted for protein and fed with cane sugar caused no decrease in the yield of milk but the fat of milk was decreased. Amino compounds cannot take the place of proteins in milk production but they exert a greater influence than do the carbohydrates.

In the later stages of lactation the actual yield of milk diminishes, although the specific gravity and the proteins are relatively increased. With regard to variation in ash constituents it has been shown that the ash varies throughout the lactation period, being as a rule smaller during the summer and spring than in autumn and winter. Fatigue causes a falling off in the milk yield, the total solids and fat being slightly higher than during a period of rest. It has also been shown that work exerts a harmful influence on the quality of the milk, especially on its keeping qualities.

Milk Poisoning, Galactotoxismus.—Through the work of Vaughan and others it is recognized that milk may acquire toxic properties and become dangerous to health in at least five distinct ways. (1) Milk may absorb metallic poisons from metallic vessels in which it has been allowed to stand—thus the absorption of copper or zinc by milk has caused outbreaks of milk poisoning which ceased on substitution of earthen vessels for metallic containers. (2) Poisonous drugs administered to animals may find their way into the milk. Such substances as ether, alcohol, lead, colchicum, euphorbin, iodin, morphin, salicylic acid, hemlock, mercury, turpentine, antimony, veratrine, and a great variety of salts are said to be eliminated in the milk. (3) The vegetable poisons present in certain weeds and contained in the food of cows may lead to distinct poisoning from ingestion of the milk of such cows. (4) The milk may acquire poisonous properties as a result of the diseased condition of the animal. (5) Bacterial contamination may produce serious results. Little is definitely known concerning the chemical nature of these substances although their effects are well recognized.

Relation of Milk Composition to Rapidity of Growth.—In an interesting table, shown below, and compiled from the investigations of Bunge and Abderhalden is shown the relation of milk composition to the rapidity of growth of different animals. It will be observed that the composition of the milk varies directly with the length of time for the young of the particular species to double in weight.

Species.	Period in which weight of newborn is doubled (days).	100 parts milk contain.			
		Proteins.	Salts.	Calcium.	Phosphoric acid.
Man	180.0	1.6	0.2	0.033	0.047
Horse	60.0	2.0	0.4	0.124	0.131
Cow	47.0	3.5	0.7	0.160	0.197
Goat	22.0	3.7	0.8	0.197	0.284
Sheep	15.0	4.9	0.8	0.245	0.293
Pig	14.0	5.2	0.8	0.249	0.308
Cat	9.5	7.0	1.0	.....	.....
Dog	9.0	7.4	1.3	0.455	0.508
Rabbit	6.0	10.4	2.5	0.891	0.997

Human Milk.—Human milk has the same appearance as cow's milk but when it is cooled small flakes tend to adhere to the sides of the bottle. When milk is warmed these flakes disappear. Human milk is sweet and has no odor. Under the microscope it is seen to consist of an emulsion which is permanent, suspended in fluid plasma. A few leucocytes and epithelial cells may also be observed. With the ultramicroscope many fine particles in lively molecular motion may be seen between the fat globules. These particles are less numerous than in cow's milk and are probably composed of casein. The specific gravity of human milk varies between 1.030 and 1.032 although it may fall as low as 1.020 or may rise as high as 1.036. Like cow's milk, human milk gives an amphoteric reaction to litmus, this reaction being due to the presence of different types of phosphates. The alkaline reaction is relatively stronger than the acid reaction although the degree of acidity or alkalinity is less than in cow's milk. From the physicochemical standpoint human like cow's milk is neutral.

The quantity of milk secreted by healthy nursing women is subject to great variation, being determined in large measure by the demands of the child. It has been shown that the amount of milk secreted by a wet-nurse nursing two infants was 720 grams which in a period of ten days could be increased to 1750 grams when five infants were nursed. In the following table are given figures representing the amount of milk taken by the infant as obtained by weighing either the mother or infant before and after each nursing. These figures also show the difference in milk secretion between primiparæ and multiparæ.

Twenty-four Hour Amount of Milk in Grams (Cramer, after Talbot).

Day postpartum.	1	2	3	4	5	6	7	8	9	10
Nine babies of primiparæ.... Average birth weight 3290 grams.....	4	78	183	199	236	299	303	274	362	384
Seven babies of multiparæ.. Average birth weight 3348 grams.....	6	129	238	324	324	354	361	365	384	415

In the following table are given figures showing the average daily amount of milk drawn by a baby according to Czerny and Keller and quoted from Talbot.

The employment of the ultramicroscope has helped to explain the coagulation of milk. The essential differences in the coagulation of human and cow's milk are the following: The casein of human milk is precipitated with greater difficulty with acids or salts and it does not coagulate uniformly after the addition of rennin. The clot formed does not assume the large coarse masses seen with casein of cow's milk but is loose and flocculent. Human milk does not

clot with rennin alone. If human milk is frozen for several days and then rennin and acid added coagulation occurs. The non-coagulation with rennin has been ascribed to the low calcium content and relative alkalinity of the milk. There is no macroscopic difference between acid and rennin coagulation. The ultramicroscope shows that neutral solutions of rennin cause the casein, which was previously invisible, to become visible. Acid subsequently added causes a distinct precipitation. The curds from acid plus rennin coagulation are not so easily dissolved as those from acid coagulation alone.

Average Daily Amount of Milk Drawn by a Baby.

Age in weeks.	Average weight of breast-fed babies according to Camerer, grams.	The calculated day's amount of milk, grams.
1	3410	291
2	3550	549
3	3690	590
4	3980	652
5	4115	687
6	4260	736
7	4495	785
8	4685	804
9	4915	815
10	5055	800
11	5285	808
12	5455	828
13	5615	852
14	5745	870
15	5950	878
16	6150	893
17	6350	902
18	6405	911
19	6570	928
20	6740	947
21	6885	956
22	7000	958
23	7150	970
24	7285	980
25	7405	990
26	7500	1000

The proteins in human milk are comparable to those in cow's milk, namely casein, lactoglobulin, and lactalbumin, but whether these substances are identical with the corresponding compounds in cow's milk has not been definitely determined. In comparing the proteins of human and cow's milk several points of interest stand out. In the first place it is difficult to separate the casein from human milk and according to some investigators human casein contains more sulphur than casein from cow's milk. The phosphorus content of human casein has been shown recently to be 0.22 to 0.28 per cent. whereas in the casein of cow's milk it is present to the extent of 0.87 per cent. From these facts it may be reasoned that the two caseins

Total Protein in Milk at Different Stages of Lactation.

Days postpartum.	Protein (per cent.).
9–10	1.81
11–20	1.81
21–30	1.94
31–40	1.50
41–50	1.75
51–60	1.56
61–70	1.44
71–100	1.25
101–140	1.25
141–200	1.29
over 200	1.31

are not identical. Bordet showed that repeated injections of cow's milk into other animals led to the formation of precipitins in the serum, and from the work of Wassermann and others it was further demonstrated that these precipitins are specific. By means of complement fixation and anaphylactic experiments the proteins of milk may be differentiated from one another. It therefore seems highly probable that the proteins of milk are specific for different species of animals, and that the caseins of different kinds of milk are not absolutely identical. The quantity of protein in human milk during the period of lactation shows a slight variation as may be seen from the preceding table by Schlossmann taken from Talbot.

The amount of protein in human milk varies during the same day and even during the same nursing but these variations are slight and without special significance. In the table below are given figures showing the variations in the protein of the milk of eight wet-nurses during a single day.

Variation in the Milk of Eight Wet-nurses during a Single Day. (Engel, taken from Talbot.)

Age of nurse, years.	Day of lactation.	Amount, c.c.	5 A.M.	9	12	3	6 P.M.	10	Average.
16	45	2000	1.38	1.46	1.30	1.32	1.31	1.28	1.34
19	58	1500	1.63	1.12	0.96	1.07	1.16	1.13	1.10
29	60	2200	1.15	1.15	1.39	1.26	1.13	1.16	1.21
25	70	2700	1.31	1.24	1.13	1.21	1.04	1.06	1.17
23	72	3000	1.20	1.23	1.15	1.31	1.15	1.16	1.20
21	100	3300	1.13	1.12	1.13	1.15	1.24	1.03	1.12
19	130	1800	0.49	1.02	1.13	1.06	0.90	1.08	0.95
25	140	2200	1.08	1.06	1.10	0.94	1.08	1.06	1.04
								Average	1.14

Fat in human milk is in a state of fine emulsion. The fat globules are more numerous in human milk than in cow's milk and as a rule they are smaller. The amount of fat in human milk is subject to great variation. At the beginning of nursing the amount of fat present is smallest and largest at the end, the rise in fat depending upon the amount of milk taken at a nursing. When a small amount is taken there is a sharp rise in the percentage of fat, and a more gradual rise is to be noted when a large amount is taken. In the first milk the percentage of fat varies between 1 and 3 per cent. and in the last milk between 6 and 10 per cent. On the other hand, there are records of cases where these conditions have been reversed. Under pathological conditions the percentage of fat may vary from 0.1 per cent. to 13.7 per cent. In general the amount of fat varies from 3 to 4.5 per cent. The melting-point of fat from human milk is between 30 and 34° C. and its specific gravity is 0.97 at 15° C. The volatile fatty acids in the fat of human milk amount to 2.5 per cent. of the total fat, in cow's milk fat to 27 per cent. of the total fat. The lower melting-point and higher iodine value of the fat of human milk when compared to that of cow's milk is due to the larger content of triolein.

Milk sugar, or lactose, is undoubtedly formed from dextrose of the blood, and it varies in human milk the least of all the constituents. The amount of lactose is nearly twice that in cow's milk, being on the average about 7 per cent. On the other hand, amounts as low as 4.22 per cent. and as high as 10.9 per cent. have been recorded.

The average amount of ash in human milk is about 0.21 per cent. The amount of ash diminishes during the course of lactation just as does that of the protein. In the following table from Camerer and Söldner quoted from Talbot this is shown clearly.

Days postpartum.	Per cent. of ash.
8–11 days	0.28
29–40	0.22
60–140	0.19
170 days and later	0.18

The percentage of various salts present in human milk as given by different investigators is shown below (quoted from Talbot).

	Bunge.	Blackhaus and Kronheim.		De Lange.	Schloss.
		1	11		
K_2O	32.14	33.74	27.33	19.9	28.77
Na_2O	11.75	11.91	15.88	29.6	10.26
CaO	15.67	17.36	15.52	12.9	20.44
MgO	3.99	3.17	2.13	2.9	4.66
Fe_2O_3	0.27	0.63	1.75	0.25	.....
P_2O_5	21.42	14.79	11.75	17.9	22.0
Cl	20.35	15.47	23.93	21.3	16.61

The distribution of the elements in the ash of human milk follows (quoted from Talbot).

Composition of Ash of Human Milk. (Engel.)
100 grams milk contains (mgms.).

	First milk.	End milk.	Average.	First milk.	End milk.	Average.
K_2O	100.8	63.4	88.4	32.5	31.9	32.4
Na_2O	44.8	17.6	35.7	14.5	8.9	13.1
CaO	37.6	38.1	37.8	12.1	19.2	13.9
MgO	5.4	5.2	5.3	1.7	2.6	1.9
Fe_2O_3	0.22	0.12	0.2	0.07	0.06	0.07
P_2O_5	32.10	28.8	31.0	10.40	14.50	11.40
SO_3	9.6	7.2	9.0	3.1	3.6	3.3
Cl	71.7	34.2	59.1	23.1	17.3	21.7

From these tables it is evident that the ash varies in amount just as do the other components according to the period of nursing when the sample is taken. For this reason therefore when the ash of milk is being investigated it is essential to take into consideration the time of drawing the milk, that is, whether at the beginning or the end of the nursing period. This precaution is equally essential for the other milk constituents.

From what has been given above it is evident that the composition of human milk is subject to quite marked variations. As a rule, the percentage of fat shows the greatest fluctuations. An average percentage composition of milk follows:

Protein.	Sugar.	Fat.	Salts.
1.5	7.0	4	0.21

The variations in the different components may be seen in the following table taken from Talbot.

Variations in Composition of Human Milk. (From Czerny and Keller.)
(Percentages.)

	Fat.	Sugar.	Protein.	Ash.	Solids.
Pfeiffer	0.75–9.05	4.22–7.65	1.0 –3.04	0.10–0.44	8.23–15.6
Johannessen & Wang	2.7 –4.6	5.9 –7.8	0.9 –1.3	.....	.....
V. and J. S. Adriance.	1.31–7.61	5.35–7.95	0.23–2.6	0.09–0.28	9.19–15.3
Guiraud.	1.75–6.18	6.7 –7.7	0.85–1.4	0.10–0.27	11.2–16.3
Camerer & Söldner.	1.28–5.77	5.35–7.52	0.82–1.86	0.11–0.36	9.41–14.1
Schlossmann.	1.65–9.46	5.2–10.90	0.56–3.4	.....	.....

A large number of investigations have been carried through with a view to the determination of the effect of food on the composition of human milk. With the exception of the influence of fat feeding the experiments do not warrant definite conclusions. When the mother is underfed the fat of milk may diminish. If to such an individual fat is fed, the milk fat will be augmented up to a certain point. When additional fat is given to well-fed mothers there is only a temporary increase in the milk fat. The conclusion may be drawn that in general the milk of nursing mothers cannot be permanently influenced except when insufficient food is ingested.

Foreign Substances in Human Milk.—Traces of certain drugs taken by the mother may pass into the milk. Among these may be mentioned potassium iodide, salicylates, antipyrin, mercury, calomel, arsenic, bromides, antimony, urotropine, and to a certain extent bodies that are soluble in fats. Morphine and atropine pass into the milk of animals but have not been shown to be present in human milk. Alcohol may occur in traces after taking large amounts. Salvarsan injected into the syphilitic mother may be excreted in the milk and under such treatment the syphilitic suckling frequently shows remarkable improvement, and in some cases has died so that such treatment may not be entirely free from danger.

The Influence of Physiological and Pathological Conditions on the Composition of Human Milk.—*Menstruation.*—The following table from Talbot, taken from Rotch, shows the effect of menstruation upon the composition of the milk.

Effect of Menstruation on Breast Milk.
(Percentages.)

	Fat.	Lactose.	Protein.	Salts.	Water.
Second day of menstruation, child's stools loose.	1.37	6.10	2.78	0.15	89.6
Seven days after menstruation, bowels regular	2.02	6.55	2.12	0.15	89.1
Forty days later	2.74	6.35	0.98	0.14	89.8

On the other hand, Bendix after examining the milk of eight women, before, during, and after menstruation concluded that such variations as he obtained were not outside of the normal physiological limits.

Uremia.—It has been shown that in nephritis and mild uremia the protein content of human milk may be increased but this increase does not affect the nursing infant so long as the quantity of the milk and the health of the mother are normal.

Beriberi.—The milk of mothers with beriberi is dangerous for the infant.

Bile.—Bile may be present in the fat when the mother is jaundiced.

Enzymes in Human Milk.—In human milk a variety of enzymes have been described, some of which are as follows: casease—transforming casein into soluble products—pepsin and trypsin—fibrin ferment—amylase, lactase, lipase, salol-splitting enzyme, oxidase, and reductase and peroxidases.

Transmission of Toxic Bodies and Immunity through Milk.—Many vegetable poisons taken in as food, or toxic substances formed as the result of metabolism, may pass into the milk. Ehrlich was the first to show that immunity may be transmitted to the infant through the milk. The fact that breast-fed infants seem to be less liable to such diseases as measles, scarlet fever, mumps, and typhoid fever, is used as an argument that immunity is transmitted through the breast milk. With regard to antitoxins and agglutinins it is impossible to state whether these properties are acquired by the infant in intra-

uterine life or through the milk. Bactericidal substances are probably carried in the milk and hemolysin is a normal property of human milk. Human milk is poorer in opsonins than the blood serum of the mother, while the colostrum is richer than the milk. Hypersensibility or sensitization toward various poisons and proteins may pass over in the milk to the infant.

Differentiation of Human Milk from Other Milk.—*Umikoff's Reaction.*—If 5 c.c. of human milk are warmed on a water bath at 60° C. with 2.5 c.c. of a ten per cent. solution of ammonium hydroxide for fifteen to twenty minutes, a reddish-violet color appears. With cow's milk there is no change in color.

Moro's Reaction.—A one per cent. solution of neutral red turns human milk yellow and cow's milk purple. The addition of one drop of stain to a teaspoonful of breast milk changes it to a reddish purple at once, if the milk has been kept too long and is unfit for use.

Bauer's Reaction.—The addition of one drop of a 0.25 per cent. aqueous solution of neutral blue sulphate (Grübler) to from 2 to 3 c.c. of human milk turns the milk violet blue. When added to cow's milk the color is greenish blue. When shaken with about five volumes of ether the color is extracted from human milk but persists in cow's milk.

Tugendreich's Reaction.—Equal amounts of a one to two per cent. solution of silver nitrate and milk are mixed, shaken, and quickly boiled for three minutes. Human milk changes in color to coffee brown or brownish violet, while cow's milk does not.

Frank P. Underhill.

References.

In the preparation of this article free use has been made of the data contained in the following publications:

For Human Milk.—Talbot: A Summary of Present Knowledge of Human Milk. Am. J. Diseases of Children, 1914, 7, p. 445. A survey of the literature is given.

For Milk in General.—Hammarsten: Text-book of Physiological Chemistry, 1911.

Raudnitz: Ergebnisse der Physiologie, 1903, p. 193. Literature is given.

Bulletin No. 41: Hygenic Laboratory, Public Health and Marine Hospital Service of the United States. "Milk and its Relation to the Public Health," 1908. Literature cited.

Milk in Relation to Public Health.—In view of the dietetic importance of milk for all classes, but especially for infants, invalids, and the sick and convalescents, it is perfectly natural that much study should have been given to this foodstuff, and that of late years the sanitarian and bacteriologist should have found it a profitable field for research. Indeed, the production of pure milk might well be considered one of the most important problems which confront the sanitarian. Few countries until recently have deemed it necessary to do more than prevent adulteration of the milk, and some of the legislators appear to think that as long as the milk has not been skimmed or watered, and contains the standard of total solids and fats, we need not worry about the germs we eat or drink. This may be a pleasing reflection to persons who do not know that such hydra-headed diseases as scarlet fever, diphtheria, and cholera infantum have been disseminated in the milk supply, that typhoid-fever epidemics have been thus caused, and that milk may be the vehicle of the germs of tuberculosis and other infectious diseases and morbific agents. Space will not permit to do more than briefly point out some of the circumstances under which milk may be the cause of disease.

1. Milk which is Objectionable by Reason of Color, Odor, Taste, and Consistency.—(*a*) *Abnormally Colored Milk.*—Fuchs was the first to point out that *blue milk* may be due to the presence of chromogenic microorganisms, and Neelson and Hueppe proved that this was caused by the bacillus cyanogenes which may even invade the udder of the cow. Mosler and Uffelmann refer to cases of gastrointestinal catarrh produced by the consumption of such milk. A uniform blue color is imparted by adulteration with water and certain kinds of cow's feed, and by some drugs. *Yellow milk* may be due to the addition of coloring matter such as annatto or saffron or the development of the bacillus synxanthus (Schrötter), but may also be caused by the ingestion of rhubarb (Mosler). *Red milk* may be caused by rhubarb or by the presence of the bacillus prodigiosus or of the spirillum rubrum, or by the admixture of blood, especially when the milk looks streaky, but it is most often due to giving the animals madder or bedstraw for food. *Brown milk* may be due to the presence of foreign matter or the products of certain fungi. A *bluish-red* color is caused by the bacterium lactis erythrogenes (Hueppe), while *green milk* is generally the result of an excess of fat and incomplete emulsification, sometimes due to the presence of the bacillus fluorescens, and occasionally, as in suppurative affections of the udder, to the presence of green pus.

(*b*) *Abnormal Odor, Taste, and Consistency.*—This may be caused by the character of the food, by exposure of the milk to air charged with foul vapors, or by the presence of foreign matter. The odor of onions is imparted when any of the alia are eaten, and after the ingestion of even a small quantity of skunk cabbage the milk yields the characteristic odor. The consumption of turnips, cabbage, or decaying leaves frequently affects the flavor of the milk. Milk is said to acquire at times a bitter taste after the ingestion of wormwood, lupine, turnips, etc., or when the animal suffers from disease of the liver, interfering with the proper elimination of the biliary acids and salts, but it is most frequently due to growth of certain forms of bacteria after the milk leaves the udder and which are generally present in dark, damp, and badly ventilated milk houses. A bitter taste is also observed in putrid milk, in which case the reaction is alkaline; a salty milk often results from cattle grazing upon marshy salt grasses.

Occasionally we see a stringy or filamentous milk which is due to the presence of certain micrococci, very generally found in dirty milk pans or other utensils; sometimes the milk is slimy, and several species of bacteria have been described as the cause of this condition; chief of these organisms is the bacillus lactis viscosus, isolated by Adametz and a micrococcus described by Freudenreich. In rare instances milk presents a soapy taste, which, according to Weigmann, is due to a specific bacillus. It is needless to add that all such milk is unfit for use.

(*c*) *Colostral milk* and the milk yielded for from ten to fifteen days before calving differ in composition from normal milk; the former frequently contains blood corpuscles from the vaginal passages. Dr. Heisch reports the case of a family using such milk who were attacked with symptoms resembling severe influenza, with high fever and great soreness of the inside of the mouth, throat, and tongue, which were covered with small pustules. The servants, who took the skimmed milk only, remained unaffected. According to Höhne, milk yielded by animals a few days before calving has induced diarrhea and colic in the consumers. For these reasons it has been deemed best to exclude from sale the milk yielded by animals fifteen days before and five days after parturition. According to LeBlanc the milk of cows in heat and even the milk products of nymphomanous cows may cause gastrointestinal disturbances.

(*d*) *Milk Sediments.*—Every consumer of milk has doubtless observed the presence of more or less foreign

matter at the bottom of the vessel or bottle in which it is kept; indeed, it is a matter of such common occurrence that it hardly excites our attention, and many are disposed to look upon it as a matter of course. Professor Soxhlet, of Munich, was perhaps the first to point out that these deposits are largely made up of excrementitious matter from the cow, which, adhering to the udder of the animal, gained access to the bucket during the act of milking. These sediments are obtained by the centrifuge or by permitting a bottle of milk to stand for two hours; then siphon off half of the top milk and add the same quantity of distilled water, and repeat this process several times until the suspended matter remains in pure water, which may then be collected on filtering paper and weighed before and after drying. If these sediments are subjected to microscopical examination, we shall find, as shown in the accompanying microphotographs, prepared by Dr. Gray of the Army Medical Museum, that they are composed of epithelial débris, hairs of the cow, excrementitious matter, vegetable fibers, organic and inorganic dust particles, bacteria, fungi, and spores of every description; fully ninety per cent. of the germs are fecal bacilli—all of which is not only disgusting, but extremely suggestive of danger. The number of microorganisms in such milk is largely increased, and while there is no evidence that milk of this description, when taken perfectly fresh, has proved injurious to the consumer, we know that bacterial development and consequent decomposition are materially hastened in such a medium, and that the conversion of milk sugar into lactic acid, apart from impairing the nutritive value, may cause gastrointestinal disorders in delicate infants.

The greatest danger from milk of this class is the possible presence of tyrotoxicon and other toxins. Professor Vaughan believes that the former poison is developed by the growth of a saprophytic germ which under favorable conditions multiplies with astonishing rapidity. The presence of the very filth referred to, a summer heat, and pernicious habit of placing the milk before cooling in covered cans or bottles, perhaps dirty besides, constitute favorable environments for the development of this poison. Fliigge (*Zeitschrift f. Hygiene*, July, 1894) found among the milk bacteria, especially those which are liable to resist the temperature of boiling, several varieties capable of evolving toxins. It is highly probable that in these cases we are dealing with ptomaines and toxins, the products of putrefactive processes which, if ingested in sufficient quantity, may be the cause of acute intoxications, not only in the so-called cases of ptomaine poisoning in adults, but also in the profound and rapidly fatal cases of cholera infantum. The views of Vaughan, Booker, Jeffries, Escherich, Baginsky, and others on the relation of saprophytic germs and toxins to cholera infantum in bottle-fed children are gaining ground and will doubtless lead to a great reform in the management of dairies.

Cases of poisoning by milk and ice cream were reported, long before we knew the nature of this poison, by Haschek, Hagner Cameron, Barruel, Orfila, Marjolini, Bonorden, Hasset, Schroff, and others; the symptoms in these cases being nausea, vomiting, dryness and a sense of constriction of the throat, vertigo, colic, and purging, with a tendency in some cases to collapse, in others to numbness of the extremities and stupor.

In 1884 Vaughan isolated a poison found in poisonous cheese and called it *tyrotoxicon;* in November, 1885, he found the same substance in old milk; in June, 1886, he demonstrated its presence in poisonous ice cream, and in milk which had already undergone lactic-acid fermentation, and he called attention to the probable relation of tyrotoxicon to cholera infantum and other kindred diseases. In July, 1886, he found this poison in a sample of milk which had evidently caused the symptoms of cholera infantum in a babe seven months of age. In April, 1887, Dr. Stanton, the health officer of Cincinnati, demonstrated tyrotoxicon in poisonous cream puffs.

2. Milk may be Rendered Unfit for Use by Improper Food and Care of the Animal.—The disease described as milk sickness or trembles by some American writers, and characterized by great weakness, constipation, vomiting, fetor of breath, and muscular twitching, was believed to be due to cows feeding on Rhus toxicodendron, white snake-root, and other poisonous plants; others attributed the disease to mineral poisons, such as cobalt, lead, and arsenic. The infected areas are generally wooded land and with the clearing of forests and fencing of pastures the disease has become less frequent. The cause is still obscure, Jordan and Harris have described an organism, B. lactis morbi, which they believe is the etiological factor. Cases of diarrhea, and even severe forms of gastroenteritis, have been traced by Sonnenberger, Ratti, and Mackay to the milk of cows and goats feeding upon meadow saffron and euphorbiaceous plants. The milk of animals fed on carrots, turnip tops, and the common artichoke, and often that which is yielded after they have been turned out to pasture for the first time in the spring, is changed in an unaccountable manner, and has frequently caused vomiting, abdominal pains, and diarrhea in hand-fed children. Among the meadow plants, apart from species of Euphorbia and Ranunculus, Husemann regards the Gratiola officinalis, Æthusa cynapium, or fool's parsley, Cytisus ramentaccus, and different varieties of sorrel and mushrooms, as being especially objectionable.

The milk of swill-fed animals has often a peculiar taste and odor, and is said to cause hyperacidity of the urine and consequent eczema. M. Toussaint called attention to the fact that in the district of Argenteuil deaths from gastrointestinal diseases have increased in frequency among bottle-fed children since the establishment of a large distillery, the cows being fed on brewers' grain and other distillery products, and the milk presenting an acid reaction. But this acidity is by no means constant, as Uffelmann and Ohlsen have often found it alkaline.

Ostertag states that the milk of animals fed with expressed sugar beets is destructive to calves on account of the excess of potassium, and hence objectionable for human consumption. Bollinger reports injurious effects from castor-oil cakes, and Schmidt-Mühlheim attributes diarrheal attacks to the admixture of wild mustard in the rape-seed-oil cakes fed to cows.

3. Milk may Acquire Injurious Properties while the Animals are being Treated with Strong Remedial Agents which are Excreted in the Milk.—This is true of the following substances: arsenic, antipyrin, aspirin, ether, bromides, urotropin, lead, iodine, copper, mercury, tartar emetic, carbolic acid, opium and morphine, colchicum, and euphorbium. Dr. James Law reports an extensive outbreak of ergotism among animals, affecting also calves, presumably through the milk; and Baum refers to salicylic acid, atropine, veratrum, strychnine, croton oil, aloes, senna, and turpentine as likely to affect the milk. The remedy is obvious; animals which are being treated with medicaments for any cause cannot produce a pure or sound milk and should be excluded.

Venomous Poison in Milk.—Dr. Francis reports a remarkable case of this kind, the details of which were furnished him by Dr. Fayrer, of Eastern Bengal, and which indicate that the milk of an animal bitten in the udder by a poisonous serpent will convey the venom.

4. Milk Itself may be Morbific as the Product of a Diseased Animal.—(*a*) *Inflammatory Conditions of the Udder and Teats (Garget) a Probable Cause of Septic Sore Throat, Pseudo-diphtheria and Pseudo-scarlet*

Fever.—There is an abundance of evidence to show that cows frequently suffer from various degrees of mammitis and other septic processes of this secreting organ. It is obvious that the character and composition of the milk in such instances are changed, and, apart from the disgusting admixture of pus, it may prove dangerous by the transmission of septic germs, such as the various forms of streptococci and staphylococci, which have actually been demonstrated in such milk by Kruger, Nocard and Mollerau, Kitt, Bang, and others; and, besides, we know from Löffler's experiments that milk also offers a suitable culture medium for such germs.

Dr. James Niven, health officer of Manchester, describes in the London *Lancet*, January 19, 1895, p. 145, an epidemic affecting 160 consumers of a particular milk supply, with symptoms of diarrhea, sickness, and abdominal pains. The milk had an odor resembling that of sweet pus, and examination revealed the presence of streptococci and a microbe having the characters of the bacillus coli communis. A searching inquiry at the farm resulted in the admission of the farmer that he had sold a cow on November 8 because she was suffering with garget, and that her milk had been mixed with the other supply. A similar milk infection was reported by Dr. Boxall, in the London *Lancet*.

As a matter of fact, many of the epidemics of scarlet fever, diphtheria, and follicular tonsillitis in Great Britain have been attributed to a milk supply from animals suffering with local affections of the teats and udder. Thus, for instance, in November and December, 1885, an epidemic appeared at Marylebone, St. Pancras, and Hampstead, which Mr. W. H. Power, the sanitary inspector, traced to a particular milk farm at Hendon, but could discover no sign of scarlet fever at or near the dairy. Upon examination of the cows some of them were suffering from an ulcerative disease of the teats and udders, and from various other circumstances he inclined to the belief of the bovine origin of this disease. In 1869, Dr. J. Fagan described a case of pseudo-membranous stomatitis produced by the milk of a cow with inflamed udder. On inquiry Dr. Fagan was informed by the mother that for some time past she had noticed a sediment of a dirty appearance in the bottom of the vessel. Microscopical examination of this sediment revealed corpuscles of both pus and blood, and on making further inquiry it was found that the cow had suffered from inflammation of the udder, which had at the time formed an abscess. In addition to Klein's testimony as to the presence of a streptococcus in these cases, Prudden reports twenty-four cases of diphtheria, in which in all but two he demonstrated a streptococcus, probably identical with the streptococcus pyogenes and streptococcus erysipelatis. Baginsky (*Berliner klin. Wochenschrift*, 1892, No. 9, p. 183) reports that of 154 cases of diphtheria treated under his supervision, in 118 cases Löffler's bacillus was present, while in the remaining thirty-six only cocci (staphylococci and streptococci) could be demonstrated. Guillebeau (*Landw. Jahrb. Schweiz*, 1892, p. 27) made an examination of the milk of seventy-six cows suffering from udder inflammation. In all cases he found the milk contaminated with pyogenic germs, and experiments convinced him that they were pathogenic in so far as they produced similar inflammation when inoculated in healthy animals. Adametz, Macé, and Hueppe observed several kinds of pus-producing germs under similar conditions, which multiplied to such an extent in the milk that the gases caused the cheese to "heave." When we further consider that toxins may and do produce a scarlatinous exanthem, we feel warranted in declaring that in all the epidemics of scarlet fever and diphtheria which were traced to milk from cows suffering with some inflammatory lesions of the udder or from puerperal fever, we have typical instances of a streptococcus and staphylococcus infection. These views were presented by the writer as early as 1895, and in August, 1897, Grey Edwards in the *British Medical Journal*, vol. ii., pp. 340–341, published cases of follicular tonsillitis, in which the staphylococcus pyogenes aureus and albus and the streptococcus pyogenes (short form) were not only found by Severn, director of a London Pathological Laboratory, in the suspected milk, and in the milk of a particular diseased cow, but also in the sweepings (culture) from the throat of the patient, and it will often be impossible to differentiate clinically such attacks from true diphtheria and scarlet fever. There is no proof that there is a disease in the cow which is communicable as scarlet fever or diphtheria to man, but when we consider the almost total absence of scarlet fever in countries like Japan, where milk is seldom used except as a medicine, the question should not be regarded as definitely disposed of, but is one that merits the most searching investigation by pathologists and bacteriologists of both medical and veterinary schools.

Septic Sore Throat.—In addition to a number of milk-borne epidemics of septic sore throat studied in England, 600 cases were traced in 1908 in Stockholm to a streptococcus abscess in the udder of a cow. Since that time similar epidemics have been investigated in Boston, Baltimore, Concord, N. H., Chicago, and elsewhere, and the conclusion has been reached, that the streptococcus may get into the milk not only from a diseased udder, but also from a human source. The epidemics studied in Boston in May, 1911, affected over 2,000 persons, with forty-eight deaths. In many of these cases, the lesions were not limited to the throat and cervical glands, but also affected the joints, heart, lungs, brain, and other organs of the body. In this particular epidemic, Winslow traced the origin to milk infected from human sources. There were cases of sore throat in a family on one of the dairy farms, and also in the family of one of the employees at the city dairy. This outbreak, like all milk-borne epidemics, constitutes a strong argument for thorough pasteurization.

(*b*) *Fever, Especially Puerperal and Other Septic Fevers.*—The milk of animals suffering from febrile diseases is unfit for use. This is especially true of the puerperal and other septic fevers, in which Karlinski, Escherich, Longard, and Adametz have demonstrated the presence of the micrococcus pyogenes aureus in milk, the last-named author in a sample which had induced vomiting and diarrhea. There is reason for believing that the germs of septicemia neonatorum are in many instances conveyed in the milk, since Escherich, who examined thirteen specimens of milk from mothers suffering from puerperal fever, found the pyogenic germs in twelve, and Karlinski not only demonstrated the staphylococci in the milk of the mother, but also in the blood and intestinal contents of the infected infant.

(*c*) *Gastroenteric Diseases.*—It has long been held that the milk of cows suffering from digestive derangements is of an abnormal character, and, according to Siedamgrotzky, Fröhner, and Bräuer, it is usually quite watery, of a bitter taste, and generally coagulates within from six to eight hours after milking, with the formation of very little acid, so-called "sweet curdling." When we remember that if nursing mothers indulge freely in fresh fruit and green vegetables their milk is apt to gripe and purge their infants, we can appreciate how cow's milk, under the above circumstances, may produce mischief.

(*d*) *Acute Specific Enteritis.*—Professor Gaffky has reported several cases with symptoms of nausea, vomiting, diarrhea, and mental confusion, which he traced to the milk of an animal suffering from this disease, and demonstrated a characteristic organism in the animal as well as in his human patients. He also referred to Professor Husemann's report of an epidemic of gastroenteritis which prevailed in 1888 at Christiania, and which within three weeks affected

over 6,000 persons, while sparing infants at the breast.

(*e*) *Foot-and-mouth Disease* (*Eczema Epizootica*).—This infection primarily affects cattle, sheep, goats, and pigs and is communicable to man, chiefly by the ingestion of raw milk and dairy products from diseased cows. The disease is caused by a filterable virus or ultramicroscopic organism first described by Löffler and Frösch in 1898. It is known in man as stomatitis aphthosa or aphthous fever. After an incubation of from four to five days, the disease is ushered in by a chill, followed by fever and the formation of vesicles upon the tongue, lips, and mucous membranes of the buccal cavity and pharynx. The vesicles soon break and leave painful ulcers, which, however, soon heal. Occasionally also miliary and pustular eruptions are observed on the fingers. The disease is very rarely fatal except in very weak children. In some of the epidemics reported there may have been a mixed infection.

Mr. E. Hart described an epidemic at Aberdeen which affected about 300 persons with rigors, fever, tonsillar enlargement, and swollen cervical glands. The boys at the reformatory school, whence the milk came, receiving only skimmed milk, entirely escaped. The symptoms resembled the outbreak at Dover in 1884 which affected in one week 205 cases, all supplied with milk from one dairy, the cows at one of the farms suffering from foot-and-mouth disease. Baum refers to a number of instances in which the infection was conveyed in the milk.

Foot-and-mouth disease has caused a number of epidemics in this country at intervals of eight to ten years, and is generally promptly stamped out by the energetic efforts of the Bureau of Animal Industry, but a complete eradication has not been accomplished as shown by the widespread epidemic in 1914–15.

(*f*) *Cowpox*.—Dr. J. M. Cotterill read, before the Medico-Chirurgical Society of Edinburgh, a paper in which he gave the history of two epidemics of sore throat which occurred at Fettes College. The first began in October, 1886, and comprised fifty cases; the second occurred a year later, and comprised eighty-four cases. The symptoms of the disease were as follows: When first seen the patients (all boys) were generally out of sorts, complaining of headache, want of appetite, and lassitude; occasionally there was sickness or nose bleeding; in most cases a furred tongue, foul breath, and other symptoms of gastric disturbances were present. The tonsils and posterior wall of the pharynx were bright red, with considerable swelling of the mucous membrane. The uvula and soft palate were also congested, but in no case was there any membranous deposit on these parts. Upon the tonsils and walls of the pharynx, however, there were always follicular exudations, and sometimes a considerable patch of deposit on the tonsils which were often much swollen and deeply fissured. These patches could always be easily removed. Albuminuria was very frequent. The disease usually lasted about seven days in its acute stage. A peculiar symptom was the implication of the uppermost of the chain of lymphatic glands behind the sternomastoid. This always happened several days after convalescence had commenced. There would be a large brawny swelling in the neck which in every case subsided slowly, without suppuration. Meantime the cows had been inspected by Professor Williams, and two of them had been certified to be suffering from variola vaccina in its later stages.

Dean and Todd, in 1902, isolated the Klebs-Löffler bacillus from such lesions and also from the milk. There is, however, no evidence to show that diphtheria is a disease of cattle and the conclusion was reached that the abrasions on the udders had been secondarily infected with B. diphtheriæ by an infected milker and by the not uncommon practice of spitting on his hands before milking. It can be readily understood how the local infection might pass up the milk duct and sinus and find there a suitable culture medium.

(*g*) *Anthrax*.—The milk of animals infected with anthrax is unfit for use, because Feser, Manotzkoff, Nocard, and others have actually demonstrated the bacillus anthracis in the milk, and if infection has not more frequently taken place it is because the secretion is arrested in the very first stage of the disease. Heusinger, however, refers to an instance which occurred in the daughter of a plantation owner, in 1795, at Barbadoes, who drank one morning most of the milk from a cow suffering from anthrax. Four days afterward the child presented symptoms of the disease. A carbuncle also appeared on the left arm. The direct transmission through the milk, although probable, has not been proven; still there can be no question as to the objectionable character of the milk.

(*h*) *Pleuropneumonia*.—It is claimed that the milk of animals suffering from this disease may convey the germs, and Lécuyer, Schüppel, Jürgensen, and others have actually reported a number of transmissions, but the question is by no means settled.

(*i*) *Rabies and Tetanus*.—In olden times the consumption of milk from rabid cows was regarded as dangerous, and Faber refers to a few instances of transmission of the disease in human milk which all date back to the last century. Feeding experiments have proved in the majority of instances negative, and Hertwig, Bollinger, Reder, Fröhner, and others conclude from them that there was no danger from this source. Since Pasteur pointed out, however, that the mammary glands were among the organs selected for the deposition of the virus, there has been a renewed interest in the subject, and Nocard has experimentally proven that the virus may be conveyed in the milk. Burdach also determined, in the Pasteur Institute, that the milk of a woman bitten by a rabid wolf proved infectious to rabbits and guinea-pigs, but was quite harmless to the child. This question remains unsettled, as the accidental admixture of virus outside of the body in the Pasteur Institute is not excluded, but all authors agree that cows may suffer from hydrophobia, and that the milk should not be used. It is not improbable that the milk of animals suffering from tetanus contains some of the specific bacterial products, but it seems almost inconceivable that animals suffering from these affections should be milked at all.

(*j*) *Tuberculosis*.—While it is possible for milk to be contaminated with the sputum or tuberculous matter of consumptives, we are considering here the transmission of bovine tuberculosis to man through the medium of milk, either directly by bacilli excreted from the udder, or indirectly by bacilli which have been coughed up, swallowed, and eliminated in fecal matter and adhering to the udder and teats have gained access during milking. When it is remembered that one-seventh of all the deaths are due to tuberculosis, and that the identity of bovine and human tuberculosis has been a source of contention for years, we need not wonder that much attention has been given to the study of milk from tuberculous cows. Dr. H. C. Ernst presents evidence from thirty-nine veterinarians representing seventeen States, most of them reporting for one year only, which indicates that there were 549 cases of tuberculosis and 242 suspicious cases, a total of 791 among 165 herds, representing about 3,000 animals, *i.e.* 18 per cent. of positively tuberculous animals and over 8 per cent. of suspicious cases, a total of about 26 per cent. According to Dr. Salmon it has been proved that in some countries from 40 to 50 per cent. of all cows have tuberculosis. In the United States the proportion is very much less, being probably on an average about 10 per cent. Yet there are many herds here as badly affected as the worst herds of Europe. It is highly probable that since the introduction of the tuberculin test and efforts of extermination, bovine tuberculosis is decreasing

both at home and abroad. The bacteriologic examinations of milk made by Touney, Anderson, Hess, Goler, and Delépine since 1907, gave the following results: The milk in Chicago revealed the presence of tubercle bacilli in 10.5 per cent. of the 144 samples; Washington in 6.72 per cent. of the 223 specimens; New York in 16 per cent. of the 107 samples; Rochester in 5 per cent.; Manchester, England, in 9.5 per cent. of the milk examined and derived from 272 different farms.

The investigations of Roth, Schuchardt, Obermüller, Petri, Rabinowitsh, Klein, Lassar, Bang, and others conclusively show that tubercle bacilli may be present in butter, buttermilk, oleomargarin, and cheese offered for sale. Swithinbank and Newman report that of 498 samples of butter examined, 15.2 per cent. contained tubercle bacilli. Morgenroth found virulent tubercle bacilli in nine of the twenty samples of oleomargarin purchased in the open market; Schroeder and Cotton have demonstrated that tubercle bacilli may survive for 160 days in salted butter, kept in a cellar without ice, and Mohler, Dawson, and Dean have found that tubercle bacilli may survive in cheese over 220 days old. The possibility of the presence of tubercle bacilli in the milk of animals was pointed out first by Virchow and by Koch as early as 1882, and subsequently the bacilli have been demonstrated by Bang, Johne, Bollinger, Ernst, Woodhead, MacFadyan, and many others in the milk of animals in which the udder was also the seat of lesion, and for some time it was doubted whether the milk from a cow is virulent unless the udder is the seat of the tuberculous deposits. In 1893, Theobald Smith from a number of experimental observations finds that tubercle bacilli may be present in the milk of tuberculous cows when the udder, so far as the naked eye could tell, contained no foci of disease, and the result presented by Ernst in his report on the infectiousness of milk appears fully to justify the conclusion reached by him in 1889 that the milk from cows affected with tuberculosis in any part of the body may contain the virus of the disease. These conclusions are, moreover, supported by the investigations of Bang, Bollinger, Adami, May, Delépine, Stein, Rabinowitsh, Kempner, and Hirschberger, the latter being also the first to point out that the inoculation experiments are the more certain guide as to whether the milk is infectious or not, as he obtained positive results from milk of undoubted tuberculous animals, in which he was unable, however, to demonstrate the presence of tubercle bacilli. The general results of inoculation experiments would seem to indicate that the infectious qualities are greatest with milk from animals with udder lesions, and next from those affected with general tuberculosis. The feeding experiments of Bang, Bollinger, Klebs, Ernst, Baumgarten, Fisher, Wesener, and others with tuberculous milk proved infectious in about forty-five to fifty per cent. of the cases. When we recall the fact that the last three observers in their feeding experiments were especially impressed with the resulting tuberculous lesions of the intestinal mucosa, mesenteric glands, and liver; when we next consider the large mortality of children under five years from primary tuberculous ulceration of the intestines, tuberculous peritonitis, and tabes mesenterica, and the fact that the food of these children consists largely of unboiled milk, the chain of evidence seems well-nigh complete but has been materially strengthened by a number of clinical cases.

Professor Klencke, in an excellent little work published at Leipsic, in 1846, gives the clinical history of sixteen children who had been fed with milk from "scrofulous tuberculous" cows, and all point to tuberculosis of the intestines, glands, skin, or bone. In three of the intestinal disorders, he refers to the presence of indurated mesenteric glands. In this connection, the writer can hardly resist the conclusion that the difference in degree of virulence observed in the various tuberculous manifestations is perhaps not always attributable to the condition of the host, but may possibly be due to an attenuated character of the tubercle bacilli. Whether or not the German habit of boiling the milk, or adding boiling water, or the action of the gastric juice modifies the virulence of the bacilli, as shown by the slower forms of tuberculosis, remains to be seen, but in the feeding experiments with raw and boiled milk, of Bollinger in 1878 and Bang in 1890, a marked difference in the resulting lesions may be noticed.

In 1903 the writer tabulated eighty-six cases of transmission of bovine tuberculosis through infected milk, twelve cases of tuberculous wound infections in veterinarians and butchers, and three cases of accidental inoculations in man by the topical application of cream and milk. Lassar has reported eleven cases of verrucose tuberculosis in butchers and abattoir employees from wound infections. In view of these facts and the presence of tubercle bacilli in about 9.5 per cent. of the samples of milk examined it is evident that the danger is real and cannot be ignored. The danger from this source has been underrated by Koch and greatly exaggerated by von Behring who believes that the primary and most important source of pulmonary tuberculosis is derived from the milk of tuberculous cows, ingested during infancy and early childhood. This dictum cannot be accepted at present, because the bovine type of tubercle bacilli is rarely found in pulmonary consumption. It is claimed that the bovine bacillus may be transformed into the human type by prolonged survival in the human body, this may be true, but remains to be proven. In the meantime we know that the human type was found exclusively in 388 autopsies and the bovine type in only 24 or 5.82 per cent. of the 412 autopsies reported by Dr. Wm. H. Park. In 1912, Park and Krumwiede presented a collection of 1,511 cases which give the following:

Percentage Incidence of Bovine Infection.

Diagnosis.	Adults sixteen years and over, per cent.	Children five to sixteen years, per cent.	Children under five years, per cent.
Pulmonary tuberculosis	4.0	0.0	2.8
Tuberculous adenitis, cervical	2.7	38.0	61.0
Abdominal tuberculosis	20.0	53.0	58.0
Generalized tuberculosis, alimentary origin	14.0	57.0	47.0
Generalized tuberculosis	0.0	16.0	8.6
Generalized tuberculosis, including meninges, alimentary origin	0.0	0.0	66.0
Tubercular meningitis, with or without generalized lesions other than preceding	0.0	0.0	4.6
Tuberculosis of bones and joints	3.3	6.8	0.0
Tuberculosis of skin	23.0	60.0	0.0

In our present state of knowledge it is fair to assume that from seven to eight per cent. of all forms of tuberculosis are of bovine origin. This estimate includes the majority of cases of abdominal tuberculosis and affections formerly spoken of as scrofula and now designated as surgical tuberculosis and about one per cent. of all cases of pulmonary tuberculosis. The degree of danger depends upon the prevalence of bovine tuberculosis and whether or not the milk has been properly pasteurized.

(*k*) *Actinomycosis* is rarely located in the udder of the cow, and while no cases have been directly traced to the milk supply, such a possibility is by no means excluded, especially since the most common channel

of infection is through the alimentary canal. *Botryomycosis* of the udder is also rare, but it is evident that milk from animals suffering from these two infections should be excluded, especially as there is an added danger from mixed infection in the way of pus-producing organisms. The milk of animals suffering from *contagious abortion* should likewise be excluded. The disease is caused by the *Bacillus abortus*, and the infection is ranked by Dr. Schroeder as one of the very great evils of animal industry in this country. The bacillus is capable of maintaining itself in the bodies of such widely different animals as cattle, monkeys, pigeons, rabbits, guinea-pigs, rats, and mice. Dr. Schroeder writes me that 1,068 guinea-pigs were injected with samples of market milk at the Experiment Station during the years 1907 to 1912 inclusive and of those that did not die prematurely of other diseases, 103 or about twelve per cent. contracted abortion disease, and revealed extensive degeneration changes of the liver, spleen, kidneys, testicles, and more rarely the bones. Dr. Schroeder also points out the interesting fact that "many cows, once they have become infected, though they seem to be in perfect health continue to excrete abortion bacilli with their milk for years." Whether this organism may infect the human body remains to be determined. The British Commission, as also Theobald Smith, believe that the possibility of the human female being infected should not be lost sight of. Larson and Sedgewick have shown that the complement deviation test for abortion disease applied to the blood of 425 children gave seventy-two positive reactions. Pasteurization, at 140° F., for twenty minutes kills the abortion bacillus in milk.

(*l*) *Malta Fever.*—It has been shown that in the majority of cases of Malta or undulant fever, the *Micrococcus melitensis* is conveyed through infected goat's milk. According to Harrocks and Kennedy about ten per cent. of the goats at Malta excrete the organism in the milk. Among the most conclusive instances of milk-borne infections may be cited the medical history of the crew of the steamship *Joshua Nicholson*, conveying sixty goats purchased at Malta for the United States Department of Agriculture. Of the twenty-three men on board, who consumed goat's milk, positive evidence was obtainable in ten cases and in five of these conclusive evidence of infection was established. The goats arrived in this country sometime in December, 1905, and a woman at the quarantine station who had drank the mixed milk of several goats, suffered from a typical attack of Malta fever (Jno. F. Anderson). It would appear from the statement of Mohler and Eichhorn (*Journ. A. M. A.*, April 13, 1912), that this particular herd was so badly infected, that all the goats and their offspring were ordered destroyed. The ten cases of Malta fever reported by Dr. C. F. Craig, U. S. A., in 1905, apparently the first recorded in this country, could have no connection with the imported herd referred to. One occurred in a nurse in a Washington hospital who, it was believed, contracted this disease from nursing infected soldiers. The other nine cases reported occurred in soldiers who had become infected in the Philippine Islands. Dr. Craig expressed the opinion that Malta fever was probably a more common disease in the United States than was suspected.

The first cases of Malta fever directly traced to goats were reported by Dr. T. L. Ferenbaugh, also of the United States Army, as having occurred in the Pecos River country in Texas (*Journ. A. M. A.*, Aug. 26, 1911). In May, 1912, Dr. E. C. Yount and Dr. R. M. Looney of Prescott reported several cases to the Arizona Med. Assoc. which had occurred during June, July, August, and September, 1911. In 1912 additional cases were observed in Arizona by Drs. Yount and J. C. Wilson. Dr. Yount in his paper in the Military Surgeon for December, 1913, expressed the opinion that "the people in the northwestern part of the United States engaged in the goat-raising industry have been familiar with 'goat fever' for twenty-five years, but the medical profession has been slow to identify it etiologically as Malta fever."

The Arizona State Board of Health in July, 1912, recommended: (1) Boiling of all goat's milk or bringing to the boiling-point. (2) All goat corrals or bedding grounds should be located at a distance from the residence. (3) Avoid sleeping in or near goat corrals. (4) After handling the goats always wash the hands with soap and water before eating.

5. Milk may Acquire Infective Properties after it Leaves the Udder of the Animal.—Numerous instances have been observed in which outbreaks of typhoid fever, scarlet fever, and diphtheria, by their sudden and explosive character, affecting families living in streets and localities supplied by the same milkman, naturally pointed to the milk supply as a common cause. Dr. Michael Taylor, however, was the first physician (in 1857) to point out definitely that cow's milk might serve as the medium of spreading typhoid fever from a dairy where the disease prevailed. In 1867 he also showed that scarlet fever might be distributed in the same way. In 1877 Mr. Jacob traced a diphtheria epidemic at Sutton to the milk supply, and in 1872 Macnamera traced an outbreak of cholera at Calcutta to an infected dairy. These facts could not fail to sharpen the powers of observation in others, and in consequence similar outbreaks were more frequently reported, so that Mr. E. Hart, the editor of the *British Medical Journal*, was enabled to present to the International Medical Congress, held in London in 1881, the history of fifty outbreaks of typhoid fever, fifteen of scarlet fever, and seven of diphtheria, all traceable to the milk supply. In a similar communication made before the International Medical Congress at Paris, in 1900, the writer presented his conclusions based upon the tabulated histories of 330 outbreaks of infectious diseases spread through the milk supply; these outbreaks consist of 195 epidemics of typhoid fever, ninety-nine epidemics of scarlet fever, and thirty-six epidemics of diphtheria. This tabulation has since been increased by Surgeon Trask of the Public Health Service and other writers.

It has been demonstrated by numerous bacteriologists that disease germs may not only survive, but in many instances actually proliferate in the milk; and it is not a difficult matter to point out the many ways by which these germs gain access, especially when some of the employees are also engaged in nursing the sick, or are suffering themselves from some mild infection while continuing their duties, or are convalescent from the disease, or have become bacillus carriers. It is quite conceivable how animals wading in filth and sewage-polluted water may infect the udder with the germs of typhoid fever and through it the milk. We can also appreciate how infected water may convey the germs by washing the utensils or by deliberate adulterations. Infection may also take place through the agency of scrubbing-brushes, dishcloths, exposure to infected air, the agency of flies, and last but not least by chronic bacteria carriers.

(*a*) *Typhoid Fever.*—Of the 195 epidemics of typhoid fever tabulated by me, there is evidence, in 148, of the disease having prevailed at the farm or dairy. In 67 instances the infection probably reached the milk by percolation of the germs into the well-water with which the utensils were washed; in 16 of these the intentional dilution with water is a matter of evidence. In 3 instances the bacillus coli communis and the typhoid germs were demonstrated in the suspected water. In 7 instances infection is attributed to the cows wading in sewage-polluted water and pastures; in 24 instances the dairy employees also acted as nurses; in 10 instances the patients, while suffering from a mild attack or during the onset of the disease, continued their work, and those who are familiar with the personal habits of the average dairy hands will

have no difficulty in surmising the manner of direct digital infection. In one instance the milk tins were washed with the same dishcloth which had been in use among the fever patients. In two instances the dairy employees were connected with the night-soil service, and in another instance the milk had been kept in a closet in the sick-room. The writers estimate that about ten per cent. of the typhoid-fever cases in the city of Washington were milk borne, was confirmed in the investigation by the Public Health Service from 1907–10.

(*b*) *Scarlet Fever.*—Of the 99 epidemics of scarlet fever the disease prevailed, in 68 instances, either at the dairy or at the milk farm. In 6 instances persons connected with the dairy either lodged in or had visited infected houses. In 2 instances the infection was conveyed by means of infected bottles or milk cans left in scarlet-fever houses. In 17 instances the infection was conveyed by persons connected with the milk business while suffering or recovering from the disease, and in at least 10 instances by persons who acted as nurses while handling the milk. In 3 instances the milk had been stored in or close by the sick-room. In one instance the can had been wiped with an infected cloth. In 19 instances the infection was attributed to disease of the milch cows, such as puerperal fever and inflammation of the udder and teats; but these outbreaks were probably not genuine scarlet fever, but a so-called streptococcus or staphylococcus infection, the symptoms of which closely resemble those of scarlet fever.

(*c*) *Diphtheria.*—Of the 36 outbreaks of diphtheria tabulated there is evidence that the disease prevailed at the dairy or farm in 13 instances. In three instances the employees continued to handle the milk while suffering themselves from the disease. In 12 instances the disease is attributed directly to the cows having inflammatory conditions of the teats and udders. These instances, however, may be regarded as typical examples of streptococcus and staphylococcus infection, giving rise to a form of follicular tonsillitis or pseudo-diphtheria, often difficult to distinguish clinically from true diphtheria or scarlet fever.

(*d*) *Cholera.*—Professor Koch, in 1884, first pointed out that milk is a suitable culture medium for the cholera bacillus, but the possibility of the virus being transmitted in the milk had been emphasized before. Gaffky, in the report of the Cholera Commission in India, refers to the unsanitary condition of the dairies in India, where the water supply is derived from tanks which are promiscuously used for bathing, laundry, and dairy purposes, and as Dr. Payne, the health officer of Calcutta, in his report in 1876, expressed it, "milch cows are stalled in the neighborhood, and the nearest water is freely mixed with the milk and distributed through the town." Dr. Cayley refers to the fact and consequent danger that at Katarhatti, a suburb of Calcutta of 300 families, 70 are engaged in the milk business, all located near one of these notorious water tanks, and that in September, 1872, not less than 16 cholera cases with 6 deaths occurred among these dairy people.

Dr. Macnamara reports an outbreak in a boarding-house at Calcutta attacking six Europeans and the cook of their department, while the other inmates and servants of the house escaped. They had all consumed the milk from a particular dairy, and it was determined that immediately before this outbreak eight cases of cholera had occurred in close vicinity of the water tank used by this milkman. Dr. Simpson, health officer of Calcutta, describes a limited epidemic which occurred on board the ship *Ardenclutha* resulting in nine cases and four deaths, and affecting, with one exception, consumers of a particular milk derived from a dairy located near a tank into which dejecta from a cholera patient found access, and the dairyman, with unusual frankness, admitted the dilution of the milk with about one-fourth of water from this source. Hesse claims that cholera germs will not survive in fresh raw milk; Basenau maintains that they retain their vitality and increase in number up to the point of coagulation, while Weigmann and Zirn declare that their activity is largely influenced by the number of other germs present.

It is interesting to note that of the 330 milk-borne epidemics analyzed by me, 243 have been recorded by English authors, 52 by American, 14 by German, 11 by Scandinavian, and 5 each by French and Australian writers. This is probably due to the fact that the English and Americans usually consume raw milk, while on the Continent the milk is rarely used without being boiled.

Adulteration of Milk.—According to the United States Census of 1910, we have 21,795,770 milch cows with an average annual production of 6,288,271,533 gallons of milk, 495,197,844 pounds of condensed milk, 1,621,796,475 pounds of butter, and 320,581,594 pounds of cheese. These figures furnish an indication not only of the extent of milk consumption but also of the amount of danger from an impure supply, and lastly of the temptation which still exists, from a monetary point of view, for the practice of shameful adulterations. The most frequent of these are the intentional dilution with water, the removal of cream, and the addition of skimmed milk. The former, apart from diminishing the nutritive value of the milk, a matter of great importance, is often the immediate cause of transmitting disease germs, if the water happens to be infected. A very common fraud appears to be the removal of cream and adding just enough separated milk until the amount of fat present is on the limit that will pass inspection. The introduction of cream separators affords an opportunity of removing almost the whole of the fat from the milk, and the sophisticator has thus the power of reducing its cream to the lowest salable standard without exposing himself to any such risk of detection as would attend the process of "watering," a process by which the total non-fatty solid might be so reduced as to lead to the detection of the fraud. Indeed Spiegelhalter, of St. Louis, from a large number of examinations, concluded that the fraud by removal of cream in that city amounts to 1,600 gallons per day, or a loss of about $900,000 per annum, largely made up of the pennies of poor and sickly women and half-starved children. Similar testimony has been recorded regarding the milk supply of other cities. Dr. W. H. Kent, the chemist of the Brooklyn Department of Health, in March, 1889, examined a number of samples of condensed milk with reference to previous skimming, and from the results he concluded that seventeen of the twenty-three different brands were made from milk the cream of which had been more or less removed. The glaring cases which come under the notice of the authorities afford no evidence as to the actual extent of these frauds, but they simply show that in these instances the milk had been so recklessly treated as to pass beyond the limit of a low official standard of milk. Formerly it was almost impossible to secure conviction on account of the difficulty of proving the addition of water or removal of cream, for there are instances of deficiency of solids in milk known to be genuine and the charge of fraud or criminal knowledge could not always be sustained.

Milk Standards.—These difficulties and the fact that the composition of milk varies greatly with the breed and feed of the animals, climate, and season, led to the adoption of legal standards of milk offered for sale. There are instances of analysis in which the total solids fluctuated from 10.33 to 15.83 per cent. and the fat varied in the same manner from 2.43 to 5.97 per cent. If between these limits a high standard were fixed the result would be to condemn much genuine milk, while if a low standard were adopted, it would virtually legalize dishonest manipulations of the milk or else place a premium on indifferent care and

breed of the dairy stock. Indeed, if we follow up cases of poor milk to their source, we usually find half-starved or badly cared-for cows, and for obvious reasons we can only deal with averages based upon a large number of samples and which, while fulfilling modern sanitary requirements, are also just to the producer. As a result of the analyses obtained by different chemists covering over 120,000 samples of milk, we have a right to expect a milk containing 12.50 per cent. of total solids, composed of 8.75 per cent. non-fatty solids and 3.75 per cent. of fat, and also that the legal standards which vary in different states be not less than 3.25 per cent. of butter fat.

By the adoption of legal standards the prosecution of milk sophisticators has been simplified, for by prohibiting the sale of milk below a fixed standard the question of fraud or adulteration need not be proven, and the allegation that it is below the prescribed standard can be sustained by the results of the analysis and suffices for conviction, regardless of the fact whether it is the product of fraudulent practices or the peculiarity of individual cows or their care.

Adulterants Most Commonly Used.—In order to conceal adulteration with water or the removal of cream and other fraudulent practices, all sorts of substances have been added. Lengfelt, of San Francisco, communicated to Professor Wiley the composition of a milk adulterant commonly used in that city and consisting of common salt, saltpeter, saleratus, a trace of caustic soda, and a large quantity of sugar, and colored with caramel. Chalk, gypsum, starch, finely ground calves' brains, and gelatin figure among the recorded instances of adulterants, but it is about time that the popular fallacy of chalk and water mixtures and emulsions of calves' brains should be dispelled. Starch and gelatin are occasionally used, and Harrington reports that a preparation largely advertised to the trade at one time as a "cream thickener" was analyzed by him and found to be a mixture of gelatin, borax, and boric acid. Annatto, turmeric, yellow coal-tar colors, and even chromates have been employed to give a rich yellow color to poor or watered milk, or during the winter season when the cream has not the characteristic yellow tint.

Preservation of Milk.—Bitter, an authority on sanitary milk, maintains that the maxium limit for milk that is fit for food is 50,000 germs per cubic centimeter. Dr. Turner, the Dairy Inspector of the District of Columbia, found only 52 of the 117 samples examined by him to contain less than 50,000 per cubic centimeter, while most of the samples showed a higher number of bacteria than the sewage of the city. The changes due to bacterial action have been described under "Bacteriology of Milk," and the effects of such changes have been pointed out in the section relating to Milk Sediments. The multiplication of milk bacteria goes on most rapidly at a temperature of between 70° and 85° F., and they practically cease to proliferate at a temperature below 50°. In order to reduce the number of germs to a minimum, it is necessary to reject the first strippings of the milk, because it has been shown by Schultz and Moore that the foremilk always contains an excess of bacteria, which have invaded the lacteal ducts and multiplied since the previous milking. Absolute cleanliness of animals, stables, milking-rooms, utensils, employees, and the very air, are equally essential. This has been demonstrated by Sedgwick, Batchelder, Freeman, and others. Freeman's experiments are especially instructive; he exposed three plates, each three and a half inches in diameter, for two minutes as follows: one in the open air, one outside a barn, and a third in front of the milk pail under a cow in the same barn while the milking was going on. The first showed 6, the second 111, and the last plate 1,800 colonies, and strikingly illustrates the dangers of dust being stirred up. Next to clean and intelligent methods in milking, the temperature of the milk should be quickly brought down to 40° F., kept cool, and delivered to the consumer at a temperature below 50° F., so as to inhibit the growth of the microorganisms. That this can be done is shown by the fact that the average number of bacteria in the product of a sanitary dairy in the city of Washington was only 6,485, against 52,000 per cubic centimeter, found in average market milk. This involves, to be sure, the free use of ice and its transport in refrigeration cars, but milk of this character can be sold with a good profit at ten cents per quart. In some parts of Europe a portion of the milk is frozen into solid blocks by the ammonia process and placed in the shipping cans to keep the other milk at a low temperature.

Heat has been employed as a preservative because the operation of certain temperatures destroys the vitality of the germs. Two methods have been proposed, viz., sterilization and pasteurization. *Sterilization* is usually accomplished by boiling the milk for ten minutes, which is sufficient to destroy all living organisms, including, of course, disease germs; a longer exposure is necessary, however, for the destruction of the spores of the anthrax bacilli, although continuous heating under pressure for two hours at a temperature of 248° F. accomplishes the same purpose. The formation of the coat on top consisting of fat, casein, and lactalbumin, can be prevented by boiling the milk in a long-necked bottle. In boiling, milk loses its gases and aromatics, and also some of its watery constituents, part of the sugar is converted into caramel, and the proteins and salts are also modified; these and other modifications affect the digestibility of the milk, and rickets and scurvy have been attributed to this cause. For these reasons *pasteurization*, or the exposure of the milk for from ten to fifteen minutes to a temperature of 158° F., was regarded as a distinct advantage. The milk does not acquire a cooked taste, but in order to inhibit the growth of some of the more resistant organisms and their spores, the temperature of the milk must be promptly reduced to 50° F. and kept there, and if need be the process can be repeated in twenty-four hours, and thus the keeping qualities increased. Bitter prefers a temperature of 155° F. for thirty minutes, while others maintain that a temperature of between 140° and 147° F. suffices for the destruction of all pathogenic organisms; but Theobald Smith's experience with the tubercle bacillus shows the necessity of a temperature of 149° F., and, on the whole, Bitter's limit of 155° F. ought not to be lowered.

It is claimed by quite a number of physicians that the operation of even such low temperatures impairs the digestibility and nutritive qualities of the milk, and that preference should be given to raw milk obtained under special sanitary precautions. Unless, however, the milk is obtained from dairies operated under special milk commissions, the writer strongly urges pasteurization as the lesser evil of the two; indeed, he believes that the dangers of pasteurized milk have been exaggerated, and the question of incomplete absorption of the salts as a cause of scurvy and rickets has not been sufficiently considered. These diseases are most frequently developed in children after prolonged diarrheal affections, and the diarrhea, and not the modified character of the component parts of the milk, may be responsible for the incomplete absorption. To overcome the objections to pasteurization of milk, Freeman recommends that the cream be allowed to rise and as it carries about ninety-five per cent. of the bacteria along to the surface it might be sufficient to pasteurize the cream only.

Chemical Preservatives.—In order to promote the keeping qualities of milk, the use of antiseptics has been invoked by farmers who ship milk by railway to the city. The agents which have been used are borax and boracic acid, salicylates, benzoates, formalin (a forty-per-cent. solution of formic aldehyde)

and sodium chloride, carbonate of sodium, saltpeter, and chromates. Of late years most of these chemicals except formaldehyde have fallen into disuse. According to the tests made by Dr. C. P. Worcester, quoted by Harrington, 1 part of commercial formalin in 100,000 parts of milk will postpone the curdling point 6 hours: 1 in 50,000, 24 hours; 1 in 20,000, 48 hours; 1 in 10,000, 138 hours; 1 in 5,000, 156 hours. Rideal and Fullerton regard formaldehyde in the proportion of 1 to 50,000 as an effective preservative of milk for 24 hours, and although it is claimed that in this strength, even during extended periods of use, this substance appears to have no injurious effects upon the consumer, the writer protests against the use of this or any other chemical preservative, so long as we possess in clean methods and cold storage a more rational and natural method. It must be remembered that few of these agents are normal constituents of the body and that their ingestion can do no good and may do harm.

Boric acid and borax are generally used in combination, and in order that it shall act as a preservative it is necessary that about ten grains of the mixture shall be added to a quart of milk. Prof. R. H. Chittenden reports that borax retards the amylolytic action of saliva, boric acid in amounts less than one per cent. favor it, and that both substances increase gastric digestion in small amounts and retard it in large. Foster and Schlenker found that boric acid limits albumin digestion and produces increased exfoliation of the intestinal epithelium and also increased phosphoric acid elimination. Dr. H. E. Annet, in the London *Lancet*, November 11, 1899, presents the results of his studies of boric acid and formalin as milk preservatives, and regards them as injurious especially to young infants.

Sodium carbonate has been used more for the purpose of neutralizing acidity than as a preservative. It forms a lactate of soda which is believed to be a mild cathartic. Saltpeter, the salicylates, benzoates, and chromates are rarely used in this country, although reports from Europe indicate their occasional employment, especially that of the chromate and dichromate of potassium. Professor Hird, chemist of the Health Department, D. C., informs the writer that as a result of his crusade against the use of preservatives he encounters only now and then samples of milk containing formaldehyde.

Milk Inspection and the Methods of Detecting Adulterations and the Preservatives of Milk.—It is practically impossible to examine all the milk brought to a large city, nor is this necessary, provided the examinations are sufficiently frequent to cover within a reasonable time all the establishments connected with the milk traffic. Accurate records should be kept of these examinations, which should be directed to the determination of the most common forms of adulteration, viz., (1) milk which has been robbed of its cream and offered for sale as sound milk; (2) milk which has been diluted with water; (3) milk which has been creamed and watered; (4) milk which is reduced by the addition of skimmed milk; (5) milk to which various substances have been added to conceal adulterations; (6) milk to which preservatives have been added. The methods usually employed by milk inspectors when dealing with a large number of samples are limited to the determination of the specific gravity and the estimation of fats by which at least the suspicious cases can be singled out, and when found, liberal samples should be taken for the more accurate methods of the official laboratory.

In some states the authorities depend chiefly upon the lactometer. The normal average specific gravity allowed is 1.030 at 60° F., or 1.029 at 70° F. If the spindle floats below 29°, the inspector usually concludes that the milk is probably watered, or if it floats above 33° that it has been skimmed. As a matter of fact, however, an excessive amount of cream might diminish the specific gravity of a really rich milk, and the inspector should take this into consideration as well as the fact that the removal of fat raises the specific gravity, and the addition of water lowers it, rendering it quite possible that a milk which has been creamed and watered may have a normal specific gravity. For all these reasons a chemical analysis should be required, in order to secure conviction; and, so far as the methods for the determination of fats, milk sugar, proteins, and mineral matter are concerned, the reader is referred to the article on *Milk, Composition of*, for the desired information.

The presence of nitrates and nitrites in milk is suggestive of adulteration with water derived probably from a polluted source. For the detection of these salts E. Pfeiffer recommends the following: Add sufficient acetic acid to 50 c.c. of the milk to precipitate the casein, filter carefully, boil the solution and filter again, acidulate 20 c.c. of the filtrate with one drop of pure sulphuric acid, and add small quantities of powdered diamidobenzol; a change to a yellow color indicates the presence of nitrous acid.

Also place 0.5 gram of diphenylamin in a clean porcelain capsule or test-tube and pour about 2 c.c. of pure concentrated sulphuric acid over it; then drop along the side of the capsule or test-tube one or two drops of the above filtrate; the development of a blue color indicates the presence of nitrites or nitrates (Soxhlet).

Bacteriological Examination.—Since it has been claimed that nitrates and nitrites may be present in the milk if ingested by the animal either in water or in food, it will be well to examine the milk and suspected water also bacteriologically, which has become a well-recognized procedure, with a view of determining not only the number, but also the character of the germs, especially of the sewage group. Milk containing over 50,000 germs per cubic centimeter is practically unfit for infant feeding. Since milk may contain such a large number and variety of liquefying organisms as to spoil the plates, the phenol methods should be employed, and it is also best to make a number of plates in which the drop of milk has been diluted with sterilized water in various proportions, properly labelled and exposed to a temperature not exceeding 68° F. With this precaution the inspector may proceed with his technique, with which it is presumed that he is fully familiar.

Detection of starch is usually accomplished with the microscope, also by the blue color developed on the addition of tincture of iodine to the milk previously heated to the boiling-point and then cooled.

Detection of Gelatin in Cream.—Stokes recommends the following: Dissolve some mercury in twice its weight of strong nitric acid (specific gravity 1.420), dilute with water to twenty-five times its bulk; to about 10 c.c. of this solution add a like quantity of the cream and about 20 c.c. of cold water; shake the mixture vigorously; leave it for five minutes, then filter. If much gelatin be present it will be impossible to get a clear filtrate. To the filtrate or a portion of it add an equal bulk of a saturated aqueous solution of picric acid. If any gelatin be present a yellow precipitate will be immediately produced. The whole operation is performed in the cold, and if the mercury solution is ready, it will not take more than ten minutes. Picric acid will show the presence of 1 part of gelatin in 10,000 parts of water.

Detection of Added Coloring Matters.—*Annatto.*—Add a few cubic centimeters of sodium carbonate solution to about 100 c.c. of milk to insure a strongly alkaline reaction during the examination, and then immerse a slip of heavy white filter paper, allowing it to remain over night in a dark place. The strip is withdrawn from the milk, gently washed in running water, and laid upon a piece of similar paper; it will present a distinct salmon tint if annatto is present in the proportion of 1 to 100,000. On dipping

the paper into stannous chloride the color is changed to pink (Harrington).

Coal-tar Colors.—According to Leffmann and Beam, these colors are detected by adding to the milk ammonium hydroxide and allowing a small piece of white wool to remain in it over night. The dye is taken up by the wool, which acquires a yellow tinge. When milk contains Martin's yellow, ammonium hydroxide intensifies the color, and hydrochloric acid bleaches it.

Chromates, according to Guérin, are detected by the following method: To 5 or 10 c.c. of milk add two drops of a one-per-cent. solution of sulphate of copper and two or three drops of freshly prepared tincture of guaiacum. Pure milk gives a greenish color; while milk containing 1 part in 100,000 of chromate will give an intense blue which reaches its maximum in a few minutes.

Caramel.—Harrington's method is as follows: Pour from 125 to 250 c.c. of the suspected sample into an equal volume of ninety-five-per-cent. alcohol and filter. The filtrate, if not perfectly clear, must be returned and passed through until it is quite free from turbidity. Any caramel present will be in solution in the alcoholic filtrate and may modify considerably its color, which is normally yellowish or greenish according to season, the latter obtaining in spring and summer. To 100 c.c. of the filtrate add 2 c.c. of solution of basic acetate of lead, which will precipitate the caramel together with any remaining proteids, the precipitate showing a slight brownish color if caramel has been used in sufficient amount to bring about the improved appearance, which is the object of its employment. Filter, wash with distilled water, and dry in an air-bath; according as the amount of caramel present is large or small, the horny residue on the filter paper will have a more or less deep chocolate tinge. The residue yielded by a pure milk will be either almost colorless or yellow, or slightly inclined to brownish, but not to chocolate color.

Determination of Free Lactic Acid—Pfeiffer recommends to mix 10 c.c. of milk with 40 c.c. of water and 1 c.c. of a concentrated solution of phenolphthalein (made with fifty-per-cent. alcohol). The acid is now neutralized by gradually adding one-tenth normal soda solution until a pink-rose color develops. It is not necessary to calculate the result in lactic acid, as it is sufficient for comparison to state the numbers of cubic centimeters of the soda solution used.

Detection of Preservatives.—*Determination of sodium carbonate* is most readily accomplished by E. Schmidt's method: 10 c.c. of the suspected milk are mixed with 10 c.c. of alcohol, and a few drops of a one-per-cent. solution of rosolic acid are added. If the carbonate or bicarbonate of soda be present, a more or less intense pink or rose color is developed, while pure milk presents a brownish-yellow reaction; for comparison it is best to test milk known to be sound.

Determination of Salicylic Acid.—Fifty cubic centimeters of the suspected milk are treated with sulphuric acid for the removal of the proteids and fat and filtered. The filtrate is shaken violently with the same quantity of ether, and after separation of the ether the liquid is evaporated in a porcelain capsule, the residue is dissolved in a little alcohol, and a few drops of a neutral solution of ferric chloride are added. If salicylic acid be present even in traces, a characteristic violet color develops.

Determination of boric acid is best accomplished by Meissel's test: 50 c.c. of suspected milk are rendered alkaline with milk of lime, evaporated and washed. The residue is dissolved in strong muriatic acid; this solution is filtered and evaporated to dryness. The residue is moistened with sufficient very dilute muriatic acid to give it a soft consistency, mixed with tincture of turmeric and dried on the water-bath. If boric acid be present the residue develops a cherry-red color, which does not disappear when diluted with water. A little of the ash may be moistened with just sufficient alcohol and ignited, when a greenish flame reveals the presence of boric acid.

Determination of Formaldehyde in Milk (*Method by Decolorized Fuchsin*).—Through a solution of fuchsin, 1 to 500, pass a current of sulphurous acid gas, obtained by heating copper wire or foil with sulphuric acid until the color is discharged. Preserve in a glass-stoppered bottle. To 10 c.c. of milk add 1 c.c of the reagent and let it stand ten minutes. Add 2 c.c. of strong hydrochloric acid and shake or stir briskly. The color which appears in the first instance is completely discharged by the acid if no formaldehyde is present, otherwise a violet-blue tinge remains. If the amount present is large the end color will be correspondingly intense. This method will detect the admixture of 1 part of formalin in 50,000 parts of milk. If the milk be first distilled and the first part of the distillate treated with the fuchsin solution, the test is delicate to the extent of revealing 1 in 500,000 (Harrington). The phloroglucin and Hehner's tests are also very reliable.

Phloroglucin Test.—Dissolve 1 gram of phloroglucin in 100 c.c. of distilled water. Put 10 c.c. of the suspected milk in a test-tube, and add 5 c.c. of the phloroglucin solution; shake and add 1 c.c. of solution of potassa, United States Pharmacopœia. If formaldehyde is present a red color is developed at once, fading usually within five or ten minutes; hence the color must be observed at once. One part in 20,000 gives a decided reaction.

Hehner's Test.—To 15 c.c. of concentrated sulphuric acid in a test-tube add one or two drops of ferric chloride test solution, United States Pharmacopœia, and mix. Then pour upon this, in such manner as not to mix the layers, the suspected milk. A violet color indicates the presence of formaldehyde. In the case of cream dilute the cream with an equal volume of water, and then apply the test as above described. The violet color is sometimes produced at once, but oftener not for five or ten minutes, and sometimes not for an hour or so, depending upon the amount of formaldehyde present. By this test 1 part in 10,000 or 15,000 is readily detected.

Control, Management, and Inspection of Dairy Farms.—Sufficient data have been given to furnish the inspector with a basis for his examination and the accomplishment of fruitful results. Pure natural milk can be secured only at dairies with sanitary buildings, a pure water supply, healthy, well-fed and well-cared-for cows, a well-equipped and well-kept milk-room, provisions for thoroughly sterilizing all utensils, intelligent people in charge, who are at the same time free from communicable diseases and cleanly methods throughout. There are a number of persons—thanks to the training received at the various dairy schools—who make an honest effort to place on the market milk obtained under such conditions, but by far the majority are ignorant or wilfully indifferent to hygienic requirements, and therefore matters of this kind should never be left to the individual, but the principles which ought to be carried out should be embodied in effective laws, and accepted and executed in a practical sense. Honorable men will not object to laws placing dairies, the herds, and the milk market under strict sanitary control, and as many of the most serious dangers are the result of ignorance, rather than of intentional negligence, the difficulties will be materially lessened by proper education and trade competition. It is highly desirable that some uniform legislation, preferably a national pure-food law, be enacted to regulate the inspection of dairy farms, etc., for, as it is now, milk consumed in New York City, for example, may be produced in a number of states over which, of course, the local authorities have no jurisdiction. A compulsory inspection of the dairy herds will be a source of ultimate profit to the owner, as

the presence of tuberculosis or other communicable diseases endangers his entire herd, and great losses can be prevented by the extermination or isolation of the first case. The farmer will also find it to his advantage if he is obliged to house his cattle in spacious, well-ventilated and lighted stables (at least 600 cubic feet of air space and nine feet window space for each animal), with good cemented floors, proper drainage, clean hay, straw, or shavings for bedding, and a standard ration.

Since the enactment and enforcement of laws regulating the production and sale of milk in a number of states, a marked improvement has been made in the milk supply with a corresponding reduction in the mortality from diarrheal diseases under two years of age and other milk-borne diseases. Indeed a goodly number of producers have come to regard the milk inspector as a real friend and helper and as a result of these educational inspections are distributing raw milk with less than 2,000 bacteria per cubic centimeter and without either streptococci or colon bacilli.

A striking example of the benefits of milk improvement is cited by Dr. A. D. Melvin, Chief of the Federal Bureau of Animal Industry in his report for 1912. The United States Naval Academy at Annapolis established a dairy under expert supervision in October, 1911. During the first year of its operation, the morbidity from digestive and intestinal diseases was reduced from 1,598 to 296 sick days, the number of midshipmen was practically the same and other dietary conditions remained unchanged.

The Feed and Care of Cows.—The animals should not be allowed to feed upon pastures with stagnant water or noxious weeds such as meadow saffron, henbane, Jamestown weed or stinkweed, poppies, mustard, carrot tops, milkweed, poison oak, sumach, skunk cabbage, and other euphorbiaceous and ranunculaceous plants, or upon the swill or products from distilleries, breweries, glucose factories, etc. The use of turnips, kohlrabies, rutabagas, carrots, mangels, and the leaves of all kinds of root crops are also objectionable.

An abundance of wholesome pasture in season with hay and meal fodder should be allowed. At some of the "milk-cure institutes" in Germany each cow is allowed daily 10 pounds of meadow hay, 17 pounds of clover hay, 6 pounds of hulled barley meal, and 4 pounds of wheat flour. The United States Department of Agriculture recommends the following:

Adjustment of Ration to Milk Yield.—In making allowance for the difference in milk yield of different cows, a uniform basal ration can be fed to all the cows, and the amount of the richer grain mixture varied to suit the demands. For example, a basal ration might be made up of 25 pounds of corn silage, 8 pounds of rowen hay, and 3 pounds each of cornmeal and wheat bran, which would supply 1.43 pounds of protein and a fuel value of 23,712 calories. To this could be added a richer grain mixture composed of 2 parts of gluten meal and 1 part of cotton-seed meal, the amount of this being varied according to the milk yield of the cow. Two pounds of this mixture would bring the ration up to 1.97 pounds of protein and 26,999 calories, which would meet the requirements of cows giving from 12 to 15 pounds of milk a day, while 4 pounds would bring it up to 2.50 pounds of protein and 30,286 calories of heat, suitable for the cows giving from 20 to 25 pounds of milk, and so on, 5 or 6 pounds of the grain mixture being fed to the heavier milkers.

The water supply should be pure and closely guarded against pollution. In the absence of a spring, a deep-driven well should be preferred. While it is true that at the majority of dairy farms wells and privies are dangerous neighbors, the agency of flies in carrying infection should not be underrated, and points to the necessity of prompt disinfection; an effort should also be made to get rid of the flies by prompt disposal of the horse manure in which they breed, the abandonment of open privies and surface pollution, removal of garbage, and other fly-breeding matter. The animal should be groomed, and the teats and udders washed with sterilized water before milking; this is of importance, as the presence of fecal bacteria in milk is next in danger to disease germs.

Milking and Care of Milk.—The requirements of cleanliness apply with equal force to the milkmen, their persons and clothing, and they should be required to keep their finger-nails clean from dirt and make a careful toilet before milking. The milking should be done in a dust-free atmosphere, preferably in a special room with cemented floors, previously sprinkled in order to reduce the number of germs to a minimum. It is impossible to secure bacterial purity of the milk when the milking is done in a stable with a hayloft above. The best results observed by the writer were obtained at a dairy supplied with one-story frame stables, cemented floors, well lighted and ventilated by windows and ridge ventilators, and where the animals after grooming were taken into a similarly constructed room for milking. Attention has already been called to the necessity of absolute cleanliness of the utensils and bottles, which can be accomplished with a weak solution of boiling soda water, subsequently rinsed in sterilized water. Before bottling, the milk must be rapidly cooled to a temperature of 40° F. and delivered to the consumer at a temperature not exceeding 50° F.

Sickness among Milkers and Employes.—All persons engaged in handling the milk should be free from disease. No family ever thinks of employing or keeping a cook afflicted with a communicable disease, or who is known as a bacillus carrier and yet not the slightest restriction is placed upon, nor a question asked about, the persons who handle our milk supply, which we know affords an excellent culture medium for disease germs. After the recital of numerous epidemics and milk-borne diseases, we need hardly insist upon the necessity of compulsory notification of all infectious diseases, and that the milk should not be permitted to leave a farm, dairy, or milk-shop during the existence of any of these diseases among the inmates or employees, nor should the latter be permitted to reside in or visit infected premises while engaged in the milk traffic, without permission from the Health Department. The farmer or retailer should, in fact, be prepared by previous instructions to guard the milk supply from these sources of danger and call upon the authorities for an immediate inspection. To prevent great loss incident to these restrictions, they may be modified so as to utilize the milk after proper sterilization under the direction of the Health Department. The retailer should be duly registered and be required to furnish the health officer with a list of customers. These lists should be arranged on the "index card system," so that the simultaneous occurrence of infectious diseases in a number of families supplied by the same milkman may be promptly discovered and the mischief checked.

Classification of Milk.—A number of classifications have been proposed from the standpoint of public hygiene as to the comparative safety of the milk supply. Among others may be mentioned the classification recommended in 1907 by a subcommittee of the Milk Commission for the District of Columbia, of which Dr. A. D. Melvin, Chief of the Federal Bureau of Animal Industry, was chairman and the writer one of its members. This classification provides for three classes, viz., 1. *Certified Milk*, 2. *Inspected Milk*, and 3. *Pasteurized Milk*. The first two classes include milk from dairies which have met all the requirements above outlined, and the milk is derived from tuberculin-tested herds. It is

also specified that certified milk should not contain more than 10,000 bacteria per cubic centimeter, and must be delivered within twelve hours after milking in sterilized containers at a temperature not exceeding 50° F. In the inspected milk the bacterial contents shall not exceed 100,000 per cubic centimeter and must be delivered in sterilized containers at a temperature of 50° F. without, however, specifying a time limit. Class 3 includes milk from dairies not able to comply with the requirements specified for the production of milk of classes 1 and 2, and must be pasteurized before being sold. This class excludes milk from diseased animals, except that cows which upon physical examination do not show signs of tuberculosis may be included in the dairy herds, although they may have reacted to the tuberculin test. All such milk is to be clarified and pasteurized at central pasteurization plants, under the supervision of the Health Department, at a temperature of 150° F. for twenty minutes, preferably in the final containers and delivered at a temperature of not exceeding 50° F. No milk shall be regarded as pure and wholesome, which after standing for two hours or less, reveals a visible sediment at the bottom of the bottle.

As long as there is a demand for raw milk we may hope to secure by the enforcement of the requirements specified for "Certified Milk" such a standard of milk as will reduce the dangers to a minimum. But in the light of our knowledge of bacillus carriers it must be frankly admitted that nothing short of pasteurization in the final container, will confer immunity from milk-borne diseases.

George Martin Kober.

Milk, Secretion of.—The mammary gland may be regarded as a compound racemose gland. Like the sweat gland it is formed by an ingrowth of the Malphigian layer of the epidermis. The gland is divided into a number of lobules, about twenty in woman, by connective-tissue septa. Each lobule has a distinct duct which opens on to the nipple by a separate orifice. The gland is, therefore, in reality not a single gland but a number of glands bound together. A section of a lobule varies according to whether the section has been taken from a discharged or a loaded gland. In the former, the alveolus has a very large lumen containing milk constituents while the cells of the alveolus are low or even flattened. When the gland is loaded these cells are tall and columnar and project unevenly into the lumen, the area of which is greatly reduced. Two or more nuclei, some showing signs of degeneration, may be seen in these cells. The cells seems to contain oil globules as well as granules or particles of other nature.

From these appearances the conclusion may be drawn that during loading of the gland the alveolar cells grow rapidly and the nucleus gives rise to two or more nuclei, in other words, karyokinesis occurs. Meanwhile active metabolism is going forward in the cell, the deposition of oil droplets as well as of other substances taking place. The oil globules are extruded from the cell, budding of the cell occurs and part of the cell without a nucleus is thrown into the lumen. These cellular elements are eventually dissolved and give rise in part at least to the presence of casein in the milk, and perhaps also to lactose. In other words, casein and lactose may be considered as specific products of the activity of the mammary gland not being found elsewhere in nature. Concerning the precursors of these substances little is positively known. It is usually assumed that lactose is formed from dextrose of the blood. Casein has been said to arise as the transformation product of the nucleoproteins of the gland substances.

The influence of the nervous system to mammary gland secretion has been investigated from many sides but the results obtained are so contradictory that no general conclusion can be drawn. Reasoning by analogy from these secretory glands it has been assumed that the mammary gland is more or less under the influence of the nervous system an assumption which has not been entirely supported by experimentation on animals. By section of the nerves supplying the mammary glands it has been demonstrated that the mammary glands continue to secrete whether nerves from the cerebrospinal or sympathetic are severed. Moreover, after extirpation of the glands and transplantation to remote regions of the body, as for instance in the neck, secretion of the gland may still continue. It is well recognized, however, that in women, "fright, grief, passion, excessive sexual indulgence, or any great excitement may entirely arrest the secretion or, if not arrested, the milk may be so altered in composition as to make the child actually ill" (Holt). Perhaps the most reasonable view at present is that while the nervous system may modify the secretory activity of the gland this secretion is not dependent upon nervous influences.

Recently the view has been gaining ground that the initial secretion of milk is started by the action of a hormone, or chemical messenger, produced by the fetus, the absorption of which has a specific influence upon the mammary gland arousing it to activity. When the mechanism is once set to work the mere act of sucking is a sufficient stimulus to maintain the gland in a state of metabolic activity.

Galactogogues.—Many investigators have alleged an interrelation between the ductless glands and the mammary glands. It has been asserted that the injection of extracts of the pituitary body, the pineal body and the corpus luteum cause an increased milk secretion. Inhibitory substances are said by some observers to be produced by the fetus, placenta, spleen, pancreas, adrenals, and thyroids. It is also claimed that the injection of milk into nursing women causes an increased secretion. This statement, however, has been contradicted. There is some evidence to show that substances secreted in the ovary cause the growth of the breast glands at puberty. Cramer believes that the ovary has no influence on the hyperplasia of pregnancy while Basch attributes the increased size of the gland to a secretion of the ovary. Engel is of the opinion that there are no artificial means of increasing the secretion of milk.

Frank P. Underhill.

Literature may be found in:
1. Basch: Ergebnisse der Physiologie, 1903, 2^1, p. 326.
2. Talbot: American Journal of Diseases of Children, 1914, 7, p. 415.

Milk-Sickness.—*Synonyms.*—Trembles, slows, tires, and alkali poisoning.

Definition.—An infectious disease, primarily of the herbivora, secondarily of man, dog, cat, and swine, due to the action of a specific virus. It is characterized by progressive muscular weakness, loss of appetite, in some cases by vomiting, constipation, fall of temperature, enlargement of the liver, and the appearance of the phenomena of acidosis.

Historical.—The first writer to record in medical literature the symptomatology and distribution of this disease was Drake of Cincinnati in 1810; followed by McCall in 1823, Yandell in 1828, and by many others in the succeeding decades of the last century, notably by Graff in 1841, Elder in 1874, and Way in 1893.

With the settlement of the country, localities in which milk-sickness was formerly rife are now either quite free, or only the seat of occasional outbreaks of the disease.

Distribution.—From the records of the older writers, it would appear that this peculiar and interesting malady had a rather wide distribution. Its

occurrence had been noted in Virginia, North Carolina, Kentucky, Tennessee, Ohio, Indiana, Illinois, and Michigan. In 1907 Jordan and Harris reported a new focus in the neighborhood of Carlsbad, New Mexico.

With the exception of the last-named locality, the infective areas seem to have been largely confined to the more luxuriant pasturage of creek bottoms, particularly in moist well-shaded ground adjacent to the streams and their tributaries or to small springs. In and around Carlsbad, however, the infected areas were confined largely to pasture land in the open that at times was irrigated, and to low-lying grazing land that in the rainy periods of the year was converted into swales, or flooded when the "runs" (small streams) overflowed their banks. The incrustations forming on the grasses following irrigation, rain, or flood (calcium and magnesium salts), were in large measure thought by ranchers to be responsible for outbreaks of the disease, called by them in consequence, "alkali poisoning."

That the disease has not entirely disappeared from its old haunts, is evident from the reports of McCoy (1907), Jordan and Harris (1909), Clay (1914), and from items appearing in local newspapers from time to time.

Etiology.—The nature of the poisonous agent has long been the subject of both debate and investigation, and numerous theories have sprung up in defense of one idea or another. Among the older beliefs regarding the cause of milk-sickness that held widest sway was that of a poisonous plant origin, whereby browsing cattle ate of some plant and became ill. Of the plant in question there was no unanimity of opinion; thus many reckoned poison-ivy, white snake-root, rayless goldenrod, or salt grass as the particular agent. Less acceptable was the idea that some poisonous mineral salt was present in the soil and taken up by edible vegetation, *e.g.* the salts of arsenic or copper. Others, as in New Mexico, think that the alkali of the soil possesses some peculiar toxic action. Recently Moseley has held that the incriminating mineral is aluminium phosphate, which he finds in abundance in the ash of white snake-root. The literature also contains more or less obscure references to a miasmatic cause, or to an "animalcular" agent as a possible factor, thus foreshadowing a possible bacterial origin.

The bacterial nature of the infection cannot be said to have been seriously put forward until modern methods of investigation were brought to bear upon the disease by Jordan and Harris, who published their results of observation in 1907, 1908, and 1909. These writers studied what they believed to have been outbreaks of milk-sickness in Carlsbad, N. M., and in Altamonte and Morris, Ill. They succeeded in isolating from the bodies of affected cattle, a horse, man, and from milk, butter, and soil of pasturage, said to be "milk-sick" (*i.e.* infective), a bacillus, which when fed to dogs, cats, lambs, and to a calf, provoked many of the symptoms of milk-sickness observed by them in the course of natural infections. This bacillus was named by them *Bacillus lactimorbi.*

Biology of Bacillus Lactimorbi.—*Morphologically,* the bacillus found in smears made from the animal body appears somewhat like the colon bacillus, being a little more slender and longer and asporogenous. Stained in methylene blue, the dye is found distributed a little unevenly in depth throughout the bacterium. On culture media the bacillus develops a difference in size and appearance in general from that found in the animal body, and approaches the general configuration of the anthrax bacillus. It is found grouped singly, in pairs, and occasionally in filaments. Particularly when grown on gelatin at 20° C. it forms a polar spore (rarely bipolar spores), which is usually quite round, although in immature rods the spores may be a trifle elliptic and removed a short distance from one end of the bacilli. When stained in methylene blue many of the sporogenous and asporogenous rods exhibit one or more metachromatic granules which in the latter type may be found at one or both ends of the bacteria, or medianally placed. When grown at 37° C. on agar both granules and spores may not be formed. The organism is possessed of some ten to fifteen peritrichal flagella, and is motile.

Cultural Characters.—On agar plates the colonies are streptococcus-like, accompanied by a rather diffuse, delicate film-growth.

On gelatin plates, at 20° C. the colonies make their appearance slowly and ultimately look not unlike those of Staphylococcus albus, and begin to liquefy the medium at the end of ten days or two weeks.

Agar slant cultures grown at 37° C. exhibit at the end of twenty-four hours' incubation a delicate and veil-like growth, which becomes more profuse at the end of forty-eight hours or three days, and appears gray white, smooth, and lustrous; there is no odor.

In the dextrose agar tube no gas is produced, and the growth extends down the needle track in recently isolated strains about 1.5 centimeters, but after several transfers to three or four centimeters. The growth is always delicate and filiform.

The gelatin stab culture shows a very scant filiform growth at the end of forty-eight hours, which becomes more pronounced at the end of seventy-two hours, extending down the needle track about two to three centimeters. No surface growth is visible until the end of a week when there is formed a definite, smooth, whitish growth. Liquefaction begins on the surface about the tenth day in a saucer-shaped fashion, and is complete in four weeks, accompanied by a definite putrescent odor.

On potato no growth is evident. When implanted on Heinemann's synthetic potato medium the only evidence of growth is found by microscopic examination.

Blood-serum culture gives at the end of forty-eight hours a fairly vigorous growth of a yellowish color, and is smooth and moist. There is no liquefaction and no odor.

In broth a barely perceptible clouding takes place at the end of twenty-four hours; at forty-eight hours a delicate pellicle forms on the surface and continues to grow in size until of its increasing weight it falls to the bottom of the tube. A flocculent sediment is formed at the bottom and on the dependent side of the tube.

In litmus milk no growth may occur unless the tube be heavily seeded, then at the end of seventy-two hours the cream ring may show a delicate blue-green color, and the upper portion of the medium will be found to be slightly alkaline. At the end of ten days the whole tube gives an alkaline reaction, and ultimately the milk may become decolorized and opalescent due to the great amount of alkali formed. Coagulation has never been observed.

Relation to Free Oxygen.—The bacillus is feebly facultative anerobic at first, but becomes more strongly so with repeated cultivation.

Thermal Death-point.—The sporogenous type is killed in fifteen minutes in boiling water; the asporogenous form is destroyed in five minutes at 55° C. in moist surroundings.

Virulence.—Even when freshly isolated the bacterium is possessed of low virulence when fed to animals in imitation of the natural mode of infection. After a year's sojourn on laboratory media this degree of virulence is lost.

Pathogenicity.—Young rabbits, guinea-pigs, dogs, cats, lambs, and calves have been infected either by injection with, or by feeding of pure cultures of *Bacillus lactimorbi.* In certain instances (dog and calf), symptoms of milk-sickness were clearly developed.

Mode of Infection.—It would seem that cattle and other herbivora become infected by the bacteria by way of the mucosa of the duodenum and the upper portions of the intestinal tract through the ingestion of grass or other herbage contaminated by particles of infected soil, or by drinking of water contaminated by flowing through infected earthy areas. The infection of man takes place through the consumption of meat, milk, or milk products of cattle suffering from trembles. The portal of entry of the bacteria being as in cattle the mucosa of the small intestine in its upper reaches.

The distribution of the microorganisms is probably very wide, if one accepts a single bacterial cause for the widespread occurrence of the disease in nature. Jordan and Harris have found a bacillus both morphologically and culturally indistinguishable from *B. lactimorbi* in tilled soils from Ontario to New Mexico; but such bacterial races have been found to be void of any virulence whatever. It might seem that this would invalidate the results of their investigations, but it must be remembered that at best the freshly isolated organisms are possessed of a relatively low grade of virulence which is easily lost by cultivation on laboratory media. And under natural conditions doubtless a large amount of contaminated food material must be ingested before the infection is set up. The observations of the older writers state that as soon as infected areas are brought under tillage, they no longer prove infective. In the light of the facts, it would seem then that although the bacteria do not disappear through tillage of the soil, the environment is so altered through exposure to sunlight and to a much lessened moisture content of the soil that what virulence they formerly possessed soon vanishes.

Luckhardt isolated from alfalfa gathered in Wisconsin, Illinois, and Indiana, and from certain weeds from the Pecos Valley, New Mexico, races of bacteria that morphologically and culturally very closely resembled *Bacillus lactimorbi* He failed in attempts to isolate the bacteria from timothy hay, red clover, bran, hominy, and silage. He noted that the original strains isolated by Jordan and Harris, after some months sojourn on culture media, appeared to be culturally in agreement with the races he had isolated, as they now grew vigorously at 37° C. on agar, potato, Heinemann's synthetic potato medium, and also coagulated milk. It would appear then that we have to deal with a bacterium, widely distributed in Nature, characterized chiefly as a saprophyte, occasionally as a facultative pathogenic parasite. The assumption of the latter quality might be considered to be dependent upon change of or adaptation to certain environmental conditions, such as afforded by moist, shaded, humic soils, or, as Luckhardt suggests, by close association with certain plants.

Compared with other theories, no other cause so fits as does the bacterial explanation of the disease. The poisonous weed theory falls to the ground, inasmuch as different species of these plants have been ascribed by different writers as the sole cause of the disease; and in some infected localities, one or other of the long list is quite unknown. That some of those plants may give rise to symptoms of illness resembling in some respects certain of the features of milk-sickness might be conceivable, but that any poisonous substance of plant origin can pass its poisonous properties unimpaired from one animal to a second, and from that to a third, seems quite incredible. The writer has failed in two carefully conducted experiments to reproduce the symptom-complex of milk-sickness in dogs by the administration of aluminum phosphate in daily doses of twenty grams, so that Moseley's explanation of the rôle that a mineral poison (aluminum phosphate) plays, seems out of the question.

Symptomatology.—In man the prodromal onset of the disease is marked by a progressive lassitude and muscular weakness of several days', or even weeks', duration; obstinate constipation appears early and remains throughout the attack. The acute onset is distinguished by severe gastric pains, nausea, and vomiting of a more or less violent order not unlike that of a severe "bilious attack;" headache, great restlessness, and perhaps an active delirium may be noted. The face is flushed and the tongue is coated with a whitish fur; the breath quite often has a most characteristic odor like that of acetone, or, as others have described it, of chloroform, or sweetish, or even putrescent. The temperature *per os* may be normal at first, but as the disease progresses it may be found to be a degree or two lower; very rarely is it ever elevated. The urine is acid to litmus, may have a decided odor of acetone, but contains no albumin or any reducing body. Particularly in the very young a sudden onset of coma may be encountered, which with the odor of acetone in the breath, simulates diabetes. Thirst is a prominent feature of the disease in almost every instance.

In cattle, as in man, increasing lassitude and muscular weakness accompanied by loss of appetite are noticeable symptoms. The peculiar muscular tremors, so significant of the illness, may usually be elicited after urging the animal into a run. As a rule, the animal is constipated, though frequently it drops a rather thin dung containing mucus mixed with blood. After a time the animal loses strength rapidly and cannot rise, although it still may be able to eat and drink when the necessary material is placed before it. In the last stages it becomes stuporous, moans, the head and neck may be twisted to one side, and it may aimlessly move its forefeet to and fro in a sort of pawing movement. Its breath may give off the odor of acetone. The rectal temperature may be found to have fallen a degree or so below normal. The sclera sometimes are injected and a reddish gummy substance gathers in the conjunctival sac at the canthi. As the end approaches the breathing develops a Cheyne-Stokes rhythm, and the animal dies quietly.

In the horse, the disease seemingly proceeds more rapidly than in the cow, and the symptoms differ in some essentials. Weakness is marked, although the animal may be able to remain standing until within a few hours of death. Profuse sweating of the neck and flanks is a prominent symptom, and its temperature falls. The breath perhaps may have the odor of acetone distinctly developed. Consciousness is retained until near the end.

In the dog, as in most other animals, the onset is manifest by a progressive loss of appetite and muscular weakness. At times, after exercising the animal actively, it may vomit. When the height of the disease is reached the eyes become suffused and the sclera much injected. Marked nervous irritability may be a noticeable feature, and the dog will snap at any one approaching it. Ultimately the animal becomes extremely weak and death soon follows.

Pathological Anatomy.—*Gross Changes.*—The essential features found postmortem in animals and man are practically the same. The most prominent condition is a parenchymatous degeneration of the heart muscle, liver, and kidneys. These latter organs usually hold a very considerable amount of blood so that the essential changes in the organs are masked. On pressing out the blood the cloudy swelling becomes apparent, or if the disease is one that has persisted for a while the previous condition of cloudy swelling has given place to a marked fatty metamorphosis. The mucosa of the upper portion of the small intestine, particularly that of the duodenum, usually exhibits a well-marked inflammatory reaction accompanied by edema and occasional punctate hemorrhages. In cattle and horses this edema is very prominent and coincident with it is the secretion of a considerable

quantity of thick bile-stained mucus. In the horse and sheep there appears to be a tendency toward the formation of small inflammatory nodules in the submucosa; and in the horse these nodules may ulcerate. The brain in cattle is often found in a state of great engorgement with petechial hemorrhages in the meninges. Petechial hemorrhages may be found below the serous membranes in a variety of locations throughout the body.

Microscopic.—The most pronounced changes are to be found in the liver and kidneys. These consist of, for the most part, a marked cloudy swelling of the parenchymatous cells, usually accompanied by fatty changes, which, in some instances, especially in the liver, are extreme, so much so that it may be difficult to determine the nature of the tissue. The kidneys show in many cases a combined glomerulitis and parenchymatous nephritis, with or without fatty metamorphosis. The heart muscle likewise presents cloudy swelling and fatty changes. In the intestine the areas noted in the gross as being hyperemic and edematous show the same characters under the microscope, often accompanied by much round-cell infiltration. In places the epithelium may be eroded, where in the horse, for instance, there is inflammatory swelling of areas of the submucoid lymphatic tissue.

Pathological Chemistry.—The interesting point in this connection is the state of the urine. It is very much like the urine in an advanced case of diabetes, in that there is found often in great abundance, acetone, diacetic acid, and beta-oxybutyric acid, but *no* reducing substance.

Diagnosis.—As the disease in several of its attributes is so unlike many of the familiar infectious processes, it ought to be diagnosed without great difficulty. Its occurrence in several members of a family or small group of individuals at or about the same time would be sufficient to direct attention to some article of diet as a possible source of infection. The frequent odor of acetone in the breath, occasionally found in those in the prodromal stage of the disease; the presence of acetone, or diacetic acid, or beta-oxybutyric acid in the urine with total absence of any sugar; the lowered temperature; extreme muscular weakness; epigastric symptoms; the usual and obstinate constipation, all would serve to mark off this affliction as a distinct clinical entity. In the past, doubtless, in communities in which the disease has not appeared for years and is forgotten, or in communities in which infected food is brought in from distant sources of supply, milk-sickness has been diagnosed as "ptomaine poisoning," acute gastritis, or even as "bilious fever."

Prognosis.—The prognosis is usually good, particularly where the case is seen early and a correct diagnosis made, and eliminative treatment promptly administered. Relapses may occur, and often are to be considered grave.

Mortality.—According to the figures presented by Jordan and Harris, the mortality as expressed in the literature is between twenty and twenty-five per cent.; but if allowance be made for errors in diagnosis and non-recognition of mild or abortive cases, the real mortality may be as low as ten per cent., or even lower.

Treatment.—In the days gone by, milk-sickness was treated in a quite empiric fashion, entirely symptomatically, without reference to the more important underlying causes. Jordan and Harris, recognizing the essential features of the disease to be those of an acidosis, recommended that sodium bicarbonate be given, as in the acidosis of diabetes, in relatively large doses. This has been carried out by Walsh, who has published most satisfactory accounts of its efficacy, even in relapses. Efforts from the very first must be made to briskly and thoroughly clear out the intestinal tract by the exhibition of epsom salts, or other saline, or of castor oil. Water or other measures should be employed to obtain good diuresis. As yet there is no specific serum therapy, and no attempts have been made to apply bacterial vaccination either as a cure or a prophylactic.

General prophylactic measures ought not to be overlooked in dealing with a local outbreak. Infected pasturage should be fenced off or brought under tillage. Infected horses or cattle should be isolated from the rest of the farm animals, and treated. Infected milch cows should be allowed to "go dry," and all milk and milk products should be destroyed, never fed to animals on the farm nor sold in the market for human consumption.

Norman MacL. Harris.

References.

Jordan, E. O., and Harris, N. MacL.: Jour. of Infectious Diseases 1909, vi., 401. Contains a full bibliography up to and including 1909.

Clay, A. J.: Illinois Med. Jour., 1914, xxvi., 103.

Luckhardt, A. B.: Jour. Infect. Dis., 1909, vi., 492.

Moseley, E. L.: Medical Record, 1909, lxxv., 839; 1910, lxxvii., 620.

Walsh, W. E.: Illinois Med. Jour., 1909, xv., 422.

Milk Sugar.—See *Saccharum Lactis.*

Millboro Springs.—Bath County, Virginia.

Post-office.—Millboro. Hotel. Cottages.

Access.—Via Chesapeake and Ohio Railroad to Millboro Depot. The hotel is situated on a gently sloping eminence about 2,000 feet above the level of the sea, the highest hotel point on the main line of the Chesapeake and Ohio Railroad. The situation commands a fine vista of green fields, fertile valleys, lofty forest-capped hills, and in the distance the towering summits of the Alleghanies. The climate here is of the usual dry, bracing character of the Virginia mountain region. The hotel is a comfortable, well-kept establishment, having a capacity for one hundred guests. Lawn tennis, croquet, bowling, riding, and driving are among the amusements offered. The Wallawhatoola River, half a mile distant, furnishes excellent bass fishing.

The mineral waters of Millboro Hotel are the crystal chalybeate and white sulphur. The following are the analyses of Dr. Taylor, the state chemist:

Chalybeate.

One United States Gallon Contains:

	Grains.
Magnesium bicarbonate	2.711
Calcium bicarbonate	1.367
Iron bicarbonate	0.581
Manganese bicarbonate	0.008
Sodium sulphate	0.957
Potassium sulphate	0.205
Lithium sulphate	0.017
Calcium sulphate	0.583
Aluminum sulphate	0.076
Sodium chloride	0.101
Calcium phosphate	0.011
Silica	0.920
	7.537

Carbonic acid (free), 5.847 cubic inches in one gallon.

The following is an acidulous chalybeate water. The latter is an excellent water of the alkaline sulphocarbonated variety. It possesses antacid, tonic, and mild diuretic properties and will be found useful in the class of cases to which such waters are applicable.

These waters are valuable in diseases due to debility, and especially in certain forms of derangement of the digestive and urinary organs.

White Sulphur.
One United States Gallon Contains:

	Grains.
Sodium bicarbonate	5.252
Lithium bicarbonate	Trace.
Calcium bicarbonate	4.937
Magnesium bicarbonate	2.385
Iron bicarbonate	0.206
Manganese bicarbonate	0.207
Potassium sulphate	0.371
Aluminum sulphate	0.053
Sodium chloride	0.074
Calcium phosphate	Trace.
Silica	1.004
	14.489

Carbonic acid (free), 8.858 cubic inches in one gallon.
Sulohureted hydrogen, 0.076 cubic inches in one gallon.

The source of the Wallawhatoola alum water is about two miles from the station. The following analysis of this water has been made by Professor C. F. Chandler, Ph. D., of New York.

Wallawhatoola Alum Water.
One United States Gallon Contains:

	Grains.
Sodium chloride	0.710
Sodium and aluminum sulphate	3.867
Potassium and aluminum sulphate	4.201
Lithium sulphate	0.128
Calcium sulphate	7.538
Magnesium sulphate	15.434
Manganese sulphate	1.245
Iron protosulphate	0.489
Iron persulphate	23.741
Aluminum sulphate	137.889
Calcium phosphate	0.055
Silica	4.111
Organic matter	Trace.
Total	199.408

The large quantity of iron as well as alum makes the water an excellent tonic.

These waters are said to be efficacious in catarrhal jaundice, chlorosis or anemia, some forms of dyspepsia, diseases of the urinary organs, and diseases due to debility. Emma E. Walker.

Miller, De Laskie.—Born in Niagara County, New York, May 29, 1818. He received the degree of Doctor of Medicine from the Geneva Medical College in 1842, and shortly afterward began the practice of his profession in Lockport, N. Y. He remained here only a short time and then removed to Flint, Michigan. In 1852 he settled in Chicago, and five years later he was invited to fill the Chair of Obstetrics and Diseases of Women and Children in the Rush Medical College. He died in 1903, after attaining the reputation of being one of the most eminent teachers of his specialty in the Northwest. For years he was connected with St. Luke's Hospital, Chicago, as Obstetrician, and with the Woman's Hospital of the State of Illinois as Consulting Physician. A. H. B.

Millipedes.—The millipedes, Order Diplopoda, differ from other Myriapoda in having two pairs of legs on each segment. These worm-like animals are usually vegetarians and entirely harmless, except when they wander into the nasal cavities or intestine and cause trouble. A. S. P.

Mindererus, Raymond.—A distinguished German writer on military medicine who flourished during the early part of the seventeenth century. He began the study of medicine in 1590 at the University of Ingolstadt, and received his doctor's degree from that institution in 1597. He then traveled extensively for several years, and finally settled down definitively, as a general medical practitioner, in Augsburg, Bavaria. He died in 1621.

It is to Mindererus that credit is due for the introduction of liquor ammonii acetatis (spiritus Mindereri) as a remedial agent in the treatment of febrile disorders. His most important published writing bears the following title: "Medicina militaris," Augsburg, 1620 (later editions in 1623 and 1634). A. H. B.

Mineral Hill Springs.—Grainger County, Tennessee.

Post-office.—Tate. Hotel and sanatorium.

These springs are located in the Bean's Station Valley, near the foot of Clinch Mountain, ten miles from Morristown, forty-two miles east of Knoxville, and 164 miles east of Chattanooga. They are one-fourth mile north of Tate Spring Station, Tennessee, on the K. and B. Railroad. The peculiar arrangement of the valleys, hills, and mountains gives rise to a cool, refreshing air current, always passing from north to south in the morning and from south to north in the afternoon.

The scenery immediately surrounding the springs is of the grandest and most charming character. Col. J. B. Killebrew, in his Resources of Tennessee, says: "The Bean's Station valley proper is one of the most beautiful spots in the world—so pronounced by the visitor and traveler, without exception. From whatever direction approached the fact is at once recognized and conceded. Seen from the pass-age of the lofty Clinch, with the distant elevation of four states on the horizon, the myriad intervening hills, appearing like broken waves of a vast ocean in tempestuous agitation, it lies below wrapped in all those charms of landscape loveliness which are so pleasing and soothing to sensibility—a scene of peace, a home of rest and health." We are informed that as many as twelve varieties of mineral water are found near the hotel, among which are mentioned red, white, and black sulphur chalybeate, Epsom, lithia, and alum waters. The Black Water appears to be the only spring of its kind upon this continent and is a natural curiosity as well as a healing agent. It runs out of the ground perfectly black.

The following analyses have been made by J. W. Slocum, of the several waters:

Mineral Hill Epsom Spring.

	Grains per gallon.
Magnesium sulpbate	40.316
Magnesium carbonate	9.780
Calcium carbonate	7.600
Calcium sulphate	3.143
Iron carbonate	1.460
Alumina	1.779
Sodium phospbates, trace.	
Silica	3.415
Sodium chloride	1.211
Lithium sulphate	1.314
Potassium sulpbate	1.816
	71.834

Mineral Hill Lithia Spring.

	Grains per gallon.
Silica	3.790
Alumina	1.430
Iron carbonate	1.348
Calcium	20.643
Calcium sulpbate	2.473
Lithium chloride	2.492
Magnesium sulphate	1.568
Magnesium carbonate	1.219
Sodium chloride	0.938
Lithium carbonate	3.781
	39.682

These waters are said to be very benefical in diseases of the liver, kidneys, stomach, and bowels; in rheumatic troubles, scrofula, skin diseases, and in cases of general debility.

The accommodations have been largely extended, and an air of genial hospitality pervades the resort.

EMMA E. WALKER.

Mineral Springs.—See *Balneology*.

Minot, Charles Sedgwick.—Born in West Roxbury, Mass., December 23, 1852, he was graduated from the Massachusetts Institute of Technology in 1872 with the degree of B. Sc., and then studied natural history for four years at the Universities of Leipzig, Paris, and Würzburg, returning to Harvard where he took the degree of D. Sc. in 1878. In 1880 he was appointed lecturer on embryology and, although not a medical graduate, instructor in oral pathology and surgery at Harvard University; instructor in histology and embryology in 1882; assistant professor of embryology in 1887, and professor in 1892. In 1905 he was appointed professor in comparative anatomy and in 1912 was made director of the anatomical laboratories in the Harvard Medical School. He was a fellow, and in 1890, president of the American Association for the Advancement of Science, and was a member of many anatomical and scientific societies in this country and Europe. He died November 14, 1914.

Dr. Minot was a scientist of unusual attainments, and his contribution to anatomy, physiology, and embryology placed him in the front rank of the leaders in those sciences, while his labors in the cause of professional education contributed largely to the advancement of medical standards in this country. He was the author of many improvements in scientific instruments and invented two microtomes, the "precision microtome" and the "automatic wheel microtome," which are in constant use in histological and botanical laboratories.

Among Dr. Minot's contributions to scientific literature were: "Human Embryology," 1892; "Bibliography of Vertebrate Embryology, 1893; "A Laboratory Text-book of Embryology," 1903; "Age, Growth, and Death," 1908; "Die Methode der Wissenschaft," 1913; "Moderne Probleme der Biologie," 1913; also numerous articles on biological and embryological subjects in this HANDBOOK and in scientific periodicals. T. L. S.

Minot, Francis.—Born in Boston, Massachusetts, April 12, 1821. He studied medicine at the Harvard Medical School and received the degree of Doctor of Medicine from that institution in 1845. From 1858 to 1887 he was one of the Visiting Physicians of the Massachusetts General Hospital, and from 1874 to 1891 he was Hersey Professor of Theory and Practice of Physic in Harvard University. He died in 1899, after enjoying for many years the pleasure of being held in high esteem by his professional brothren as well as by the community at large. A. H. B.

Miostagmin Reaction.—This reaction was devised by Ascoli and Izar on the basis of the fact that the mixing of an antigen with its corresponding antibody results in a reduction of the surface tension of the liquid containing them. This change in the surface tension they estimated by counting the number of drops of the fluid in a given volume under constant conditions by the use of an instrument known as Traube's stalagmometer. The number of drops in 1 c.c. of diluted normal serum is first determined and the antigen is so diluted that when mixed with this normal serum it does not increase the number of drops by more than one. If the number of drops in a mixture of antigen and patients serum is from two to eight more than in the normal control the reaction is considered to be positive. The reaction has been used almost wholly in the diagnosis of cancer and is claimed to be highly specific though the method has not come into general use. The technique as described by Kolmer (Infection, Immunity and Specific Therapy, 1915, p. 527) is as follows:

"The antigen is most difficult to prepare. A recent method described by Ascoli is as follows:

"1. Cut non-degenerated portions of malignant tumor (cancer or sarcoma) into small pieces and dry *in vacuo* or spread out in a thin layer on clean glass plates and keep at a temperature of 37° C.

"2. Pulverize the dried substance and extract with pure methyl alcohol (in the proportion of five grams to 25 c.c.) for twenty-four hours at 50° C. in closed vessels, and shake occasionally.

"3. Filter while still hot, and allow the filtrate to cool, and then filter again through Schleicher and Schüll's filter-paper No. 590.

"4. It is now necessary to titrate the antigen and to determine in what dilution it should be employed. Various dilutions of the antigen are made with distilled water, as, *e.g.* 1 : 10, 1 : 25, 1 : 50, 1 : 100, 1 : 150, 1 : 200, etc. A fresh normal serum is diluted 1 : 20 with normal salt solution, and 9 c.c. of this are mixed with 1 c.c. of the various antigen dilutions. Into another test-tube place 9 c.c. of the diluted serum and 1 c.c. of distilled water. All test-tubes, pipettes, and other glassware used must be perfectly dry.

"The tubes are gently shaken and placed in an incubator at 37° C. for two hours. The drop number for each fluid is then estimated by Traube's stalagmometer. This instrument is merely a finely and elaborately graduated pipette with a central bulbous reservoir. The dropping end of the instrument ends in a flattened ground base, thus insuring uniformity in the size of the drops. The instrument is so graduated that a fraction of a drop can be estimated. That antigen is to be chosen that does not alter the drop number for normal serum by more than one drop in a cubic centimeter—the strongest dilution that fulfils this condition being chosen.

"*The Test.*—The patient's serum is diluted 1 : 20 with normal salt solution and its drop number determined. Then take two tubes, and into one place 9 c.c. of diluted serum plus 1 c.c. of antigen dilution; into the other place 9 c.c. of diluted serum plus 1 c.c. of distilled water. A third tube may be prepared, which should contain 9 c.c. of normal serum (1 : 20) plus 1 c.c. of the same antigen dilution. A fourth tube contains 9 c.c. of a known positive serum (1 : 20) from a case of cancer and 1 c.c. of the antigen dilution.

"All tubes should be carefully labeled, their drop numbers determined, and then placed in an incubator at 37° C. for two hours or in the water-bath at 50° C. for one hour. At the end of this time they are removed, allowed to cool, and the drop number of each is determined.

"The controls are first examined to show that the antigen has not undergone any change. *Variations of the number above one and a half or two drops (as compared with the control containing distilled water instead of antigen) are regarded as positive reactions.* The increase in drops is seldom greater than eight."

The test is said to be very delicate so that antigen dilutions up to 1 : 100,000,000 may be detected but unless the technique is followed rigidly errors are apt to creep in and render the results worthless. Ascoli and Izar obtained ninety-three positive reactions in 100 cases of malignant tumors and only one positive reaction in 103 other cases. It is said that a negative reaction has a greater value than a positive one. The test has been used in the diagnosis of various

infectious diseases but other immunological reactions have generally been preferred.

RALPH G. STILLMAN.

Miracidium Larva.—The eggs of flukes, after they escape from the host, develop into a ciliated larva, the miracidium, which swims about in the water and finally bores into a pond snail. This free-swimming larva is an elongated mass of cells with two eye spots and a pair of excretory organs. See *Trematoda*. A. S. P.

Mistletoe.—See *Loranthaceæ*.

Misturæ.—In the United States Pharmacopœia the title mixture (*mistura*) applies to many incongruous mixtures affording fluid preparations. The word is properly restricted to such preparations as represent an insoluble substance in powder mechanically suspended in a viscid fluid menstruum. Such condition of suspension is often a convenient one for extemporaneous prescription of powders. In so prescribing, the necessary viscidity is to be obtained by the use of a mucilage, or of syrup, or glycerin, ordered in the proportion of from one part to one, to one part to three, of watery basis. In such viscid menstrua five per cent. of powdered extracts, or twenty per cent. of light vegetable powders, may be ordered to be suspended. Heavy metallic powders, as a rule, should not be prescribed in mechanical suspension.

There are four misturæ official in the United States Pharmacopœia, and nine in the British Pharmacopœia; several are also included in the National Formulary.

		Composition.
Mistura Ammoniaci (Ammoniacum mixture).	B. P.	Ammoniacum, ½ ounce; syrup of tolu, 4 fl. drams; distilled water, 7½ fl. ounces. Dose, ½ to 1 fl. ounce.
Mistura Amygdalæ (Almond mixture).	B. P.	Compound powder of almonds, 2 ounces; distilled water, 16 fl. ounces. Dose, ½ to 1 fl. ounce.
Mistura Creosoti (Creosote mixture).	B. P.	Creosote, 16 minims; spirit of juniper, 16 minims; syrup, 1 fl. ounce; distilled water, a sufficient quantity.
Mistura Cretæ (Chalk mixture).	U. S. P.	Compound chalk powder, 20; cinnamon water, 40; water, to make 100. Dose, 4 drams.
Mistura Cretæ (Chalk mixture).	B. P.	Prepared chalk, ½ ounce; tragacanth, 15 grains; refined sugar, ½ ounce; cinnamon water, a sufficient quantity. Dose, ½ to 1 fl. ounce.
Mistura Ferri Composita (Compound iron mixture).	U. S. P.	Ferrous sulphate, 6; myrrh, 18; sugar, 18; potassium carbonate, 8; spirit of lavender, 60; rose water, to make 1,000. Dose, 4 fl. drams.
Mistura Ferri Composita (Compound mixture of iron).	B. P.	Ferrous sulphate, 25 grains; potassium carbonate, 30 grains; myrrh, 60 grains; refined sugar, 60 grains; spirit of nutmeg, 50 minims; rose water, 10 fl. ounces. Dose, ½ to 1 fl. ounce.
Mistura Glycyrrhizæ Composita (Compound mixture of glycyrrhiza).	U. S. P.	Pure extract of glycyrrhiza, 30; syrup, 50; acacia, 30; camphorated tincture of opium, 120; wine of antimony, 60; spirit of nitrous ether, 30; water to make 1,000. Dose, 2 fl. drams.
Mistura Guaiaci (Guaiacum mixture).	B. P.	Guaiacum resin, ½ ounce; refined sugar, ½ ounce; tragacanth in powder, 35 grains; cinnamon water, 1 pint. Dose, ½ to 1 fl. ounce.
Mistura Olei Ricini (Castor oil mixture).	B. P.	Castor oil, 3 fl. ounces; mucilage of gum acacia, 1½ fl. ounces; orange-flower water of commerce, undiluted, 1 fl. ounce; cinnamon water, 2½ fl. ounces. Dose, 1 to 2 fl. ounces.
Mistura Rhei et Sodæ (Mixture of rhubarb and soda).	U. S. P.	Sodium bicarbonate, 35; fluid extract of rhubarb, 15; fluid extract of ipecac, 3; glycerin, 350; spirit of peppermint, 35; water, to make 1,000. Dose, 1 fl. dram.
Mistura Sennæ Composita (Compound mixture of senna).	B. P.	Magnesium sulphate, 5 ounces; liquid extract of liquorice, 1 fl. ounce. Compound tincture of cardamoms, 2 fl. ounces. Aromatic spirits of ammonia, 1 fl. ounce; infusion of senna, a sufficient quantity. Dose, 1 to 2 fl. ounces.
Mistura Spiritus Vini Gallici (Mixture of brandy).	B. P.	Brandy, 4 fl. ounces; cinnamon water, 4 fl. ounces; refined sugar, ½ ounce; two yolks of eggs. Dose, 1 to 2 fl. ounces.

R. J. E. SCOTT.

Mitchell, Silas Weir.—Born in Philadelphia, Pa., February 15, 1829. He was of the third of four generations of successful physicians. His grandfather, Alexander Mitchell, a Scotchman, was one of the ablest physicians of Virginia. His father, John Kearsley Mitchell, established himself in Philadelphia, became a professor in the Jefferson Medical College, and a writer of verse and stories of no mean merit. S. Weir Mitchell, as he always signed himself, was one of nine children. He received his preliminary education at the grammar schools of Philadelphia and at the University of Pennsylvania, and was graduated in medicine from the Jefferson Medical College in

FIG. 4008.—Silas Weir Mitchell.

1850, when but twenty-one years of age. While doing general practice, the first ten years of his medical life were more or less devoted to research work in comparative anatomy, the study of the chemical nature and toxic action of snake poisons, and physiology. His ambition was to become a physi-

ologist, but his work along these lines opened the avenues which eventually aroused his interest in diseases of the nervous system.

In 1862 he was commissioned Assistant Surgeon of Volunteers of the Army of the North, and served until the end of the war. During the war years, the opportunity offered for much valuable research work on gunshot wounds and the resulting nervous disorders. He was given wards in two large hospitals in Philadelphia, for the study and treatment of nervous diseases, many of which were the outcome of wounds of the nervous system. Later, the Turner's Lane Hospital of Philadelphia, which accommodated several hundred cases, was practically given over to nervous conditions, the work being almost entirely in the hands of Drs. Mitchell, Morehouse, and Keen.

At the close of the war, Dr. Mitchell resumed practice in Philadelphia, and devoted himself exclusively to the practice of neurology. He was physician for many years to the Philadelphia Orthopedic Hospital and the Infirmary for Nervous Diseases, and was consulting neurologist to almost all of the Philadelphia hospitals. He was a member of the American Neurological Association and of the Philadelphia Neurological Society, and a corresponding member of many medical societies in the various European countries. He died at his home in Philadelphia, January 4, 1914, from influenza, within six weeks of his eighty-fifth birthday.

Dr. Mitchell was for many years recognized as the leading authority on nervous diseases in America, and also won distinction of a high order in the field of fiction through his poems and novels. He inherited from his father the gift for writing, and this, combined with his extensive work in research, enabled him to contribute over 140 original scientific books and papers to medical literature. In 1860, as a result of his research on snake poisons, he published his first monograph called "The Venom of the Rattlesnake." In 1864 his second monograph, "Gunshot Wounds and Other Injuries to the Nerves" was published. The material for this paper had been collected during the period of his association with Drs. Morehouse and Keen in Turner's Lane Hospital. In 1871 "Wear and Tear; or Hints for the Overworked" was published, and in 1872 "Injuries of the Nervous System and their Consequences." But the work which won for him his greatest distinction in the medical field was the paper, "Fat and Blood: An Essay on the Treatment of Neurasthenia and Hysteria," published in 1877. This contained an account of the rest treatment for these conditions, which has been called after him, "the Weir-Mitchell cure." This paper was translated into five European languages. In 1888 "Doctor and Patient" was published. As late as 1907 he published some memoranda in regard to William Harvey.

As a novelist he won both the love and admiration of the public. His writings possess a charm of style very rare in medical authors. In the first decade of his practice he became acquainted with Dr. Oliver Wendell Holmes, who praised his verse, and of whose friendship Dr. Mitchell was very proud. His first short story "The Case of George Dedlow," appeared in 1863 in the Atlantic Monthly. From then until his death Dr. Mitchell was constantly engaged upon some literary work, which he considered a recreation, aside from his practice and medical writings. His first novel, "Hephzibah Guinness," appeared in 1880. His "Collected Poems" appeared in 1896. The one which really represents him to his public is "Hugh Wynne, Free Quaker," which was published in 1897. There followed "The Adventures of François" in 1898; "The Adventures of a Quack" in 1900; "The Red City" in 1909; and his last "Westways," in 1913. In all, his literary productions number almost thirty volumes. His "Ode on a Lycian Tomb" was perhaps his finest contribution to letters. E. L. J.

Mites.—Acarina. Arachnids having a sac-like unsegmented body without distinct regions. Most are free living but there are many parasites. The most important families are: *Thrombidiidæ*, harvest mites; *Dermanyssidæ*, on poultry; *Tarsonemidæ*, grain mites; *Tyroglyphidæ*, causing grocer's and copra itch; *Sarcoptidæ*, itch mites, *Demodecidæ*, follicle mites. See *Arachnida*. A. S. P.

Mitosis, Pathological.—Atypical forms of karyokinesis are found in certain pathological condi-

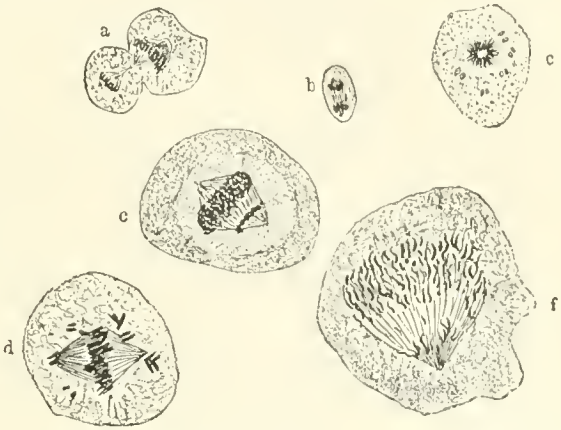


Fig. 4009.—Pathological Mitoses. *a*, Asymmetrical mitosis; *b*, hypochromatic mitosis; *c*, *d*, mitoses with displaced and partly degenerating chromosomes; *e*, *f*, asymmetrical mitoses. (After Hansemann.)

tions. In place of normal bipolar division multipolar division may take place, two, four, six, eight, or more nuclear spindles with a correspondingly increased number of equatorial plates being formed. The number of chromosomes may be greater or less than normal. Asymmetrical splitting of the nuclear chromatin, or the destruction of some of the chromosomes may lead to the formation of daughter stars having an unequal number of chromosomes. In the place of a single mother star a complicated chromatin figure may be formed from which a number of daughter stars may be developed. The separate chromosomes may vary greatly in size, or they may be altered in form through irregularities in the course of the fibers of the spindle, spherical, spindle- or biscuit-shaped chromosomes being in this way produced. The division of the cell protoplasm may be delayed or entirely fail of occurrence. Multinuclear giant cells are formed in this manner. Deviations from the normal division axis may also occur. Degeneration of the chromosomes is sometimes shown by their displacement, granular disintegration, or loss of staining power (abortive or degenerative mitoses).

Multipolar mitoses were first described by Eberth, but his statements were at first discredited, particularly by Flemming and Strassburger. The existence of such forms was, however, confirmed later by Arnold who observed numerous multiple mitotic figures in carcinoma cells. As a result of the great amount of interest excited in the subject by Arnold's observations numerous investigations were made, among the most important of which may be mentioned the studies of v. Hansemann, Ströbe, and Galeotti. According to Ströbe, atypical mitoses are found in a great variety of pathological conditions—cancer, sarcoma, different forms of benign tumors, tissue regenerations, etc. He regards them as a constant phenomenon in all tissues showing strong proliferative tendencies with active mitosis. Galeotti claimed to have found atypical mitoses in tissues irritated by

antipyrin, quinine, chloral, peptone, etc., as well as in tissue exposed to high temperature.

Von Hansemann divides the pathological forms of mitosis into three classes—the hypochromatic, hyperchromatic, and irregular variations. Hypochromatic mitoses are those which contain fewer chromosomes than normal. The number of chromosomes may be reduced to six or eight. Hypochromatic cells arise in two ways, either through asymmetrical division or through the destruction of some of the chromosomes. According to v. Hansemann, the hypochromatic mitoses occur only in malignant tumors, much more frequently in carcinoma than in sarcoma. They are to be regarded as evidences of cell degeneration; in the majority of cases cell division does not follow. He regards them as being only of biological interest, their significance with relation to tumor malignancy not being at the present understood. The hyperchromatic forms contain more chromosomes than the normal cells. They are very abundant in malignant growths, much more so in carcinoma than in sarcoma. They may be divided into two classes, the bipolar and the multipolar. The bipolar forms are very large, containing over a hundred large chromosomes at times. On division they form similar hyperchromatic cells having the same number of chromosomes. In the multipolar forms a reduction of the number of chromosomes occurs through division, so that their number may ultimately return to the normal. The multipolar mitoses usually result in the formation of multinuclear giant cells, the latter being most numerous in tumors containing the greatest number of multipolar mitoses. As irregular forms of atypical mitosis v. Hansemann includes changes in size and form of the chromosomes and centrosomes, irregular spindle forms, delayed division of the cell, etc., v. Hansemann was unable to confirm the work of Ströbe and Galeotti, and is therefore inclined to regard atypical mitoses as being characteristic of malignant tumors. The presence of numerous atypical mitoses in the cells of a new growth may be taken as positive evidence of its malignancy, but the absence of such pathological forms in a tumor is not to be taken as conclusive proof of its benign character.

A practical application of the above principle has been made by a number of writers in the case of the diagnosis of bits of tissue obtained by the stomach tube, aspirator, etc., or of cells found in pleural and peritoneal exudates, urine, uterine discharges, etc. The existence of carcinoma has been diagnosed by Rieder, Dock, etc., from the presence of numerous atypical mitoses in the cells of the centrifugated peritoneal fluid. Sarcoma of the pleura has been diagnosed by the writer in like manner. In other cases, however, the examination of the pleural and peritoneal fluids yielded negative results, though malignant growths were found to be present. Only in the case of very soft, cellular, quickly growing tumors are positive findings likely to occur. In suspected cases the fluid obtained by aspiration should be quickly centrifugated, cover-glass smears made of the sediment; and these, after drying in the air, should be fixed in equal parts of absolute alcohol and ether, and stained in hematoxylin and eosin. The presence of numerous mitoses in the cells of such exudates, either typical or atypical, may be regarded as strong evidence of the presence of a malignant tumor. Negative findings are without significance.

ALDRED SCOTT WARTHIN.

Molasses.—See *Sugar*.

Moleschott, Jakob.—Born in Herzogenbusch, Holland, Aug. 9, 1822. He began his medical studies at the University of Heidelberg, and received the degree of Doctor of Medicine from that institution in 1845. During the following two years he engaged in general practice in Utrecht, in his native land; and during the first part of this period he worked in Mulder's laboratory. From 1847 to 1854 he taught physiological chemistry, comparative anatomy, physiology, and anthropology at the University of Heidelberg, his official position being simply that of a Privatdozent. In 1856 he was called to fill the Chair of Physiology at the University of Zürich, Switzerland. After holding this position for five years he was invited by the Italian Government to fill the same position in the University of Turin. He accepted the invitation, and during the following eighteen years (1861–1879)

FIG. 4010.—Jakob Molesehott.

he was successful in building up an excellent school of experimental physiology and of physiological chemistry and physics. In 1876, having been previously naturalized, Moleschott received the honor of being made a senator of Italy. In 1879 he accepted an invitation to be Professor of Physiology in the University of Rome, and he retained this position up to the time of his death in 1893.

Of Moleschott's published writings the following deserve to receive special mention: "Physiologie der Nahrungsmittel," Darmstadt, 1850 (a second edition was published in Giessen in 1859); "Lehre der Nahrungsmittel," Erlanzen, 1850 (third edition in 1858, and translations into Dutch, French, English, Russian Italian and Spanish); and "Der Kreislauf des Lebens," Mainz, 1852 (later editions, 1875–1885). In addition to the above there are two publications of considerable importance in the preparation of which Moleschott took a leading part. They bear the following titles: "Holländische Beiträge zu den anatomischen und physiologischen Wissenschaften," Düsseldorf and Utrecht, 1846–1848; and "Untersuchungen zur Naturlehre des Menschen und der Thiere, Frankfort und Giessen, 1857–1885. A. H. B.

Molluscum Contagiosum.—*Synonyms:* Molluscum epitheliale; Epithelioma contagiosum; Molluscum sebaceum; Molluscum verrucosum.

Definition.—A contagious disease of the skin, characterized by whitish to yellowish-pink, pearl-like, rounded elevations, with a central depression, and varying in size from a pin-head to a hazelnut.

SYMPTOMS.—Typical molluscа are firm, rounded, elevated bodies, of a waxy appearance, with a depressed aperture of a darker color than the lesion itself, and situated usually on or immediately around its central point. On pressure a milky, curd-like, semi-fluid mass can be expressed. They average in size the dimensions of a pea, and are not usually of an inflammatory character. They have a broad base, but occasionally, especially in older lesions, there is a marked tendency to become pedunculated. At times, the lesions after some months attain the size

of a large pea or even a small cherry, become inflamed, break down and suppurate, and heal usually without scarring. The disease is comparatively rare; there were only ten cases among 7,968 patients in our service at the New York Skin and Cancer Hospital, during one year. The lesions are insidious and slow of development, their individual course lasting from a few weeks to one or two years. As the older lesions gradually disappear, new growths may make their appearance. They are as a rule comparatively few in number, usually not exceeding ten to fifteen, but exceptionally an enormous number may be present, a few cases having been reported where the lesions amounted to several hundred. They are most frequently located on the face, especially on or about the eyelids; but may be found on the scalp, neck, arms, trunk, and genitalia. In the same individual they vary much in size, and are usually from the size of a pin-point to that of a small pea; in extremely rare cases they have been known to be from one to several inches in diameter. The lesions are not inflammatory, there are no subjective symptoms. Because of the depression in the center of the little tumors and their slight resemblance to the prepustular lesions of variola, they were described by Bazin under the term acné varioliforme; this term now designates an entirely different dermatosis.

Etiology and Pathology.—The contagiousness of the disease has been generally admitted, convincing proofs having been presented by Fox, Allen, Mittendorf, Jackson, Graham, Knowles, and Stelwagon. Several investigators have been accidentally inoculated. Retzius, Vidal, Peterson, and Wigglesworth have succeeded in producing the disease by inoculation of the contents of molluscous lesions. Contagion may be direct, as from the breast of the mother to the face of the nursing infant, or indirect, through the medium of towels, etc. The disease seems especially propagated through bathing establishments; this may be due to the maceration of the skin from the bath, and the subsequent use of an infected towel. Hartzell reports an epidemic occurring in a large institution for young men, about five per cent. of the student body having been found affected. The epidemic was traced to the promiscuous use of bath towels in the gymnasium, and immediately ceased with the elimination of the cause. The disease is seen in either sex, and at all ages, but is most frequently met with in children who are kept amidst dirty and squalid surroundings. It was formerly held that the disease originated in the sebaceous glands, but this has been proved erroneous. The investigations of Virchow, Crocker, Boeck, Robinson, Thin, Neisser, Fordyce, and Gilchrist conclusively prove that the disease originates from the epithelium, that it is in fact a benign epithelioma, and that it has no connection with the sebaceous glands. On section the lesions show that they are made up of several lobules; each lobule is lined with a layer of palisade cells, and is filled with epithelial cells, the first two or three rows of which are usually normal. The cells above them show more or less marked degenerative changes. The so-called "molluscum bodies" are small hyaline bodies, oval in shape, with tapering or pointed ends, and containing a nucleus. They are not parasitic, play no rôle as a causative factor, and are nothing but degenerated epithelial cells. Because of the contagious character of the disease, it must undoubtedly be of parasitic origin, but what particular parasite is responsible for its production is yet unknown.

Diagnosis.—Molluscous lesions are as a rule easily diagnosed; the waxy, glistening appearance, much resembling a small pearl button, with a central depression, could not easily be mistaken for anything else. In variola, pustules and constitutional symptoms are present. Warts are harder, contain no semi-fluid mass, and the dark central punctum is missing. Milia are white, lack the waxy appearance and central punctum. Molluscum fibrosum in no way resembles molluscum epitheliale.

Prognosis and Treatment.—The prognosis is essentially favorable. The lesions are readily amenable to treatment, and usually disappear without scarring. The most efficient treatment consists of boring into the central punctum with a wooden applicator which has been previously dipped in pure phenol. The lesions may also be clipped off with curved scissors, and the base touched with silver nitrate. If the lesions are very numerous and located on a limited region, a four to ten per cent. ointment of white precipitate or sulphur acts very favorably. Frequently the lesions disappear spontaneously.

Paul E. Bechet.

Molluscum Fibrosum.—*Synonyms:* Fibroma molluscum; Molluscum simplex; Fibroma.

Definition.—A benign new growth, characterized by one or more sessile, pea- to egg-sized or larger, soft or firm, painless tumors.

Symptoms.—The tumors are usually numerous, and show great variations as to size and shape. In early development, the tumors are of the size of a pea to that of a bean, softish to the touch, and are covered with normal epidermis. They can easily be compressed between the fingers, and be made almost to disappear, but when released they regain their shape immediately. As they grow older, they become

Fig. 4011.—Molluscum Fibrosum. (From the collection of Dr. W. B. Trimble.)

much firmer, many of them becoming pedunculated. A few of the pedunculated ones sometimes form a large hanging pouch, and are then known as fibroma pendulum. A favorite region for these pendulous

growths is the upper part of the trunk. The tumors are painless and produce no subjective sensations. When the growths are unusually large or pendulous, they may become inflamed from pressure, weight, or accidental injury, and may ulcerate or even become gangrenous. The tumors as a rule tend to grow very slowly, and never undergo involution; new ones make their appearance from time to time, so that in a given case tumors of all sizes and in all stages of development may be present. Other lesions occasionally associated with the disease are freckle-like pigmentary discolorations. The tumors are most numerous on the trunk; the scalp and other parts of the head are also favorite localities, but any part of the surface of the body may be affected.

Etiology.—Fibroma is not as frequently seen in this country and Europe as it is in the far East. It is more common in those of darker skins. The disease is peculiar to neither sex, and while heredity is considered a factor, and any great tax of the system through severe disease a predisposing factor, the true etiology of the disease is most obscure.

Pathology.—The majority of observers agree that the growths are due to a hyperplasia of the connective tissue, but their point of origin is a matter of controversy. The cause of this hyperplasia is unknown. Von Recklinghausen believes the tumors are neurofibromata, and are formed by proliferation of the connective-tissue sheaths of the nerves. On section the tumor consists of an encapsulated mass of fibrous tissue, the central portion of which is gelatinous. The cells are spindle shaped and round, and have a nucleus, with gelatinous protoplasm.

Diagnosis.—This is usually not difficult. The only two diseases which might faintly resemble it are lipoma and sarcoma cutis. Lipomata are much less frequently multiple, are not pedunculated, are somewhat flattened, and commonly lobulated. They are much softer to the touch. Sarcomata are of a violaceous or reddish color, are never pedunculated, and are much firmer to the touch. They grow much more rapidly, and show a greater tendency to ulceration. Their malignant nature is evident.

Prognosis and Treatment.—The tumors are essentially benign and do not affect the individual's health. The presence of large tumors may give rise to great discomfort, and at times they may through pressure become inflamed, with resulting degeneration and danger of septicemic infection; but as a rule, very few lives are shortened by the disease. The treatment is essentially surgical, care being taken to remove the tumor so thoroughly as to prevent any possibility of regrowth. In the small tumors electrolysis has proved valuable. In multiple cases arsenic has been observed to have an occasional favorable influence. Whitehouse reported a case in which the tumors rapidly disappeared under the use of Asiatic pills. Paul E. Bechet.

Monadidea.—An order of minute Mastigophora with one or more flagella, which contains many of the parasitic flagellates. See *Protozoa*. A. S. P.

Monarda.—This is a genus of about twenty species of North American plants in the *Labiatæ* or Mint family, of highly aromatic and more or less pungent properties, but without specific medicinal value. The stems and branches are slender and erect and are terminated by flattened, circular, densely flowered heads, reminding one of small or medium-sized chrysanthemums. Very often there are also dense whorls of flowers in the upper axils of the opposite leaves, similar in form and size to the terminal heads. The essential oils distilled from a number of the species are articles of commerce. That from *M. punctata* L. contains thymol as its important constituent, together with cymene, carvacrol, and other substances. That from *M. fistulosa* L. contains cymene, carvacrol, and limonene. Because of their sensible aromatic, and pungent properties, these plants have found much use in domestic practice and also have been largely prescribed in country practice. *M. punctata* is the common horse mint or American origanum. It grows in vast quantities in the middle and southern parts of the eastern United States, covering vast tracts of sandy barrens. With a little disposition toward original enterprise and independence on the part of American manufacturers, this plant could be made to furnish our entire supply of thymol. This species is mostly about one or two feet high and has pale purplish or lilac flowers, thickly marked with darker spots. *M. didyma* L. replaces the former in the west. It is taller and has deep scarlet or crimson flowers. It is known as Bee, Rose, Red or Scarlet balm, or Oswego tea. It has a slight peppery effect upon the nares, if the crushed leaves or flowers are smelled. *M. fistulosa* grows like the preceding, but its flowers are pinkish, and the heads are usually subtended by whitish bracts. All these and other species have been much used as carminatives, intestinal stimulants in serous diarrhea, diaphoretics, errhines, vulneraries, etc. H. H. Rusby.

Monas.—A genus of minute mastigophorans with a principal flagellum and one or two small accessory flagella. *M. pyophila* has been found in pus from pulmonary and hepatic abscesses. See *Protozoa*. A. S. P.

Mono Lake.—Mono County, California.

This remarkable body of water is located near the center of Mono County, about ten miles south of the town of Bodie. The length of the lake from east to west is about fourteen miles, its greatest breadth nine miles, and its circumference forty miles. Its altitude is 6,370 feet above the sea-level. In his article on the "Mineral and Thermal Springs of California," read before the Ninth International Medical Congress, Prof. W. F. McNutt likens this lake to the Dead Sea of the Holy Land. The analysis shows, however, that the waters of this lake (see below) are not so salty as those of the ancient Palestine sea. The lake receives much of its water and its salts from the rivers and creeks which flow through volcanic soil and empty into it. Numerous springs are found all over the lake. The most curious of these are some of the fresh-water springs, holding in solution small quantities of calcium carbonate, which precipitate and deposit around the openings of the springs, forming irregular tubes clustered together in columns. These vase-shaped structures are from ten to forty feet long and rise from the bottom of the lake upward and above the surface. In the center of these columnar pillars are small holes through which flows this sweet water. In Mono Lake we find two islands situated almost centrally. The larger, Paoha Island, has an area of 1,500 acres; the smaller, Negit Island, an area of 300 acres. Their composition is of volcanic material, and all over the surface are hot springs and jets of hot steam, making the surrounding water quite warm. On Paoha Island are small craters, fifty or more feet in diameter. They are now filled with water. On this island there are also three inland lakes, a seepage of petroleum, and considerable vegetation. The smaller island is really the crater of an extinct volcano. Mono Lake has no visible outlet. All around Mono Lake are unmistakable evidences of great volcanic activity during the tertiary and post-tertiary periods, and there are the best of reasons for believing that the lake itself is a large extinct crater. The water, being likened to that

of the Dead Sea, was supposed to be destitute of life. There are found, however, numerous worm-like minute organisms, plainly visible to the naked eye in the water near the surface. The larvæ of these animals are thrown upon the shores of the lake by the waves, and there accumulate in large quantities. The fact that snow-capped mountains surround Mono Lake lends a grand and impressive character to its scenery. On the west side of the lake at the foot of the Great Sierra Mountains is Hotel Hammond. Hammond, or Mono Lake, is on the line of the proposed Lincoln Highway, with fairly good automobile roads from various directions. For beauty of scenery and natural facilities, the resort cannot be surpassed. There is stage connection with the railroad at Thorne, Nevada, about sixty miles distant. When repairs to the State Highway and Tioga Road are completed, there will be a direct and first-class motor route to The Yosemite National Park. To the taste the water is more like a bitter brine than a mineral water. The action of the water, even when it is taken in small quantities, is exceedingly diuretic. Several analyses of this water have been made. The following one by Dr. Winslow Anderson is, perhaps, the most complete and comprehensive:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	795.24
Sodium carbonate	26.40
Sodium sulphate	17.10
Sodium phosphate	5.93
Potassium chloride	281.17
Potassium carbonate	10.60
Potassium phosphate	3.05
Magnesium chloride	365.60
Magnesium carbonate	9.45
Magnesium sulphate	127.50
Calcium chloride	1,075.55
Calcium carbonate	52.76
Calcium sulphide	Trace.
Calcium sulphate	57.07
Ferrous carbonate	7.14
Alumina	26.63
Borates	19.75
Silicates	9.62
Organic matter	24.60
Total solids	2,915.16
Gases	Cu. in.
Free carbonic-acid gas	17.16
Free sulphureted hydrogen	0.62

Temperature of water, 63° to 80° F.

The composition will probably vary somewhat in different localities, being influenced by the proximity of the various springs. Emma E. Walker.

Monomastigoda.—A group of minute mastogophorans. These protozoans have one flagellum, one or more simple contractile vacuoles, a definite point for the ingestion of food near the base of the flagellum, and usually have reserves of fat in the cytoplasm. *Cercomonas* is the principal parasitic genus. It occurs in the intestine and vagina. See *Protozoa*.
A. S. P.

Monosaccharides.—Under this term are included all the simple sugars as dextrose, levulose, galactose, etc. They are either aldehyde or ketone derivatives of polyhydric alcohols and the more complex carbohydrates are derived from the monosaccharides by the formation of anhydrides. See also *Aliment*.
F. P. U.

Monostomidæ.—A family of flukes. These worms are digenetic and possess only one oral sucker; the form is more or less rounded. *Monostomum* is the only genus known to occur in man. See *Trematoda*.
A. S. P.

Monostomum.—A genus of flukes in which the ventral sucker is absent. *M. lentis* is a minute species that has occurred in the crystalline lens. See *Trematoda*.
A. S. P.

Monro, Alexander.—Born in London in 1697. He studied medicine in Edinburgh, Scotland, and then visited the more important centers of medical knowledge in Europe. After witnessing the best practice of the hospitals in Paris, he went to Leyden and gained the friendship of Boerhaave. In 1719, upon his return from abroad, he began teaching anatomy in Edinburgh. In 1721 and 1722 he gave instruction in surgery; and from that time onward, for a period of forty years, he continued to give these public courses. He died in 1767. To the anatomical student the name of Monro is familiar, being associated with normal anatomical structures—M.'s foramen, M.'s line, M.'s gland, etc.

Monro's contributions to medical literature are highly esteemed. Only a few of them may here be mentioned: "Osteology; or a Treatise on the Anatomy of the Bones, etc.," 6th edition, 1758; "Improvement in Performing the Operation of Paracentesis or Tapping of the Belly," Essays of the Society of Medicine of Edinburgh, vol. i.; "On the Coats of the Arteries, their Diseases, and particularly Aneurism," ibid., vol. ii.; "Remarks on Chalybeate Waters," ibid., vol. iii.; "Remarks on the Amputations of the Larger Extremities," ibid., vol. iv.; "Mechanism of the Cartilage between the True Vertebræ," ibid., vol. v.; "An Essay on Caries of the Bones," ibid., vol. v.; "Unexpected Cures," ibid., vol. v.; and "The Ureters Obstructed by Small Stones," ibid., vol. v.

The son of Alexander Monro bore the same name as his father, and was no less celebrated as an anatomist. He was born in Edinburgh about 1733, and received the degree of Doctor of Medicine in 1755. Afterward he was chosen Professor of Medicine and of Anatomy in the university, and President of the Royal College of Physicians. He died in 1817. Of his published writings the most famous, and certainly the most original, is that entitled: "A Description of all the Bursæ Mucosæ of the Human Body, their Structure explained and compared with that of the Capsular Ligaments of the Joints, and of those Sacs which line the cavities of the thorax and abdomen; with Remarks on the Accidents and Diseases which affect those several Sacs, and on the Operations necessary for their Cure," with plates, Edinburgh, 1788. A. H. B.

Monstero.—See *Teratology*.

Monte Carlo and Monaco.—These two promontories separated by the little plain of La Condamine, occupy one of the most beautiful positions on the Riviera. Monte Carlo, the more important of the two, is a small town of about 3,800 inhabitants, but is said to have upward of 1,000,000 visitors yearly; the larger number being attracted by the "Casino," the notorious gambling palace. From Nice on the one side Monte Carlo is only nine miles distant, and from Mentone on the other, six miles. The general climatic characteristics are essentially the same as those of Nice and Mentone, and the reader is referred to the articles upon these places in the Handbook for meteorological data. The mean winter temperature is 48° F., and the rainfall and proportion of sunny days to cloudy ones is about the same as at Nice and Mentone. Every writer emphasizes the beauty and attractiveness of this region, and the present writer from personal acquaintance heartily confirms this opinion.

Monte Carlo is considered one of the warmest winter stations on the Mediterranean coast, and is well protected from the cold winds, this being particularly true of the little plain of the Condamine lying on the

harbor and bay of Monaco. The northwest portion of this quarter is protected by the rock of Monaco to the west and southwest, and by the high mountains, which approach within a short distance of the sea, to the north and northwest. Also on the opposite side of Monte Carlo good protection is afforded from the cold winds. The sea bathing is excellent, and the accommodations are abundant and good, but perhaps rather more expensive than some of the other Riviera resorts. Naturally, Monte Carlo is one of the best winter stations on the coast, but the moral atmosphere of the place, on account of its unenviable reputation as a gambling resort, is hardly conducive to the well-being of an invalid.

Although the situation of Monte Carlo is one of great natural beauty, art has done much to add to the attractiveness of the place. In corroboration of the truth of this statement I have only to point to the beautiful gardens in front of the "Casino," in which gardens are to be seen many exotic tress and plants. The excursions round about are many and varied; the most beautiful of all being the one to La Turbie and the walks from that point. La Turbie is 1,594 feet above sea level, and is reached in twenty minutes by a mountain railway from Monte Carlo. The views both in the ascent and at the summit are superb, and from La Turbie one can see the famous Corniche road in either direction.

The maladies for which one seeks the resort of Monte Carlo are such as are benefited at the other Riviera stations, such in brief as require a mild sunny winter climate. The malady of gambling, however, is likely to meet with a fatal issue at this resort where

"Every prospect pleases,
And only man is vile."

EDWARD O. OTIS.

Monterey.—This old Spanish settlement is 125 miles south of San Francisco by rail, and is situated on a peninsula which forms one of the sides of the Bay of Monterey, Santa Cruz forming the other. The climate is moist, equable, and mild, and outdoor life can be enjoyed throughout the year. The annual mean temperature (Solly's "Medical Climatology") is 56° F.; maximum, 88° F.; minimum, 26° F. The mean temperature for January is 50° F. and for July, 65° F. The mean annual rainfall is 14.4 inches. Fogs are more or less prevalent.

The scenic attractions at and about Monterey are very great; the roads are good and the drives most attractive, while boating, bathing, and fishing can be enjoyed in the bay. The temperature of the water however is rather low, being only 60° F. in July. The Hotel Del Monte is a vast structure attractively situated in a great park of several thousand acres with lawns, flower gardens, and groves of various trees, and it affords excellent accommodations.

For those desiring *rest* or recuperation from febrile disease in a sedative, mild, equable climate, amidst beautiful scenery of sea and land, Monterey offers an ideal retreat. It is said to be "an excellent place" (Hinsdale "A System of Physiologic Therapeutics," vol. iv., Book II., "Climatology") "for the relief of *insomnia* and for building up the *neurasthenic*." It is obviously not so well suited for the consumptive on account of its dampness. EDWARD O. OTIS.

Montreal.—Montreal (Latitude 45° 30′ N.; Longitude, 4 h. 54 m. W.), the commercial metropolis of Canada, with a population, including its suburbs, of 600,000, is picturesquely situated at the head of the ocean navigation of the St. Lawrence River, here nearly two miles wide. The city is built on a series of natural terraces which rise from the river's edge till they culminate abruptly in Mount Royal, a volcanic hill 750 feet high about two miles northwest of that portion of the river termed the harbor.

Its buildings are, for the most part, well constructed of limestone and brick, and while cool in summer are rendered by their double windows and doors warm and comfortable in winter.

The soil on which the city is built is composed of a series of marine clays and sand with some gravel terraces. While some of the streets in the lower portion of the city are narrow and ill-paved, all the more important thoroughfares are broad, well-paved, drained, and lighted and are kept cleanly; those in the upper part of the city are lined on each side with shade trees which in summer add much both to their appearance and to their pleasantness. The city is well supplied with water drawn from the St. Lawrence River. This water, except during the time of the spring floods and after heavy autumn rains, has a very slight tinge of color and contains only a small amount of solid matter, not more than from eighty to one hundred parts per million, with chlorides from one to two and one-half parts per million; its total bacteriological content is from 120 to 240 per cubic centimeter. An excellent filtration plant is now in course of erection in the outskirts of the city, which is under contract to be ready for effective use early in the spring of 1916. Montreal water will then rank among the purest and best of waters supplied to American cities. Montreal has an excellent street railway; its parks are numerous; the largest, comprising over three hundred acres, occupies the greater portion of the sides and top of the mountain and is well laid out with carriage drives and bridle and foot-paths.

Montreal is one of the most important educational centers in Canada; it possesses two well-equipped universities: one English, which is Protestant but undenominational, the other French and under the control of the Roman Catholic Church. There are also numerous public and private schools, in both languages, of a high order of excellence. There are public libraries, an art gallery, and several very fine private collections of paintings.

The flora of the district is a very rich one and comprises not less than one thousand species of flowering plants. Several kinds of elm, maple, ash, and birch flourish in the district; also the oak, beech, butternut, poplar, willow, and lime trees.

The St. Lawrence River runs in a northeasterly direction through a broad alluvial plain, bounded on the north by the Laurentides, a range of undulating hills from one to two thousand feet high, composed chiefly of metamorphic rocks and holding in their valleys numberless small lakes and watercourses. Bounding this plain on the south are the northern spurs of the Adirondacks, the Green Mountains, and the Appalachians. Toward the center of it rise several isolated hills of volcanic origin from five hundred to eight hundred feet high, composed chiefly of trap rock, their sides and summits for the most part well wooded. Four miles above Montreal the river tumbles in a series of small cataracts over a rocky ledge forming the "Lachine Rapids," and still farther up, at a distance of about nine miles, it widens into Lake St. Louis, six miles broad.

In Montreal and its neighborhood winter as a rule is most enjoyable and healthful. Snow falls about the latter half of November, and generally remains until the later weeks of March; only occasionally during all these months does a thaw occur for a few days. The air is dry and cold, but the cold is rarely extreme, and, owing to the dryness of the air, is quite endurable. The sunshine is bright, and there is an absence of high winds. During the bright and starlit nights outdoor sports of all kinds may be enjoyed; of these the most notable are sleighing, snow-shoeing, skating, skiing, and tobogganing. In spring the melting snow in the streets, with the accumulated dirt of the winter, is apt to render the last two weeks in March and the first two weeks in April decidedly insalubrious. Bright, warm weather generally sets in with the first

TEN YEARS (1885–94) MEANS OF BI-HOURLY TEMPERATURES AT MONTREAL. (DEGREES FAHRENHEIT.)

Month.	1 A.M.	3 A.M.	5 A.M.	7 A.M.	9 A.M.	11 A.M.	1 P.M.	3 P.M.	5 P.M.	7 P.M.	9 P.M.	11 P.M.	Means.
January	11.34	10.59	9.76	9.53	10.41	12.88	14.37	14.95	13.92	13.5	12.69	12.13	12.17
February	12.21	11.46	10.49	9.95	11.82	14.60	16.24	17.01	15.85	14.86	14.16	13.45	13.51
March	22.39	21.41	20.09	20.36	23.08	25.98	27.76	28.42	27.55	25.83	24.68	23.81	24.28
April	36.78	35.46	34.14	36.38	39.86	43.32	45.47	46.27	45.65	42.31	40.25	38.73	40.39
May	50.66	49.12	47.73	51.08	55.29	58.76	61.41	62.33	61.22	57.55	54.77	52.81	55.23
June	60.69	59.4	58.64	62.26	65.82	69.13	71.21	71.80	70.31	66.86	63.89	62.23	65.19
July	64.25	62.82	62.11	65.69	69.65	73.07	75.04	75.75	74.02	70.25	67.42	65.83	68.83
August	61.44	60.32	59.44	62.02	66.22	69.75	71.78	72.09	70.39	66.30	63.90	62.53	65.52
September	54.48	53.46	52.77	54.04	58.25	61.91	63.78	64.29	62.53	58.68	56.93	55.52	58.05
October	43.00	42.16	41.65	41.69	44.98	48.20	49.72	49.94	48.10	45.77	44.43	43.50	45.26
November	31.95	31.49	31.03	30.77	32.44	34.64	35.64	35.56	34.28	33.37	32.54	31.88	32.97
December	18.64	18.31	17.37	16.83	17.73	19.71	20.73	21.02	19.96	19.61	19.12	18.77	18.98

MEAN FOR TEN YEARS, 1890–99.

Month.	Thermometer (Degrees Fahrenheit.) Maximum.	Minimum.	Mean daily average.	Mean relative humidity.	Per cent. possible bright sunshine.	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and melted snow.	Number of days on which rain and snow fell.	Number of days on which rain or snow fell.
January	42.37	−17.58	15.24	84.07	36.63	0.9	4.3	28.41	18.7	3.72	2.5	20.5
February	41.66	−13.02	15.03	82.97	43.27	0.69	3.2	23.52	15.1	2.98	1.9	16.9
March	46.60	− 1.29	13.96	77.81	47.99	1.53	7.6	18.94	11.7	3.68	3.2	16.1
April	70.70	17.05	16.96	67.16	51.78	1.7	11.4	3.56	3.7	2.05	1.4	14.2
May	80.49	33.97	18.25	68.14	49.59	2.98	16.6	.....	.....	2.98	.....	16.6
June	85.95	46.19	17.39	71.71	52.94	4.1	15.6	.....	.....	4.10	.....	15.6
July	88.54	50.56	17.06	72.59	59.96	3.94	17.6	.....	.....	3.94	.....	17.6
August	86.04	48.26	16.13	74.47	56.41	4.25	16.9	.....	.....	4.25	.....	16.9
September	82.21	37.43	15.8	76.94	53.15	3.14	14.8	.....	.....	3.14	.....	14.8
October	70.70	27.71	13.52	77.27	40.68	2.45	14.9	2.5	1.6	2.48	1.0	15.5
November	56.46	9.01	12.63	80.13	28.87	2.13	11.1	10.68	9.7	3.24	2.8	17.9
December	45.91	− 8.64	14.19	84.22	32.88	1.46	5.5	22.68	16.6	3.29	2.2	19.9

week of May. The summer is warm and dry, but showers are sufficiently frequent to maintain the general verdure. The heat of the day is followed by an evening and night always sufficiently cool to permit of restful sleep. The autumn is bright, cool, and invigorating. The accompanying tables present the average meteorological data for the past ten years.

Montreal has connections by rail with all the important points on the continent. Three transcontinental lines connect it directly with the Pacific Coast. It is the terminal port for the Government system of canals which allow passage for large steamers to the upper lakes. It is also the port of departure for the Canadian steamship service to Europe, and to the summer resorts on the lower St. Lawrence, the Gulf, the Lower Provinces, and Newfoundland.

ALEXANDER D. BLACKADER.

Montreux.—The village of Montreux, in the Canton de Vaud, Switzerland, lies at the northeast corner of the Lake of Geneva (Latitude 46° 25′ 59″ N., Longitude 6° 55′ E.), directly opposite the opening of the Rhone Valley. Beside Montreux proper some twenty other villages and hamlets, lying close together at this point, are included in the district, or parish, bearing the same name; and it is all these places taken collectively which constitute the health station of Montreux. Of the other villages comprised within the district, Les Bassets, Clarens, Vernex, Territet, and Chillon are perhaps those most widely known. Glion, 1,000 feet above Montreux, and Les Avants, about 2,000 feet above Montreux, are also well-known health stations. The elevation of Montreux itself above sea-level is 1,220 feet. Montreux proper is abundantly provided with hotels and pensions of every description—excellent shops—English physician and churches, and every convenience and luxury for a longer or shorter stay. The chief climatic characteristics of this district are its immunity from cold winds and the prevailing stillness of its atmosphere, both of which are due to the very exceptional degree of shelter afforded by the mountains which stand back of the district to the north and east. Montreux itself is the most sheltered of all the group of contiguous villages. "The indentation of the lake, which is here called the Bay of Montreux, is protected by the mountains around from the north and east winds, and in some degree from the northwest wind, so that it is said to be, with the exception of Bex, the most sheltered place in Switzerland. It is also the hottest of all the Swiss stations north of the Alps except Sion, but that applies only to the summer and spring, as Montreux is warmer than Sion in autumn and winter. The 'bise'—the cold northeast wind—is not nearly so much felt at Montreux as at Geneva and Morges; and it has been noticed, during the prevalence of a 'bise,' that it has been intensely cold at Geneva (temperature 14.3° F.) and at Morges (temperature 18° F.), while at Montreux (temperature 23.6° F.) the air has been almost calm and not disagreeably cold. There are also less variations of temperature at Montreux—a smaller range between the maxima and minima" (Dr. J. Burney Yeo, "Climate and Health Resorts"). To the "föhn" wind blowing up from the south, down the Rhone Valley, Montreux is much exposed. Dr. Yeo tells us that at Montreux "the air is very calm and still, the number of calm days reaching eighty-five to ninety per cent., whereas at Morges it only reaches thirty-three per cent., and it has been noticed that the lake is often calm from Vevey to Villeneuve, when it is agitated in the rest of its extent. But when the hot

wind blows from the south, the *föhn*, here called the *vaudaire*, . . . makes the bay of Montreux very rough." The winter temperature of Montreux is moderately cold. Dr. Kisch, in Eulenburg's "Reäl-Encyclopädie," gives the following figures for the mean temperature of each of the seven months from October to April: October, 50.9° F.; November, 41.2° F.; December, 36.5° F.; January, 33.4° F.; February, 39° F.; March, 41° F.; April, 50.7° F. The mean temperature at the hours of 7 A.M., 1 P.M., and 7 P.M., in each of the four seasons, and in each of the seven colder months of the year; the mean temperature of the winter, of the spring, and of the year; and the mean and absolute maximum and minimum temperatures, all of them derived from seven years of observation, are given by Dr. Yeo., and are quoted below:

	7 A.M.	1 P.M.	7 P.M.
	Degrees.	Degrees.	Degrees
October	47.0	56.6	49.0
November	38.7	47.5	41.0
December	34.3	41.5	35.9
January	31.8	39.7	33.9
February	35.0	44.0	38.1
March	37.0	45.2	39.7
April	46.0	57.6	50.4
Spring: March to May	46.6	56.4	49.4
Summer: June to August	61.7	72.7	63.7
Autumn: September to November	47.3	57.4	49.8
Winter: December to February	33.8	41.7	35.9

	Degrees.
Mean annual temperature	51.0
Mean winter temperature	36.5
Mean spring temperature	50.8
Mean maximum temperature (July)	77.0
Mean minimum temperature (January)	35.2
Absolute maximum temperature (July 8, 1870)	89.0
Absolute minimum temperature (February 12... 1865)	11.4

Dr. Kisch states that the nycthemeral range of temperature at Montreux varies from 12° C. to 16° C. (53.6° F. to 60.8° F.); but this statement is very surprising in view of the figures just quoted from Dr. Yeo. The mean annual rainfall is fifty inches; the number of rainy days in winter and spring is twenty-one, the total number of such days throughout the year being sixty (Dr. Yeo). Dr. Kisch puts the annual number of rainy days at seventy, and tells us that the mean relative humidity is 74.7 per cent.

Snow falls, of course, at Montreux, but how frequently and to what depth I do not know. In Flechsig's Bäder-Lexikon we are told that the snow melts rapidly, a thing which might readily have been inferred from the sheltered position of Montreux, freely exposed only to southerly and southwesterly winds. We are also told by the same authority that, despite the very considerable degree of winter cold and the occurrence of snow, there are, almost every winter, even in December and January, certain days during the warmer part of which an invalid can safely sit out in the open air for several hours.

As a rule, fogs occur but rarely during the winter season. What remains to be said respecting the climate cannot be better told than by direct quotation from Dr. Yeo's admirable work on "Climate and Health Resorts."

"In an average winter a good deal of cold weather must be expected at Montreux, as its mean winter and spring temperature is some 5° F. lower than that of Ventnor, and 4° F. lower than that of Torquay; but in favorable seasons, on the other hand, a good many bright, clear, sunny days may be expected, and comparatively few rainy ones. In November there are often a good many cold, damp, and disagreeable days.

"In spring the weather is often very variable. There are, perhaps, some very fine days, and then a sudden and unexpected return of cold, with rain or snow; so that invalids need to take great precautions at this season. Patients often ascend to Glion at this period of the year. Few people spend the summer at Montreux on account of the heat, but the autumn is a fine season up to the middle of October, when storms of rain frequently set in and there is occasionally a passing snowfall. It is in the autumn that the grape cure is in active progress at Montreux.

"It is an advantage at Montreux to have two mountain stations of different elevations, such as Glion and Les Avants, so readily accessible; for it does happen during some seasons that there is much more sunshine to be found at the higher resorts than at the lower one, and this fact is easily ascertainable.

"The winter and spring climate of Montreux, it will be seen, is by no means a perfect one; it has, however, been pointed out, as a kind of compensation, that the hotels and *pensions*, which abound here, are very comfortable, and that if the weather out of doors is bad, the invalid can find good shelter and protection indoors."

Despite its climatic inferiority in many respects to many more southerly health resorts, the general excellence of its hotels and *pensions*, the moderate cost of living, and the facilities for good schooling which there exist, combine to render Montreux an attractive place of winter residence to many families; and to these attractions must be added the surpassing beauty of the scenery. The view of the Savoy Alps, which rise like a wall on the opposite side of the lake, and of the grand, snow-crowned peaks which hem in the Rhone Valley, must be seen to be adequately appreciated.

Climatotherapy.—Dr. Yeo tells us that prolonged residence at Montreux is said to be serviceable in "cases of simple chronic laryngitis, of chronic laryngo-pharyngitis, of granular pharynx;" and that "all these chronic throat affections have a good chance of cure at Montreux, especially if they are, at the same time, submitted to local treatment by inhalation," etc. He includes in his list of cases, said to be benefited by prolonged sojourn at Montreux, "cases of recurrent bronchial catarrh or tendency to catarrh, as well as cases of chronic bronchial catarrh when not too inveterate or severe; persons with hereditary predisposition to pulmonary tuberculosis when the general health and strength are otherwise good and there is an absence of fever; cases of chronic pleurisy with suspicion of the commencement of tuberculosis, as well as cases of chronic empyema healing slowly; cases of cardiac valvular disease of rheumatic origin, to ward off bronchial catarrh and fresh rheumatic attacks, also cardiac neuroses, especially if induced by excess of tobacco-smoking." The "grape cure" is practical at Montreux beginning the end of September and lasting a month.

Les Avants and Glion.—These two resorts are in such close proximity to Montreux that mention may be made of them in this connection. Les Avants is 3,230 feet above sea-level, and is reached from Montreux by an excellent electric railway, and also from Spiez on Lake Thun via Zweisimmen. It is both a summer and a winter climatic station. The plateau upon which this resort stands is sheltered from the north and east by mountains, which are well wooded, and is open to the south. The climate is a mild, slightly tonic, mountain one. "The air is pure and free from dust; the heat is modified in summer by the woods and the lakes, and in winter the sun is very powerful, and the sky almost free from cloud." . . . "Great and frequent changes of temperature are, however, of not infrequent occurrence, and prove very trying to consumptive patients" (Loetscher, "Handbook to the Health resorts of Switzerland").

It snows about twenty-eight days in winter, the sky is overcast forty-seven days and quite clear during sixty-seven. The air is very dry. The meteorological data given under Montreux are applicable to Les Avants, allowance being made for the difference in elevation. The snow generally disappears by the middle of March, and by April the vegetation is well advanced. By May the flowers are in the meadows. For such cases as require a milder climate and lower elevation than the higher Alpine resorts, such as Davos, St. Moritz, Arosa, Leysin, etc., Les Avants can be recommended. The "Grand Hôtel des Avants" affords excellent accommodations. The cases to which this climate is applicable are incipient pulmonary tuberculosis without active symptoms, in individuals of good general health; although from a recent visit the writer found that consumptives were not desired at Les Avants and this resort was principally visited for the winter sports; bronchitis with scanty expectoration, tardy convalescence from pleurisy and pneumonia asthma of a neurotic origin; anemia, chlorosis, and scrofula.

Glion, 2,300 feet high, is reached by a cable railway from Montreux in nineteen minutes. It is situated on a mountain spur, affording from its Rigi-like terrace "a magnificent view, surpassing in extent all others on the bay." It is well protected from the north and east winds, and enjoys a comparatively mild winter; hence it is adapted for a winter-cure station of moderate elevation, although it is most frequented in spring, summer, and autumn.

Like Montreux it has a milk and grape cure, as well as a Terrain cure. It is known for the purity and dryness of its air and its equable temperature. In the height of summer it is a very popular resort for visitors from Montreux. The climate of Glion is suitable for much the same class of cases as that of Les Avants. It is especially recommended for nervous patients, convalescents the early cases of pulmonary tuberculosis, and weakly children. There are a number of good hotels and pensions, and during the summer there is an English church service.

Still higher than these two resorts is the Grand Hôtel de Caux (3,610 feet), open all the year round, less sheltered than Les Avants. (The mean annual temperature is 43° F., and relative humidity 55. Fog and mist are rare and as in the other altitude resorts one can sit out in the sun in the depth of winter.)

EDWARD O. OTIS.

Montvale Springs.—Blount County, Tennessee.

POST-OFFICE.—Montvale. Hotel and cottages.

ACCESS.—From Knoxville via Knoxville and Augusta Railroad, to Maryville, the present terminus of the line, thence nine miles over new pike by carriage or automobile to springs. The springs are twenty-five miles south of Knoxville. This resort is located at the foot of the Chilhowee Mountains, 1,500 feet above the sea-level. The springs have been celebrated in East Tennessee for a period of fifty years or more, and long before the Civil War the location was a fashionable summer resort, where people of this and other States found health and pleasure during the heated term. From year to year extensive improvements have been made, and now we find among the picturesque mountains a watering place supplying about everything which goes to make up a healthful and agreeable refuge from the summer heat of the semi-tropical Southern States. The big hotel building, with its seven gables, is located in a romantic spot, and around it cluster thirty neat cottages, giving the place the appearance of a charming little village built among the forest trees. Walks, fountains, beautiful brooks, and flowers are found on every side, and with the evergreen mountains for a background form a picture of great loveliness. Fronting the hotel is a large park, with broad, smooth drives and walks, and grassy lawns, affording ample scope for outdoor diversions. Fountains, swings, hammocks, and rustic retreats are scattered here and there. The table offers the best of fresh vegetables and poultry. Electricity is used for lighting the hotel and grounds. The hotel is supplied by a system of water-works from a fine free-stone spring halfway up the mountain, the "Sweet William's Spring." The medicinal springs are the "Great Chalybeate" Spring, nearest the hotel, and the "Black Sulphur" Spring, on the road near Montvale. The following analysis of the Chalybeate Spring was made by Prof. S. B. Mitchell:

ONE PINT CONTAINS:

	Grains.
Ferrous carbonate	0.300
Calcium carbonate	1.657
Sodium chloride	0.245
Magnesia chloride	Traces.
Calcium chloride	Traces.
Sodium sulphate	0.564
Magnesium sulphate	1.500
Calcium sulphate	9.276
Ferric oxide	Trace
Alumina	0.062
Silica	Traces.
Total	13.604

In addition to its ferruginous tonic effects this water also acts as a saline aperient. It has long been recommended as a safe and reliable remedy for many of the protean ills included under the name of dyspepsia. It is also valuable in the uric-acid diathesis, especially in those conditions characterized by genito-urinary manifestations. The Black Sulphur Spring contains 109.30 grains of solids to the United States gallon, of which the sulphate of magnesia (grains 17.07) and the oxide of iron (grains 1.19) are the most important.

EMMA E. WALKER.

Moonseed, Canadian.—See *Menispermum.*

Mooren, Albert.—Born at Oedt, Germany, July 26, 1828. He studied medicine at Bonn and at Berlin, and received his doctor's degree from the University of the latter city in 1854. It was through the influence of Albrecht von Graefe that he was led to devote himself to ophthalmology. During the first seven years of his career as a specialist he practised in his native town, and then (1862) he accepted an invitation to be at the head of the Düsseldorf Ophthalmic Clinic. In 1883 he resigned this position, and devoted himself exclusively to private practice. Rodent ulcer of the cornea, first described by the subject of this sketch, is commonly known as Mooren's ulcer. He died December 31, 1899.

Mooren was highly esteemed throughout Europe as an exceptionally skilled ophthalmic surgeon. His records show that he performed more than 25,000 operations. On the celebration of his seventieth birthday the title of Honorary Citizen of the City of Düsseldorf was conferred upon him; he had already, before that date, received that of Geheimer Medicinal Rat. Of his published writings the following deserve to receive special mention: "Ueber Rotinitis pigmentosa," Düsseldorf, 1858 (also an English translation); "Die verminderten Gefahren einer Hornhautvereiterung bei der Staarextraction," Berlin, 1862; "Ueber sympathische Gesichtsstörungen," Berlin, 1869; "Die Indicationen der Cataractdiscission," 1893; and "Die operativen Behandlung der natürlich und künstlich gereiften Staarformen," 1894.

A. H. B.

Morbidity.—See *Vital Statistics.*

Morgagni, Giovanni Battista.—Born at Forli, Italy, February 25, 1682. Great pains were taken with his general education, and, as a result, he was found—already at the early age of fourteen—to have acquired such an extensive and profound knowledge of literature that the Academy of Forli did not hesitate to elect him to full membership. In 1701 he received the degree of Doctor of Medicine from the University of Bologna. When Valsalva left the latter city for Parma, Morgagni took his place as Demonstrator of Anatomy; and he performed the duties of the position with such distinction that he soon acquired the reputation of being one of the first anatomists of Europe—a reputation which was doubtless greatly enhanced by the publication, at about this time, of Part I of his "Adversaria Anatomica." After the lapse of several years Morgagni left Bologna and settled first at Padua and then at Venice. But, a few years later still, he removed to Forli, his native town, and began there

Fig. 4012.—Giovanni Battista Morgagni.

the practice of his profession. His success as a practitioner was very pronounced; but it was because of this very success, which wearied him greatly and left him no time for other work, that he was led to accept (1712) a call from the University of Padua to occupy the Chair of the Theory of Medicine—a chair which he soon exchanged for that of Anatomy. For nearly sixty years Morgagni, by reason of the profoundness and great variety of the knowledge which he possessed, and by reason of his remarkable gift of imparting this knowledge to others, surrounded the University of Padua with a halo of glory. Among the different writings which he published during this period, there was one which, by itself alone, might well suffice to perpetuate his name for all time—viz., his book entitled "De sedibus et causis morborum per anatomen indagatis," published at Venice in 1762. Morgagni died Dec. 6, 1771, in the ninetieth year of his life. A score or more of anatomical terms are associated with the name Morgagni.

A. H. B.

Morgan, John.—Born in Philadelphia, Pa., in 1736 He was apprenticed to Dr. Redman, one of the leading physicians of Philadelphia during the middle period of the eighteenth century. Upon the expiration of the term of his apprenticeship he devoted himself for four years to the duties of a military surgeon, and thus gained considerable knowledge from handling diseases of every sort. Then, during the following five years, he resided in London, where he became familiar with the teachings and practice of some of the best medical authorities in that great city—men like the Hunters and Hewson. In 1763 he received the degree of Doctor of Medicine from the University of Edinburgh. From England he went to Italy, and visited Morgagni at Padua. Upon his return to this country Dr. Morgan urged the idea of establishing a medical school in connection with the College of Philadelphia, and he had the great satisfaction of witnessing the realization of this idea. On May 3, 1765, the first medical professorship in America was established and Dr. Morgan was elected to fill the new Chair of "Theory and Practice of Physic." In October, 1775, he was appointed by Congress Director-General of the military hospitals, and Physician-in-Chief of the American Army; and he immediately joined General Washington in Cambridge, Massachusetts. He did his best to restore order and efficiency to the management of the hospitals and to put competent and trustworthy medical men in the places of those who had brought conditions to such a state that Washington described them to be "a disgrace to the profession, the army and to society." Such a course soon led, as often happens under such circumstances, to active hostilities on the part of those whose anger he had aroused by his attempts at reform, and on January 9, 1777, he was dismissed by Congress without reason. Some time afterward, however, a committee of that body investigated his conduct and honorably acquitted him. Morgan died at the comparatively early age of fifty-four years.

Benjamin Rush, who was the successor of Morgan in the Medical College says: "His memory was extensive and accurate; he was intimately acquainted with the Latin and Greek classics; had read much in medicine, and in all his pursuits he was persevering and indefatigable. I never knew a person who had been attended by him that did not speak of his sympathy and tenderness with gratitude and respect."

Shortly after these lines had been penned there was placed before us a printed "Appeal for a Monument in Honor of John Morgan, Founder of the First Medical School in the United States." In this document the statements are made that Morgan's remains lie buried within St. Peter's Church, Philadelphia, and that no monument marks the place. Then the appeal goes on to say: "Much has been done to commemorate the heroes of war, but to few men indeed does the country owe a heavier debt than to John Morgan, who is certainly the undisputed parent of our first medical school, and therefore of medical education throughout the country. It is hoped, therefore, that all medical institutions here and elsewhere may be in sympathy with this commemorative movement and unite with us in suitably marking the last resting-place of John Morgan, and erecting a monument in memory of his great services to the medical profession."

A. H. B.

Morphea.—(Gr. μὸρφή, form, shape.) *Synonyms:* Keloid of Addison; circumscribed scleroderma. A disease of the skin characterized by the presence of variously sized, round, oval, or band-like patches, violaceous, white, yellowish-white, or brown in color, situated on various parts of the cutaneous surface, without definite arrangement or, less frequently, distributed along the course of some nerve. These patches vary in size from a small pea to the palm of the hand and even larger, are sharply circumscribed, and are usually surrounded by a pink or lilac-colored border, of variable width, which is composed of minute blood-vessels. They may project slightly above the surrounding normal skin or be on a level with it; they are firm and inelastic to the touch, smooth, and shining, presenting an appearance, when the patches are white, which has been aptly compared to old ivory. In patches which have existed for some time there may be moderate scaling, or the center may be occupied by a number of small pit-like depressions looking like the dilated mouths of the ducts of sebaceous glands, with which, however, they have no connection. The number of lesions present varies from a single one to a half dozen or more, but is rarely considerable. While

no part of the skin is exempt, the disease shows a predilection for certain regions, the parts most commonly affected being the face, the breasts in women, the arms, and the thighs. When the lesions assume a zosteriform arrangement they occur most frequently over the branches of the fifth pair, in the course of some of the branches of the brachial plexus, over the intercostals, or down the thigh. As a rule, subjective symptoms are rarely marked and are often entirely wanting. There may be slight itching, tingling or burning, and in a small number of cases more or less severe neuralgic pains. The affection, which in recent years has been described under the name "White Spot Disease," and which is characterized by a variable number of chalk-white, pea-sized, occasionally larger, patches, situated usually on the chest, neck and back, is probably nothing more than a variety of morphea.

The malady is a chronic one and its course is apt to be extremely irregular. After gradually increasing in size for a time the patches may remain unchanged for months or years, and then slowly and almost imperceptibly the skin may resume its normal condition. On the other hand, the skin may become thin, shrivelled, and scaling, adherent to the parts beneath, assuming, particularly in the case of the band-like patches, the appearance of deep scars. When such an atrophic process occurs in patches situated in the neighborhood of joints motion may be more or less seriously interfered with.

Morphea is seen much more frequently in women than in men. Age is apparently without influence. Long-continued irritation of the skin, such as may result from the pressure of a garter or the rubbing of the stays, a blow, or an injury to a nerve, have seemed to be the exciting cause in some cases. In the great majority of cases, however, no satisfactory explanation of the occurrence of the disease can be given.

Pathology.—Although the exact nature of the malady is not yet definitely determined, there is much in favor of the view that it is a trophoneurosis. Its frequent occurrence in neurotic subjects, the arrangement of the patches over the course of some nerve, and the neuralgic pains which accompany it in a certain proportion of cases are some of the features which lend probability to the neurotic theory of its origin.

The tissue changes characteristic of the affection are found almost exclusively in the corium, the epidermis being little if at all affected. The papillary layer is markedly flattened, and its blood-vessels are greatly narrowed and even in places obliterated. About the vessels of the deeper parts of the corium there is a round-cell exudate which produces narrowing of their lumen and occasional thrombosis. According to Unna the elastic fibers are unchanged, but there is an hypertrophy of the collagenous tissues. About the margins of the sclerosed areas there are numerous dilated vessels—the result of a collateral hyperemia—which give rise to the peculiar lilac-colored border about the patches. The sebaceous and sweat glands are more or less atrophied, the result of the pressure from the hypertrophied fibrous tissues.

Diagnosis.—Well-developed morphea presents such marked and peculiar features that there is seldom any difficulty in its diagnosis. The smooth, ivory-like patches surrounded by a violet border are quite unlike any other disease of the skin.

In the white patches of vitiligo, which only remotely resemble those of morphea, there is simple loss of pigment without any structural alteration of the skin.

Prognosis.—In cases of moderate extent and severity the prognosis is usually fairly favorable. In the majority of cases, after a duration of some months, or it may be two or three years, the skin gradually resumes its normal aspect. When, however, marked atrophy has taken place with adhesion to the deeper structures, forming scar-like patches, the prognosis is extremely unfavorable.

Treatment.—Treatment is rather unsatisfactory. Internally such remedies as cod-liver oil, arsenic, quinine, and iron may be administered with the view of improving the patient's general health. Thyroid extract has been given with asserted good results in a small number of cases. Locally, frictions with bland oils and fats are useful, and so also are mild galvanic currents applied, as Crocker suggests, in the neighborhood of, rather than directly to, the patches, to avoid any possible irritant effect. Brocq recommends electrolysis, employed as in the removal of hairs. The needle should be inserted in every portion of the patch, the current used varying from eight to fifteen milliampères, and the needle should be allowed to remain fifteen seconds at each puncture. Between the sittings mercurial plaster is to be applied. Hebra has obtained good results from intramuscular injections of a fifteen-per cent. alcoholic solution of thiosinamin, half a Pravaz syringeful of the solution being injected every second day. The *x*-rays occasionally produces excellent results and should always be tried, care being taken, of course, not to produce a dermatitis.

Milton B. Hartzell.

Morphine.—*Morphina* ($C_{17}H_{19}NO_3 + H_2O$ = 302.34). An alkaloid obtained from opium.

Origin.—Morphine is of great interest as being the first alkaloid ever discovered and probably of more medicinal importance than any other article of the materia medica. Its origin and occurrence are fully discussed under the title *Opium*. Its occurrence in the vegetable kingdom elsewhere than in the poppy capsule is not positively proven, but it is probable that it exists in minute amount in the milk juice of Argemone. Its preparation consists essentially in repeated macerations of the opium in distilled water, by which the morphine salts are dissolved out, filtering the solution, and adding alcohol and ammonia water, by which latter the salts are decomposed and the morphine is precipitated. The resulting crystals contain more or less impurities, consisting of other alkaloids, coloring matter, etc., and require repeated purification processes.

Description and Tests.—Colorless or white, shining, prismatic crystals, or fine needles, or a crystalline powder, odorless, and having a bitter taste; permanent in the air. It loses all its water of crystallization at 100° C. (212° F.).

When heated to about 200° C. (392° F.) it assumes a brown color, and then melts at 254° C. (489.2° F.). Upon ignition, it is slowly consumed without leaving a residue.

Its aqueous solution shows an alkaline reaction to red litmus paper.

Sulphuric acid (free from nitrous compounds) added to morphine produces no color or only a slight yellowish tint, but on heating, a brown color is developed.

Sulphuric acid containing a crystal of potassium iodate gives with morphine a dark brown color. (*Codeine* yields a moss-green color, changing to brown, and *narcotine* a cherry-red color.)

Sulphuric acid containing a trace of selenous acid gives with morphine a blue color, changing to green and then to brown. (*Codeine* yields a green color, changing to blue, and afterward to grass green; *narcotine* gives a green color, changing to brown, and then to cherry red.)

Nitric acid produces with morphine an orange-red color fading to yellow (difference from *quinine*). Sulphuric acid containing a trace of molybdic acid gives a purple color, changing to blue. Sulphuric acid containing in each cubic centimeter one drop of solution of formaldehyde yields an intense purple color.

Mercuric potassium iodide T. S. produces in a solution of morphine a white gelatinous precipitate.

A solution of sodium phosphomolybdate (1 in 20) produces in solutions of morphine a yellow precipitate soluble in ammonia water.

Sulphuric acid containing a crystal of potassium dichromate gives no color at first, but after a time a green color (absence of *strychnine*, which yields a purple color, or of *acetanilide*, which gives a crimson color, changing to green).

Morphine solutions, when heated with an aqueous solution of potassium ferricyanide containing a drop of neutral ferric chloride solution, give a deep blue solution, from which, after standing, a blue precipitate separates (difference from *codeine*).

If 0.1 gram of morphine be dissolved in 10 c.c. of diluted hydrochloric acid, no red coloration should be produced by the addition of a few drops of ferric chloride T. S. (absence of *meconic acid* or *meconates*).

If to a neutral solution of morphine (1 in 100), made by the careful addition of diluted sulphuric acid, a few drops of ferric chloride T. S. be added, a blue color will be produced, which is destroyed by acids, alcohol, or by heating.

On adding 4 c.c. of potassium hydroxide T. S. to 0.2 gram of morphine, a clear, colorless solution, free from any undissolved residue, should result (absence of, and difference from, various *other alkaloids*), and no odor of ammonia should be noticeable (absence of *ammonium salts*).

Actions and Uses.—In a general and brief way, morphine may be described as the typical somnifacient and general analgesic, with moderate locally analgesic powers also, a depressor of the motor spinal centers, an inhibitor of the pulse, a paralyzer of the respiration, a mild antipyretic, and an inhibitor of general metabolism and of all secretions and excretions excepting the perspiration. The ordinary effects upon man are as follows, and occur in nine-tenths or more of those who take it: A short spell of conscious comfort and good feeling; freedom of thought; bodily and mental calm; a warm, pleasant, slightly numb feeling, especially in the finger tips and toes; absence of hunger; slight dizziness and absent-mindedness; dryish tongue; indifference to slight annoyances and discomforts; diminished pupils; sleepiness, and, if yielded to, sleep. Upon waking, if the dose is an ordinary medical one, more or less uncomfortableness, slight nausea or aversion to food, dry tongue, and the omission of the next regular stool. There is probably an undercurrent of each of the other classes of effects in every case, but in a typical one like the above they are so entirely overshadowed by the brain stupor as to be unnoticeable.

The specific effects of morphine may be described as follows:

Absorption, Circulation, and Elimination.—Morphine is readily absorbed from the stomach, slightly less quickly from the rectum, more slowly from the vagina, very little from the skin, and almost not at all from the bladder. From the air passages, administered in spray or powder, enough is absorbed for local effect, and but little more; from abraded surfaces and granulations absorption is irregular, and may be too little to be of any benefit, or, on the other hand, too much for safety. From subcutaneous injections it is diffused with great regularity and effectiveness. In man, the usual time of absorption of a medicinal dose is as follows: By the stomach, empty or in active condition, the first symptoms appear in fifteen or twenty minutes, the full effect in, say, an hour; by the rectum, one must allow from one and one-half to twice as long, and about one-third larger dose for the same results; by the vagina, at least twice the time and twice the dose for any general effect; by the skin, only local results can be looked for. Hypodermatically, the first effects are generally felt in from three to five minutes, and the full influence in from fifteen to thirty. In the system it circulates as morphine, and a certain amount of it (what portion is not definitely known and probably varies under different conditions) is so eliminated. It is believed to be chiefly eliminated in the urine, as a result of which poisoning is readily induced when, for any reason, this channel of elimination is inactive. It is now known that much of it is excreted into the stomach and intestines, a varying portion of which is liable to be again absorbed. Advantage is taken of this fact, in opium poisoning, to destroy the morphine, by various methods, as the successive portions thus enter these organs. An appreciable amount is excreted by the liver and appears in the bile, and another small portion may make its appearance in the perspiration. In nursing mothers, morphine is very apt to make its appearance in the milk, and fatal cases of poisoning of infants have thus occurred. The question of the oxidation of morphine in the system, to any appreciable extent, is an open one, though this method of destruction in the stomach, in cases of poisoning, by the use of such agents as potassium permanganate, is thoroughly established. Owing to the action of the drug in checking those excretions upon which its elimination depends, poisoning is especially liable to result, through accumulation in the system, and this highly important fact should ever be borne in mind during its prolonged administration. The doses should not be brought so close together as to fail in affording sufficient time upon the one hand for elimination and upon the other for tolerance to be established.

Idiosyncrasy.—Great variation is observed among individuals as to the effects produced upon them by morphine. In almost all cases, except when large doses are introduced suddenly into the circulation, it is possible to observe a primary stage of excitation before that of depression comes on, and it is in this direction that the differences referred to are most plainly visible. In very sensitive subjects, or those in whom control is less perfect, this primary stage may border on intoxication, being accompanied by a mildly convulsive condition of the spinal centers. In the after-effects of the drug, idiosyncrasy again strongly asserts itself, one subject waking refreshed and with but slight disagreeable sensations, while another suffers from headache, nausea, and general malaise. Itching is a frequent symptom and becomes extreme in some individuals. Again, the intestinal effect differs greatly in different persons, differences which can be understood only through a knowledge of the mechanism of the action of the drug upon this part of the system.

The action of morphine in inducing constipation is the effect of depression of the motor functions; yet it is possible for large doses to paralyze the inhibitory power of the splanchnic nerves, thus permitting increased peristalsis, with a laxative result. Thus has been explained the effect of opium in overcoming the constipation of lead colic, in which condition such inhibition is excessive. The somnifacient effect of opium is to be explained by its direct depressing effect upon the centers, in which the order of effects proceeds regularly from the higher to the lower faculties. It is customary to think of the existence of a primary stage of stimulation as accounting for the early symptoms of exhilaration; but it is doubtful if this be not merely a manifestation of the first stage of depression, affecting the cerebral inhibitory powers. How morphine acts in inducing a powerful and extreme contraction of the pupil is uncertain. Most physiologists are inclined to charge it to stimulation; but it is more in line with its known effects in other directions to regard it as the result of inhibitory depression.

The primary cause of the diminished secretions resulting from the action of morphine is believed to be a depression of the secreting centers.

The action of morphine upon the circulation, and more especially upon the respiration, and in other ways than those mentioned above, is more conveniently considered in connection with the toxicology of the subject.

Therapeutical Uses.—Among all the uses of morphine that of relieving pain undoubtedly stands at the head. There is no form of pain which cannot be relieved or wholly removed by its use, nor in which it may not be employed, subject of course to special contraindications. In this line may be cited its use as an anodyne in relieving an irritable cough. Although the modern use of codeine, heroine, etc, has to a great extent taken its place, morphine is still largely used and is of great value in such cases. It also gives great relief in pleurisy, although its employment should here be accompanied by great caution since it favors the formation of adhesions. Many cases of vomiting are relieved by morphine, even when the seat of the irritation is not directly in the stomach.

Morphine is of the greatest value in the treatment of peritonitis and other abdominal inflammations, though opium is here to be preferred, as elsewhere stated.

It is frequently of great value in surgical operations, not only to relieve the patient and afford sleep after the operation, but, with or without other anesthetics, to deaden sensation as a preliminary thereto.

As a diaphoretic morphine is not a good agent, opium, especially in connection with other drugs, being preferable.

Morphine is a valuable supporter of the system, both in acute cases in overcoming shock, and in the exhaustion of disease, although its depressing effect upon the heart must here be reckoned with. Even in diseases of the heart itself, great benefit is sometimes to be derived through the rest afforded.

Its use in insomnia is subject to the very great risk of establishing the opium habit. Even when the insomnia is but temporary, the exceedingly pleasant results are liable to lead to its use upon similar future occasions, and the temptation is most insidious.

Other uses of morphine, for which opium itself is more appropriate, will be considered under the latter title.

Compounds, Preparations, and Doses.—Morphine is rarely used in the pure state, since one may obtain numerous salts which are far more soluble and absorbable than itself. Its ordinary dose is gr. $\frac{1}{8}$ to $\frac{1}{4}$ (0.008 to 0.015). This dose, however, as well as those of its salts, is subject to a degree of variation scarcely equalled in any other drug. Children are far more susceptible than adults, women are distinctly more susceptible than men, and there is a great difference among the latter, depending upon temperament. The effect of the drug is directly counteracted by pain or excitement, and large quantities must frequently be given to overcome the former. Tolerance is quickly established, and under it, or under the influence of habit, the production of medicinal effects demands a great increase in the dose.

The acetate (*Morphinæ Acetas*—$C_{17}H_{19}NO_3C_2H_4O_2 + 3H_2O = 398.12$) is white or faintly yellowish, crystalline or powdery, has a faint odor of acetic acid and a bitter taste, is soluble in 2.25 parts of water, 21.6 of alcohol, and 480 of chloroform at 25° C. (77° F.). Upon exposure it gradually loses its acetic acid and becomes less soluble.

The hydrochlorate (*Morphinæ Hydrochloridum*—$C_{17}H_{19}NO_3HCl + 3H_2O = 374.63$) occurs in a white feathery silky mass of fine acicular crystals or in minute cubical crystals, which are bitter and permanent, soluble in 17.2 parts of water, 42 of alcohol, at 25° C. (77° F.) and very little in ether or water chloroform. It is neutral.

The sulphate (*Morphinæ Sulphas*—$[C_{17}H_{19}NO_3]_2 H_2SO_4 + 5H_2O = 756.38$) presents an appearance similar to that of the hydrochlorate, but dissolves in 15.3 parts of water and 465 of alcohol at the above-named temperature.

The doses of these salts are about the same as those of morphine, and they are, especially the acetate, because of its high solubility, readily available for hypodermatic use. The official preparations are wholly of the sulphate. The compound morphine powder or Tully's powder (*Pulvis Morphinæ Compositus*) has a strength of one part of the sulphate of morphine in sixty, the remainder being nineteen of camphor, twenty of powdered liquorice, and twenty of precipitated calcium carbonate. The dose is gr. v.–xv. (0.3–1.0). The troches of morphine and ipecac (*Trochisci Morphinæ et Ipecacuanhæ*) each contain 0.0016 gram. (gr. $\frac{1}{40}$) of morphine sulphate, with about three times as much powdered ipecac, mixed with sugar, mucilage of tragacanth, and a little oil of wintergreen to flavor. The dose is one to five troches. The *Liquor Morphinæ Sulphatis* is made by dissolving thirty-five grains of morphine sulphate in two fluidounces of alcohol and about six fluidounces of distilled water, so that it has a strength of about half a grain of morphine sulphate to the fluidram. The dose is fl. ʒ ss.–i. (2.0–4.0). Magendie's solution is somewhat similar, but contains sixteen grains of morphine sulphate to the fluidounce, or two grains to the fluidrachm, thus four times as strong as the last; the dose is ♏v. to xv. (0.3–1.0). There is still another Liquor Morphinæ Sulphatis, of an earlier pharmacopœia, containing one grain to the fluidounce. Because of these wide differences in strength, it is not advisable to prescribe this solution by name without specifying the strength.

HENRY H. RUSBY.

Mortality.—See *Vital Statistics.*

Morton, Samuel George.—Born in Philadelphia in January, 1799. Educated in the strictest school of the Quaker sect he began the study of medicine under Dr. Joseph Parrish. In March, 1820, he received his degree of Doctor of Medicine; and in the autumn of the same year he sailed for Europe, for the purpose of perfecting himself still further in medical knowledge. In 1823 the doctor's degree was conferred upon him by the University of Edinburgh. In 1824 he returned to Philadelphia and began at once the practice of his profession. In 1839 he was appointed Professor of Anatomy in the Pennsylvania College of Philadelphia, and he held this position until 1843. He died May 18, 1851.

Of Dr. Morton's contributions to medical science the following deserve to receive special mention: a paper on "Parasitic Worms," published in 1831; "Illustrations of Pulmonary Consumption," etc., 1834; an American edition of "Mackintosh's Principles of Pathology and Practice of Physic," 1835; and "An Illustrated System of Human Anatomy, Special, General, and Microscopic," 1839. Morton, however, owed his great reputation, not to the work which he did in the field of medicine, but rather to his attainments as a naturalist and to his ethnological researches. The latter are recorded in his "Crania Americana" (published in 1839) and "Crania Egyptiaca" (published in 1844). A. H. B.

Morton, William Thomas Green.—Born at Charlton, Mass., August 9, 1819. He was graduated from the Baltimore College of Dental Surgery and for some time practised dentistry in partnership with Dr. Horace Wells in Hartford. The latter had used nitrous oxide gas to prevent the pain of tooth extraction. Later, when Morton was practising by himself, he was advised by Dr. Charles Thomas Jackson, a chemist of Boston, to use sulphuric ether in place of nitrous oxide. This he did, and on September 30, 1846, administered it to one of his own patients and extracted a tooth without pain. On October 16

of the same year the substance was used for the first time in surgery, Dr. John C. Warren, Surgeon to the Massachusetts General Hospital, removing painlessly a small vascular tumor from the neck of a patient who was under its influence. The substance used was a mixture of sulphuric ether with aromatic oils which had been patented under the name of "letheon." Although this operation was entirely successful, "letheon"

Fig. 4013.—William Thomas Green Morton.

made little headway, surgeons being loath to employ a substance of unknown composition, until Morton stated that the active agent was simply sulphuric ether; then it quickly came into use in capital operations and the new era of surgical anesthesia began. Morton's claim to priority was disputed by Dr. Jackson, but the matter was adjudicated by the French Academy of Sciences which awarded a Monthyon prize of 2,500 francs to both Jackson and Morton, to the former for the discovery of the anesthetic properties of ether and to the latter for the practical application of this discovery in dentistry and surgery.

Dr. Morton died in New York City, July 15, 1868.

T. L. S.

Morvan's Disease.—See *Panaritium Analgesicum.*

Moschus.—Musk. "The dried secretion from the preputial follicles of *Moschus moschiferus* L., U. S. P. This little animal, the so-called musk-deer, is a slender-limbed, active, and very timid inhabitant of the mountain regions of Central and Northern Asia. In its general shape it resembles a young deer. It is sixty or eighty centimeters long (from two to three feet), from forty to sixty centimeters in height, with the rump higher than the shoulders, of a grayish or blackish-brown color, with long, slender ears, large dark eyes, and two long, curved tusks projecting downward from the upper jaw. The secreting organ containing musk is a large, simple sac, situated in the median line just beneath the skin of the abdomen, in front of the preputial canal (of the male; it does not exist in the female), with which its posterior wall is connected. It is of a round or oval, plano-convex shape, six or seven centimeters in its longest diameter, and one or two centimeters or more thick. Internally, it is incompletely divided by folds and partial partitions reflected from the wall. The orifice, often double, is situated over the middle portion of the sac, and is one or two millimeters in diameter. Its position is easily determined from the outside, because the hairs converge toward it and fairly grow within it. In the living animal the secretion contained in the gland is a soft solid, not much thicker than honey, of a brownish-red color, and of a most intense, offensive smell. As it dries it darkens, becomes greasily brittle, and less odorous.

The musk-deer is laboriously hunted in the central and northern provinces of China, in the countries to the north of India, and in Siberia—in short, over a very extensive portion of Central Asia—for its skin and musk glands. These "pods," as they are called, are cut out as soon as the animal is killed, and dried, often with the aid of artificial heat, when they are ready for the market. In this condition they are flattish, shrivelled pouches, covered on one side with hairy skin, in the center of which is the orifice; the other side has the black appearance of dried meat. As now usually marketed, they are prepared so as quite closely to resemble a large fowl's gizzard. The contents are dryish, crumbly, breaking as they are turned out into coarse fragments (called grains), of an almost black color and penetrating odor. The very high cost of musk has led to numerous ingenious methods of adulteration. Thus, stones and other heavy minerals, hair, dried blood, feces, etc., are sometimes introduced through the natural opening; occasionally, also, the sac is split and emptied, and then filled and dextrously sewed up again, with a mixture containing but little musk, or that of an inferior quality—Siberian musk, for example, instead of that from Tonquin. Or the musk itself, when sold in grains, may be tampered with in similar ways. Sometimes artificial pods are made and filled—the scrotum of some animal is used, or a bag is made entirely *de novo* from skin, with a bladder, or some other membrane, for the back. The geographical source is important in determining the quality of musk; that of China and its tributaries is the most fragrant and best. Its pods are rounder, of more uniform shape, and its grains more odorous and larger. That from the north of India comes in irregular sacs, and that from Siberia in larger and longer ones. The following are the characters of musk as given by the Pharmacopœia: "In irregular, crumbly, somewhat unctuous grains, dark reddish-brown, of a peculiar, penetrating, and persistent odor, and bitterish taste. It is contained in oval or roundish sacs, about one and a half to two inches (four to five centimeters) in diameter, on one side invested with a smoothish membrane, on the other side covered with stiff, appressed, grayish hairs, concentrically arranged around two orifices near the center. About ten per cent. of musk is soluble in alcohol, the tincture being light brownish-yellow, and on the addition of water becoming slightly turbid. About fifty per cent. of musk is soluble in water, the solution being deep brown, faintly acid, and strongly odorous.

When ignited with free access of air, musk gives off a peculiar, somewhat urinous odor, and leaves behind not more than eight per cent. of a grayish ash.

Composition.—Musk is a very complex substance, and consists chiefly of common animal tissues and secretions. The following synopsis is from Hager's "Pharmaceutische Praxis": *Fats, cholesterin, wax, biliary matters, mucus, albumin;* besides traces of *lactic, butyric, phosphatic, sulphuric,* etc., *acids;* traces also of *ammonia* and a *volatile oil.* The odorous principle has never been separated. It is supposed to be formed by the gradual decomposition of some of the other constituents.

Action and Use.—This substance was for centuries the leading antispasmodic, and was, during most of this time, much more highly esteemed in medicine than it is at present, and it was given for numerous diseases involving disturbance of the nervous or mental faculties—*e.g.* hysteria, epilepsy, mania, etc. In a similar manner several other odorous animal secretions—civet, castor, etc.—have been employed, but of them all, musk is by far the least disgusting. Its high cost and impressive odor made it well adapted to hysterical outbreaks, for the relief of which it undoubtedly has some real value. As it is, however, it acts in these cases merely as a palliative, and as

there are now a dozen or more remedies which are more certain and far cheaper (a single dose of musk, which might be repeated several times a day, costs two dollars or more), musk as a medicine may be considered as fairly out of use. It can, however, be given, if desired, in doses of about gr. xv. (1.0) in pill or emulsion. A tincture (*Tinctura Moschi*, U. S. P., strength one-tenth) is official and may be used, but is mostly employed as a basis of perfumery, where the persistent or "staying" qualities of musk make it of the greatest value.

The odor of musk is considerably diminished by fennel, ergot, tannin, sour fruit juices, and some other things. Mixed with sugar it keeps very well.

H. H. Rusby.

Von Mosetig-Moorhof, Albert.—Born at Trieste, Austria, January 26, 1838. He studied medicine in Vienna, received the degree of Doctor of Medicine in 1861, was made a *Privatdozent* in Surgery in 1866 and a First Surgeon (*Primarchirurg*) in 1871, and became Professor Extraordinary of Surgery in 1875. He held the position of Chief Surgeon in the following military campaigns: that of 1866, in Bohemia; the siege of Paris, in 1870–1871; the invasion of Bosnia, in 1878; and the Servo-Bulgarian war, in 1885. He died in 1907.

Of von Mosetig-Moorhof's published writings the following deserve to receive special mention: "Der Iodoformverband," in Volkmann's klin. Vorträge, No. 211; "Handbuch der chirurgischen Technik," Vienna, 1886 (fourth edition in 1899); "Vorlesungen über Kriegschirurgie," Vienna, 1887; and "Erste Hilfe bei plötzlichen Unglücksfällen," three successive editions.

A. H. B.

Mosquito.—Dipterous, or two-winged, insects which are of great medical importance because they carry diseases. The family *Anophelinæ* includes those that spread malarial fevers; certain species in this family also carry *Filaria*. The family Culicinæ contains the genera *Stegomyia* (yellow fever), *Culex* (dengue), and *Mansonia*. See *Insects, Poisonous*, and *Insect Carriers of Disease*.

A. S. P.

Moss, Iceland.—See *Cetraria*.

Moss, Irish.—See *Chondrus*.

Mosses.—(Class *Musci*.) The true mosses, while very ornamental, and of great biological and botanical interest, are insignificant from an economic standpoint, while to the Materia Medica they yield not one important substance. Some of them, like Sphagnum and Polytrichum, have, upon totally unscientific grounds, been used domestically in menstrual disorders. Others, like *Funaria hygrometrica* Hedw., have some reputation as expectorants, the effect probably depending chiefly upon the syrup used as a vehicle. Many have been very useful, in the absence of more refined agents, as substitutes for tow, oakum, and lint. *Chondrus* and *Cetraria*, much used under the titles of Irish and Iceland moss, respectively, are not of this class at all.

Henry H. Rusby.

Mott, Valentine.—Born in Glen Cove, Long Island, N. Y., August 20, 1785. He received the degree of M. D. from Columbia College in 1806, and afterward visited London and Edinburgh, for purposes of further study. While in the former city he was a pupil of Sir Astley Cooper, the famous English anatomist and surgeon. He returned to New York City in 1809, began the practice of his profession, and rapidly attained a reputation as a surgeon. In 1810 or 1811 he was made Professor of Surgery in Columbia College. In 1813 his connection with this institution was severed, and for several years he delivered lectures elsewhere. In 1835 he went to Europe and remained there until 1841. Upon his return to New York he was made Professor of Surgery and Relative Anatomy in the New York University Medical College, and he retained this position until 1850, when he made a third trip abroad. From 1852 until his death, which occurred April 26, 1865, he was Emeritus Professor, and lectured only occasionally to the classes.

Stone, in his "Biography of Eminent American Physicians and Surgeons" thus describes the more

Fig. 4014.—Valentine Mott.

striking qualities of Dr. Mott as a surgeon and the achievements which contributed most to the celebrity which he attained: "Dr. Mott early gained a world-wide reputation for boldness and originality as an operative surgeon. . . . When but thirty-three years of age, he was the first to place a ligature around the innominate artery for aneurysm of the right subclavian artery. The neighboring arteries became involved and the patient died from secondary hemorrhage, due to ulceration, on the twenty-third day. Dr. von Graefe, of Berlin, repeated the operation three years later, with the same result, and it was not until 1864 that Dr. Andrew W. Smyth performed it, and insured the recovery of the patient by tying also the common carotid and the vertebral arteries. . . . In 1827 he ligated the common iliac artery for a large aneurysm of the external iliac artery, placing the ligature within half an inch of the aorta. The artery had been secured once before for the arrest of hemorrhage, with a fatal result, but never for the cure of aneurysm. Another of his original operations was cutting out two inches of the deep jugular vein, which was imbedded in a tumor. He was also the first surgeon to tie both ends of that vein, and the first to close with fine ligatures longitudinal or transverse wounds in large veins, even when slices had been cut out. He tied the common carotid artery forty-six times. In 1828 he removed the right clavicle, on which a large sarcomatous tumor had formed that had contracted adhesions with important structures on every side. (This was not the first operation for the removal of the entire clavicle; Dr. Charles McCreary had performed the same operation in Hartford, Kentucky, in 1813.) . . . From an early period in his practice he was remarkably successful in rhinoplastic operations, and in many instances restored the form of cheeks and lips that had been badly mutilated through the excessive use of mercury. . . . He was the first to remove the lower jaw for necrosis. He was one of the foremost lithotomists of his day. . . . His amputations numbered nearly a thousand. It is said that Dr. Mott possessed all the qualifications for a great operator. . . . He could cut with one hand almost as well as with the other, and developed a dexterity in the use of the

knife that has never been surpassed. . . . Although the most intrepid operator of his age, performing, as said by Sir Astley Cooper, 'more of the great operations than any man living, or that ever did live,' yet he was a friend and advocate of conservative surgery, and never performed an operation without weighing the question of its necessity with much deliberation.

"His published papers on surgical topics number only twenty-five, though some of them are of great length, and illustrated with numerous engravings. It is said that literary composition was distasteful to him." A. H. B.

Mount Desert.—The island of Mount Desert, the largest one on the New England coast, lies off the coast of Maine, nearly midway between Portland and Eastport, about one hundred and ten miles east of Portland and forty miles southeast of Bangor. It is a very popular summer resort and has wide notoriety.

The island has an area of about one hundred square miles, and is fourteen miles long and eight miles wide at the widest part. A chain of mountain peaks extends across it from southeast to northwest, these peaks being separated from one another by deep gorges and ravines, which at several points descend below the level of the sea.

The average elevation above the sea-level is almost 500 feet, and Green Mountain, the highest point, is 1,527 feet in height. The coast line is bold and rocky and much indented. "Somes Sound," a fiord of the sea seven miles long, runs up to nearly the center of the island, cutting through the center of the mountain range. The various indentations, or bays, furnish many good harbors, such as Bass Harbor, Southwest Harbor, Northeast Harbor, Seal Harbor, and Bar Harbor—the finest of all, lying upon the broad Frenchman's Bay.

The island is well wooded with pine, balsam, and spruce, although numerous fires have made sad havoc with the forests. Inland, in the valleys and high up among the mountains, are many beautiful lakes and ponds, the most extensive being Eagle Lake at the foot of Green Mountain, Echo Lake, Jordan's Pond, and Long Pond.

Lying about Mount Desert are numerous smaller islands which are attractive and picturesque, the principal of which are the Porcupines at Bar Harbor, the Cranberry Islands, near Southwest Harbor, and Bear, Baker's, Duck, Greening's, and Sutton Islands. "The western sides of the mountain range slope gradually upward to the summits, but on the east they confront the ocean with a series of stupendous cliffs" ("Appleton's General Guide to the United States and Canada").

The island is of granite formation, exhibiting evidence of the great glacial movement; and the soil is dry and porous. On the northern side the mainland is separated from the island only by a narrow stream, and a bridge affords communication between the two. The scenery of the island is most attractive, varied, and grand, affording innumerable delightful excursions by land and by sea. Good roads and footpaths extend in every direction, and in the town of Eden alone there are 120 miles of excellent road. The reader is referred to the various guide books for an enumeration and description of the many excursions and various points of interest. Mount Desert has become such a popular resort that every facility is afforded the visitor for enjoying and exploring its beauties. Local steamers run from one point to another of the island; hotels and boarding-houses of various prices abound; and the island can be easily and comfortably reached either by rail or by boat from New York, Boston, and Portland.

Bar Harbor is the most frequented and fashionable resort, and the cottage life has quite supplanted that of hotels and boarding-houses. Here beautiful and luxurious cottages abound, and in the season the social life resembles that of New York or Philadelphia in winter.

Every kind of outdoor and indoor diversion is afforded. There are many clubs and churches of various denominations. The Kebo Valley Club offers opportunities for golf on its attractive grounds.

The water supply of Bar Harbor is taken from Eagle Lake, 240 feet above the village, and is abundant and pure. There is also an extensive and thorough system of sewerage. There are adequate protection against fire; many shops and good markets; excellent postal, telegraph, and telephone accommodations; two banks; a good police force; an intelligent and efficient board of health, and good medical service. The streets are lighted by electricity, which is also furnished to private residences.

Northeast Harbor and Seal Harbor are much frequented by "cottagers," and at the former is the attractive Episcopal Church founded by the late Bishop Doane of Albany. Southwest Harbor is beautifully situated at the entrance to Somes Sound, and is a favorite resort for those desiring a more quiet and simpler life. Indeed, almost any portion of the island has its especial attractions for the summer resident, and one can visit the island year after year and always find some new portion to explore. "On the coast of America it (Mount Desert) has no rival, except, perhaps, at the bay of Rio Janeiro" (Appleton, *loc. cit.*).

Through the kindness of William Miller, Esq., of Bar Harbor, who made the observations, and the chief weather forecaster at Boston who placed them at my disposal, the following compilation has been made of the climate of Mount Desert. In general it may be

Climate of Mount Desert Island, Maine, Latitude 44.38° N., Longitude 68.36° W., for the Years from 1896 to 1901. Observations of William Miller, Esq., of Bar Harbor.

Data.	January.	April.	June.	July.	August.	September.	October.	Year.
Temperature (degrees Fahrenheit)—								
Average or normal	21.08°	42.4°	59.48°	65.9°	64.9°	58.6°	48.5°	39.4°
Average range	19.3	21.7	22.8	22.2	22.2	22.0	21.3	
Mean of warmest	30.7	53.6	71.1	77.2	76.3	70.1	59.3	
Mean of coldest	11.4	31.9	48.3	55.0	54.1	48.1	38.0	
Highest or maximum	49.0	72.8	86.3	90.5	89.0	87.6	73.8	
Lowest or minimum	−11.5	18.6	37.8	45.0	43.8	33.2	24.4	
Precipitation—Average in inches	5.60	3.14	2.85	3.86	3.28	3.77	4.62	
Wind—Prevailing direction	N. W.	E.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.
Weather—								
Average number of clear days	11.2	15.1	16.5	18.3	17.6	15.3	14.3	
Average number of partly cloudy days	8.2	6.3	7.5	6.0	6.5	7.8	8.3	
Average number of clear and partly cloudy	19.4	21.4	24.0	24.3	24.1	23.1	22.6	

said that the summer climate is a cool, invigorating one, with a fair number of clear days and the average amount of rain for this latitude. Fogs are not infrequent and they sometimes last for several days or even a week.

There are no recorded observations of the humidity, but it cannot be very different from that of Eastport on the same coast, about eighty miles to the northeast. There the average relative humidity for July is 78.7 per cent.; August, 78.9 per cent., and for the year 76.3 per cent. The variations in temperature are considerable, and the air is apt to be chilly and damp. Such a climate would hardly be suitable for the delicate, for those who had a tendency to or were suffering from pulmonary or bronchial troubles, or from neuralgia. For any one who needs the influences of a bracing, cool, summer climate, or for a convalescent from any acute disease, who is well on the road to recovery, it can be recommended. It is also useful in some cases of neurasthenia and insomnia.

Some patients who are subject to hay fever find immunity on the island at one or the other harbors, especially at Northeast Harbor.

EDWARD O. OTIS.

Mountain Springs.—See *Ephrata Springs.*

Mouth, Abnormalities of the.—ASTOMIA.—This condition, absence of the mouth, is an exceptionally rare anomaly which is necessarily incompatible with life. It is due to a complete closure or coalescence of the embryonal fissures associated with the development of the face.

ATRESIA ORIS.—This term implies the presence of a mouth and its component parts but with no external opening. Delicate and well-planned surgery may

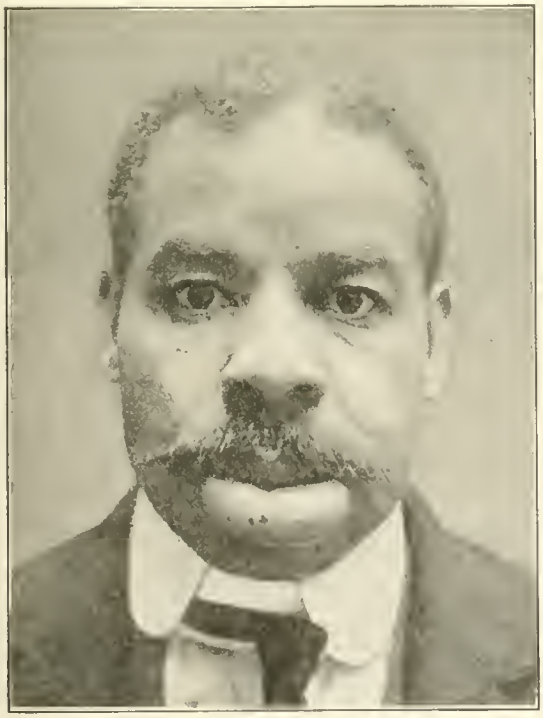


FIG. 4015.—Macrocheilia of Luetic Origin.

here ultimately produce an acceptable imitation of the lips by an eversion of the mucous membrane upon a denuded skin surface, but the initial step should be the establishment of an aperture for the entrance of food. Care must be exercised to maintain this opening until such time when the condition of the infant will permit of a more thorough plastic restoration of the lips.

MICROSTOMIA.—This is a condition bordering on atresia oris but where there is a small opening into the mouth usually insufficient for the infant to nurse. The opening should be enlarged to conform with a normal mouth for it will be found in most of these cases that the interior of the mouth is of usual size. The mucous membrane and cutaneous borders should be stitched together upon either side with a view to ultimate symmetry of the mouth opening.

MACROSTOMIA.—This term is applied to a marked deformity of the mouth more frequently affecting one side only, due to the non-closure of the fissure between the mandibular and maxillary processes or to the persistence of the lacrymal fissure. It should be surgically treated by paring and uniting the cleft sufficiently to reduce the oral aperture to normal size.

MACROCHEILIA denotes an abnormal or excessive size of one or both lips. Though this may be congenital, occurring as it sometimes does in association with cretinism, it is more often due to the presence of angiomata or lymphangiomata of the lip which though small at birth, later develop to considerable size. A luetic disturbance of the lymphatics of the lips is occasionally responsible in adults for a macrocheilia, which is sometimes designated elephantiasis of the lip. Operative measures are indicated in the angiomatous and lymphangiomatous enlargement of the lips and should be carried out as early in infancy as possible. Specific treatment is naturally called for in the syphilitic cases and the dosage of potassium iodide should be gradually increased up to its full tolerance. Definite improvement in these cases seldom results from medication alone owing to marked structural changes in the lymphatics, so that surgery may eventually have to be resorted to.

HARELIP AND CLEFT PALATE—These conditions are discussed, under their own titles in previous volumes of this HANDBOOK.

TONGUE-TIE.—By this term is denoted a partially immovable tongue caused by a congenital shortening of the frenum linguæ. The restricted movements of the tongue render suction difficult and may thus, at an early period, attract the attention of the mother, nurse, or physician. Some cases are not detected until the child is old enough to speak when an impediment in the speech is noticed. A routine examination of the mouth to determine whether the tongue can be protruded from the mouth would invariably disclose any shortening of the frenum. The treatment consists of grasping the tip of the tongue between the thumb and forefinger of the left hand, after applying a thin piece of gauze over the tongue to prevent its slipping. The tip of the tongue is then raised, placing the frenum upon the stretch so that it can be nicked with a pair of blunt-pointed scissors at or near its lower attachment. Finally, with the left hand curling the tip upward, the thumb of the right hand is pressed backward against the frenum causing it to tear until the tongue is given a normal amount of motion. Bleeding is never severe if ordinary care is exercised so as not to wound the ranine arteries.

MORRIS I. SCHAMBERG.

Mount Clemens Mineral Springs.—Macomb County, Michigan.

POST-OFFICE.—Mount Clemens. Hotels. Boarding-houses.

ACCESS.—From Detroit via the Grank Trunk Railroad, twenty miles northeast. The Rapid Railway

and the Lake Shore, electric roads, make regular stops every half hour.

The Clinton River, circling through the city affords fine boating, and Lake St. Clair, a link of the great chain of lakes, offers excellent fishing grounds. The steamer ride through the Government Canal past the "Flats," often called the "Venice of America" to Walpool Indian reservation and return is most enjoyable. Mount Clemens, known as the Bath City, has become a famous health and pleasure resort, and the hotels and bath-houses are open for the reception of guests and patients during the entire year. The expenses here may be made very moderate. The climate is delightful, the town being located on the Michigan peninsula. The summers are cool, while the winters are tempered by the open waters of Lake St. Clair. The town is supplied with artesian well water for drinking purposes. There is a resident population of 9,000, and a floating population that sometimes reaches 25,000.

The mineral waters here are classified as sulpho-bromo-iodo-salines. They do not flow from thermal springs, but they have a mean natural temperature of approximately 50° F. The wells are bored to a depth varying from 1,000 to 1,200 feet. The water is pumped to the surface and stored in high tanks. Thence it is piped to boilers and heated as desired. The number of gallons of water used in each bath is 65; the amount of mineral salts in one bath is 125 pounds, 5¾ ounces.

Following is the

Official Analysis of Mount Clemens Mineral Water.

Physical Character:	Temperature 13.61° C., or 56.5° F.	
	Reaction	Faintly alkaline.
	Specific gravity	1.116

Chemical Constituents.

Grains in one United States Gallon:

Hydrogen sulphide	8.53961
Hydrogen selenide	0.01047
Hydrogen telluride	0.01574
Carbonic acid, free	8.69022
Carbonic acid, half combined	1.86033
Calcium carbonate	3.83609
Magnesium carbonate	0.03557
Ferrous carbonate	0.34810
Cobaltous carbonate	0.06530
Calcium sulphate	91.09819
Calcium hyposulphite	7.86260
Sodium sulphite	40.64125
Sodium seleuite	0.31122
Sodium tellurite	0.33529
Sodium chloride	5,713.65182
Potassium chloride	463.91670
Lithium chloride	2.72483
Ammonium chloride	10.29402
Calcium chloride	4,678.80376
Magnesium chloride	2,406.75932
Magnesium iodide	0.85266
Magnesium bromide	71.10401
Strontium sulphate	0.75916
Sodium biborate	2.21372
Aluminum chloride	1.73764
Sodium silicate	0.85096
Sulphur, in suspension	0.41584
Ferrous sulphide in suspension	0.36261
Rubidium	Trace.
Cesium	Trace.
Total	13,518.09703

The baths are especially efficacious in rheumatic troubles, some extraordinary cures being recorded. Among other complaints that have been cured or relieved are neuralgia, neuritis, lead paralysis, writer's cramp, pseudotabes of alcoholics, hysteria, neurasthenia, progressive muscular atrophy, chlorosis, skin diseases, catarrhal conditions, autointoxication, gastrointestinal disorders, diseases of kidneys, and liver, diabetes, metal poisoning, and convalescence from wasting diseases. The waters are used commercially.

Emma E. Walker.

Mucilagines.—A mucilage (*mucilago*) is a thick, viscid product which results from treating a gum with water, hot or cold. Mucilages are not permanent, and should be made as required. There are four mucilages official in the United States Pharmacopœia, and two in the British Pharmacopœia; four are included in the National Formulary.

		Composition.
Mucilago Acaciæ (Mucilage of acacia).	U. S. P.	Acacia, 340; lime water 330; water, to make 1,000. Dose, 4 fl. drams.
Mucilago Acaciæ (Mucilage of gum acacia).	B. P.	Gum acacia, 4 ounces; distilled water, a sufficient quantity.
Mucilago Chondri (Mucilage of Irish moss).	N. F.	Irish moss, 30; water, to make 1,000.
Mucilago Cydonii (Mucilage of cydonium).	N. F.	Cydonium, 2; distilled water, 100.
Mucilago Dextrini (Mucilage of dextrin).	N. F.	Dextrin, 335; water, to make 1,000.
Mucilago Salep (Mucilage of salep).	N. F.	Salep, 10; cold water, 100; boiling water, 900.
Mucilago Sassafras Medullæ (Mucilage of sassafras pith).	U. S. P.	Sassafras pith, 2; water, 100. Dose, 4 fl. drams.
Mucilago Tragacanthæ (Mucilage of tragacanth).	U. S. P.	Tragacanth, 6; glycerin, 18; water, to make 100. Dose, 4 fl. drams.
Mucilago Tragacanthæ (Mucilage of tragacanth).	B. P.	Tragacanth, 60 grains; alcohol, 2 fl. drams; distilled water, a sufficient quantity.
Mucilago Ulmi (Mucilage of elm).	U. S. P.	Elm, 6; water, 100. Dose 4 fl. drams.

R. J. E. Scott.

Mucin is a member of the group of glycoproteins that is a compound made up of protein plus a carbohydrate group shown to be glucosamine. The mucins have variable properties among themselves and they have been divided into two groups, the true mucins and the mucoids. The true mucins are characterized by being soluble in dilute alkalies and by being precipitated by weak acetic acid. The mucoids fail to show these solubilities. True mucins are secreted by the larger mucous glands, by certain mucous membranes, and by the skin of snails and other animals. The mucins are acid in reaction. They yield the color reactions of the proteins.

F. P. U.

Mucoid Degeneration.—See *Degenerations and Deposits, Pathological.*

Mucoids.—Those non-phosphorized glycoproteins which are neither true mucins or chondroproteins are designated mucoids. To the mucoids belong pseudomucin, the body called colloid, ovomucoid, etc.

F. P. U.

Mucous Membranes.—Within the body proper are a number of recesses and tracts that communicate normally with the exterior; these are lined with epithelial cells that are supported in an especial manner constituting thus mucous membranes. These in themselves are quite extensive, but their area is greatly increased by offshoots in the form of *glands*, *ducts*, and *recesses*. These tracts are the *alimentary*, *respiratory*, and *genito-urinary systems*, *lacrymal apparatus*, and their connective glands and cavities. To any and all of these air has access. These all have their beginning or ending or both at the skin and the line of connection is usually sharply marked. The lining of each tract may differ somewhat from

that of the other, as their functions are not the same, but the general structure is identical in all cases.

These membranes are firmly attached to the underlying structures in certain regions, as in the nasal cavities and their accessory fossæ; in other regions as stomach, bladder, etc., the connection is rather loose permitting of considerable distention of these organs without injury to the lining. In some organs the mucous membrane is nearly even and regular in its course, as gland ducts; in others it is formed into finger-like projections called *villi*, as in the small intestines. In still others, it is thrown into extensive *folds*, as in the intestines, stomach, and bladder. By the formation of villi and folds the absorptive and secretive surfaces are enormously increased without a marked increase in the bulk of the organ.

Normally, mucous membranes are soft, opaque, or nearly so, slimy and easily torn by moderate force. Ordinarily they are of a pinkish color, but the depth of color depends upon the organ and its function. This color is due to the vascularity of the part and naturally where the membranes are thinner and the vascularity greater, the color will be deeper, as for instance in the stomach, pharynx, and rectum. The color is deeper in the fetus and infant than in the adult.

Structure.—A typical mucous membrane consists of four layers, (1) epithelium, (2) basement membrane, (3) tunica propria, (4) muscularis mucosæ.

The *epithelium* may be of any variety and will depend upon the function of the membrane. In such regions where protection alone is desired the epithelium is stratified squamous, transition, or stratified columnar. Where secretion and excretion are being carried on, the variety is simple columnar, cuboidal, or goblet. Where protection is desired and at the same time removal of minute foreign bodies entangled in mucus must be maintained, the variety is either simple, or stratified ciliated.

The *basement membrane* is not always demonstrable and when noticeable it is thin and apparently homogeneous. It usually consists of flattened cells that may form a continuous layer or be united to one another by protoplasmic processes making thus a sort of network.

The *tunica propria* consists of a delicate network of fibroelastic tissue that varies in different organs. In some structures (esophagus) the white fibrous tissue predominates and is more closely packed and therefore tougher. In other organs, as stomach and intestines, it is looser as glands and lymphoid tissue in great abundance are found here. It is this layer that supports the capillary blood-vessels, smaller lymph channels and the smaller nerve trunks and fibers. Here also are found, in certain organs, glands and lymphoid tissue. In the small intestine the tunica propria is thrown into an enormous number of small finger-like projections called *villi*. These consist of a central core of tunica propria covered by basement membrane and a single layer of tall columnar and goblet cells. These structures are of the greatest importance in absorption of the digested food products.

The *muscularis mucosæ* is not present in all mucous membranes. It consists of involuntary non-striated muscle tissue arranged in two layers. The fibers of the inner layer run transversely, while those of the outer layer run longitudinally. For a detailed description of the structure of mucous membranes and glands see the article *Epithelium*.

Functions.—The variety of epithelium that is found on a mucous membrane depends upon the function of the part. These functions may be classed as absorption, secretion, excretion, and protection.

Absorption.—As a result of the action of the digestive fluids, the food products ingested are converted into substances that are absorbable. As part of the digestive process is carried on in the stomach, it would naturally be supposed that the organ would absorb such products. This, however, is not the case, as the dextrose, levulose, peptones, soaps, fatty acids, glycerin, salts, etc., that result from gastrointestinal digestion are absorbed chiefly by the villi of the small intestine. These villi are minute finger-like projections of the mucosa of the small intestines and are covered by a single layer of columnar and a few goblet cells. By a "selective action" of these epithelial cells, water and inorganic salts are passed through them and ultimately reach the blood capillaries. All sugars, except possibly lactose, are converted into levulose or dextrose and as such are taken into the epithelial cells and transferred to the blood-vessels. Whatever the form in which carbohydrates are absorbed, they never leave the cells except in the form of dextrose or levulose. Proteins are converted into peptones by the digestive fluids and as such are absorbed by the epithelial cells of the villi. Native proteins are also absorbed by the mucosa of the large intestine. After absorption the epithelial cells of the villi convert these peptones into plasma-albumin and as such are given over to the blood-vessels. Recent investigation seems to point to the fact that the end products of protein digestion are not peptones, but less complex bodies, as polypeptids, peptids, and amido-acids. It is these simpler products that the epithelial cells convert into plasma-albumin and plasma-globulin. Fats are believed by some investigators to be converted into an emulsion during digestion and from this emulsion the fat globules are taken by the epithelial cells and passed through them to the lymph vessels. Others believe that as a result of digestion, fats are converted into soaps and glycerin. The epithelial cells take these and reconstruct fats within the cell body and the fat is then passed to the lymph vessels, where with the lymph it constitutes chyle. Experimentation seems to indicate that this latter is the real method of fat absorption.

Secretion.—The term secretion is applied to a fluid that is made by the vital activity of epithelial cells from the constituents of the lymph that surrounds them. This juice is used in the vital processes of the body. Such juices are the pancreatic and gastric, saliva, bile, etc., and the various internal secretions. These fluids are formed as the result of chemic changes within the cells. That the epithelial cells of the stomach give rise to an entirely different fluid from that of the liver or other glands and membranes is probably due to the difference in histologic and chemical structure. These epithelial cells are not active all the time, but discharge their secretions at periodic intervals and in between enjoy a period of rest and recuperation. During the inactive period, certain substances as mucin, glycerin, proteins, and antecedents of enzymes accumulate in the cell as a result of cellular activity, these substances constitute the secretion. At such times the blood supply is not great. During glandular activity, the organ becomes red, due to increased vascularity, and as a result a rapid transudation of water and salts into the lymph spaces occurs. As the water passes through the cells, the above-mentioned constituents are dissolved and ultimately discharged into the lumen of the organ. The changes taking place in the cells, vary according to the secretion and organs involved and are too detailed to be considered here.

The formation and discharge of secretions are controlled by the nerve system. These nerve centers may be excited by emotional states or by impressions upon the terminals, as, for instance, the flow of saliva is increased either by the presence of desirable food in the mouth, or the mere thought and odor of desirable food.

Excretions.—The formation and elimination of waste products which, if retained, would lead to injurious results, constitute excretion. These waste

products are emptied into the blood and are the result of the activity of the cells and tissues. Epithelial cells are the prime factors in excretion and are aided by osmosis and filtration. The chief excretions are the urine, perspiration, and bile. The urea and salts of the urine are not made by the kidneys, but merely eliminated by these organs. The epithelial cells of the kidney possess a selective power by means of which they take these substances from the blood and pass them toward the tubules. The liver does not make the cholesterin (the excrementitious part of the bile), but merely removes it from the blood and passes it into the intestines. The sweat glands merely remove a small amount of urea and certain inorganic salts, by selective action, and water from the blood as perspiration.

Protection.—In certain organs that do not secrete or excrete, a protective lining only is required, as in the mouth, pharynx, esophagus, bladder, ducts of glands, etc. The epithelial cells here are usually of the stratified squamous variety, though gland ducts have stratified columnar cells and the bladder and ureters transitional cells. The stratified squamous variety is adapted for protection as there are many layers of cells. In such organs very little distention occurs. The upper layers are flattened and overlap, while the superficial layers may even be keratinized or horny, thereby increasing greatly their protective ability. The bladder possesses transitional cells and these have the advantage here over stratified squamous cells in that the organ may become greatly distended under which conditions the cells then flatten to accommodate themselves to the increased surface. When the organ is empty they assume their natural shape. Stratified squamous cells would not react in this manner.

H. E. Radasch.

Mucous Membranes, Inflammations of.—The subject of inflammations of the mucous membranes is treated in this article in only a very general way. The specific inflammations (diphtheria, tuberculosis, syphilis, rhinoscleroma, gonorrhea, erysipelas, influenza) will be discussed under their respective heads; the object of this article being to include only the simple non-specific forms of inflammation of these structures according to the definition of inflammation as given by Ziegler—namely, a tissue lesion accompanied by circulatory disturbances, an exudate, and tendency toward repair.

Classification.—The factors which enter into inflammatory phenomena are the tissue lesion, circulatory disturbance, the exudate, and the tendency toward repair. Based upon this the following classification of inflammations of mucous membranes is offered.

Inflammations of Mucous Membranes.
- Acute
  - Catarrhal.
  - Mucopurulent.
  - Purulent.
  - Fibrinopurulent.
  - Fibrinous.
  - Hemorrhagic.
  - Gangrenous.
- Chronic.
  - Hypertrophic.
  - Atrophic.

According to the amount of the reaction on the part of the connective-tissue elements, the general division of inflammations into acute and chronic is made. The term acute is applied to those inflammations in which the fixed connective-tissue cells have not begun to show a reactive change other than the sudden defense needed to protect themselves from the injurious agents. No fibroblasts or angioblasts are seen in sections of such inflammatory processes.

According to the lesion and exudate which they show the acute inflammations of mucous membranes may be divided into catarrhal, mucopurulent, purulent, fibrinopurulent, fibrinous, hemorrhagic, and gangrenous.

Sooner or later, if the irritation causing the inflammation continues, the fixed connective-tissue cells, especially the endothelium, show a reactive change, and form a fibroblastic connective tissue, which later becomes firm scar tissue.

Chronic inflammations of mucous membranes are divided into *hypertrophic* and *atrophic*, depending upon the changes in the mucosæ themselves. Chronic hypertrophic inflammations are characterized by hypertrophy of the epithelial elements of the mucosæ such as occurs in chronic hypertrophic rhinitis or in chronic endometritis. In chronic atrophic inflammations, on the other hand, the glands and epithelial lining cells undergo atrophy such as occurs in chronic atrophic gastritis.

Acute Catarrhal Inflammation.—Any mucous membrane (mouth, nose, pharynx, larynx, etc.) may be the seat of a catarrhal inflammation. On macroscopical examination, the surface of the mucous membrane presents a shiny, glistening coating due to a thick, stringy, more or less homogeneous exudate. Sections of these mucous membranes show that their epithelial cells are swollen and the cell protoplasm is replaced by a finely granular or slightly stringy homogeneous substance (mucin), which stains deeply with Delafield's hematoxylin. The nuclei of these cells are pushed to one side or toward the base of the cell and stain faintly with nuclear stains. The epithelial cells lining the glands show a similar change. The submucosa is edematous and may show an infiltration of leucocytes and few red blood cells. The edema and the leucocyte exudate may extend into the muscular layers.

Acute Mucopurulent Inflammation.—Change of temperature, some irritating dusts or gases will produce in mucous membranes, especially of the respiratory tract, an inflammation characterized by a light yellow, semi-translucent, slightly stringy fluid exudate which is tenacious and adheres to the mucous membrane. The mucosa is swollen and the vessels are injected. Microscopically the picture presented is the same as that in a catarrhal inflammation, with the exception that a more marked leucocyte infiltration exists in all the layers and the exudate contains more leucocytes than does that of the catarrhal form.

Acute Purulent Inflammation.—Bacteria are the most frequent causes of this form of inflammation of a mucous membrane, but certain foreign bodies and drugs will produce identical phenomena. Foreign bodies in the nose, esophagus, or bladder will cause a purulent rhinitis, esophagitis, or cystitis. Turpentine or phenol in the mouth will produce a similar condition, and bacteria will cause a purulent inflammation of any mucous membrane. Macroscopically, the mucous membranes affected with acute purulent inflammation are reddened and swollen and their surfaces are covered with a thick yellowish or greenish-yellow, semi-fluid, opaque exudate. Microscopically, the epithelial cells lining the mucosa show a simple coagulation or liquefaction necrosis. The exudate is composed of cell débris, desquamated epithelial cells, and necrosing leucocytes. The connective tissue of the mucosa and submucosa, and often of the muscular layer, shows a marked leucocyte infiltration which may contain a varying number of red blood cells, and the vessels are congested and the connective-tissue fibers are swollen, due to edema.

Acute Fibrinopurulent Inflammation.—The same agents which cause a purulent inflammation may cause a fibrinopurulent condition, depending upon the lesion produced. Cystitis which follows sounding of the bladder or results from an enlarged prostate or from calculi is very frequently a fibrinopurulent inflammation; and a foreign body in the vagina or rectum may cause a similar condition. The mucous membrane is covered by a yellowish-gray or greenish,

tenacious exudate which adheres to the surface and when it is pulled off leaves a reddened surface. The mucosa is thickened and reddened, and the submucosa and muscular coats are edematous and congested. Sections of the organ affected with fibrinopurulent inflammation show an exudate made up of a varying amount of stringy, granular, or hyaline fibrin, which forms a network enclosing desquamated epithelial cells and collections of necrosed or necrosing leucocytes. The epithelial cells of the mucosa are desquamated and show fatty degeneration, cloudy swelling, or necrosis. In the subepithelial connective tissue of the mucosa and in the submucosa are masses of leucocytes which may be degenerating and which are surrounded by edematous connective-tissue fibers.

Acute Fibrinous Inflammation.—The ordinary pus germs in the rectum, vagina, mouth, pharynx, or nose may produce an acute fibrinous inflammation. Fraenkel's pneumococcus and Friedländer's pneumobacillus will produce on the tonsils and in the pharynx, larynx, and nose a similar condition; furthermore, this form of inflammation is the casue of death in cystitis due to enlargement of the prostate or to calculi, and fibrinous proctitis or enteritis may follow prolonged rectal feeding in cachectic individuals. The difference between this form of inflammation and fibrinopurulent inflammation is shown in the character of the membranous exudate. In the former the color of the membrane is pearly white or light yellow streaked with red, and the membrane itself is spongy and adherent to the surface, and when it is forcibly removed it leaves a reddened surface, usually differing from the diphtheritic membrane due to the Klebs-Loeffler bacillus in the fact that the latter can be withdrawn only with great difficulty and leaves a depressed surface which looks like an ulcer. Microscopically, the mucous membrane which is the seat of an acute fibrinous inflammation is covered with an exudate composed of granular, stringy, or hyaline fibrin, which forms a firm network enclosing few leucocytes, red blood cells, and desquamated epithelium. The epithelial cells lining the mucosa show a simple or coagulation necrosis, and the nuclei do not stain; fine threads of fibrin separate the epithelial cells and extend deep into the submucosa; leucocytes and red blood cells are scattered throughout the mucosa and submucosa and to a slight extent in the muscular layers, and the connective tissue of all the layers is markedly edematous.

Acute Hemorrhagic Inflammation.—The poisons produced by putrefaction outside of, and taken into, the body, cause a hemorrhagic gastritis and enteritis. Turpentine and croton oil in large doses produce a similar condition. The mucosæ vary in color from dark red to brown and are greatly swollen, and the contents of the stomach and intestine are streaked with fresh and decomposed blood. Microscopically, the epithelial cells lining the lumina show cloudy swelling, fatty degeneration, simple necrosis or coagulation necrosis; the spaces between the epithelial cells are occupied by edema and red blood cells, the connective tissue of the mucosa and submucosa shows a varying number of red blood cells scattered or collected in small masses, and all the blood-vessels are greatly congested.

Acute Gangrenous Inflammation.—The bronchi frequently become the seat of this form of inflammation; in some of the cases the disease having originated by the penetration of an ulcer from an esophageal diverticulum into the bronchi, while in others it represents a simple extension of a gangrenous process in the lung. The presence of foreign bodies in the nose, esophagus, or vagina, or the occlusion of the nutritive vessel of any mucous membrane, or a simple trauma may eventuate in an acute gangrenous inflammation. The condition is accompanied by foul odors, caused by hydrogen sulphide, ammonium sulphide, etc. The mucosa in the early stages resembles that of acute purulent inflammation, with the exception that the pathological changes are more marked. In the later stages the mucosa may slough away and the necrosis may be so extensive that the deeper layers are involved.

Chronic Hypertrophic Inflammation.—This form of inflammation is most often found in the uterus, but hypertrophic rhinitis is common. The mucous membrane is thickened and varies in color from gray to gray pink; the glands of the affected mucous membrane become hypertrophic and some become cystic; and, finally, the connective tissue of the mucosa becomes increased in bulk.

Chronic Atrophic Inflammation.—The prolonged use of alcohol will cause this condition in the stomach, and caries of some part of the bony framework of the nose or the mere presence of a foreign body somewhere in the nasal cavities is competent to produce chronic atrophic rhinitis. The mucosæ are thin and in the stomach the outer layers become atrophic; the glands of all surfaces affected show marked atrophy and their epithelial cells show mucous degeneration; and the connective tissue of the mucosa and submucosa is greatly increased and may cause constriction of the lumina of some glands. In the latter event these glands become cystic, and the muscular coats undergo marked atrophy. FREDERICK A. BALDWIN.

Mudlavia.—Warren County, Indiana.

POST-OFFICE.—Kramer. Hotel. Bath departments.

ACCESS.—Via the Chicago and Eastern Illinois Railroad (Brazil Division), and the Wabash Railroad to Attica, Indiana. Here all trains are met by automobiles.

Mudlavia, located at Kramer, five miles from Attica, Indiana, nestles among picturesque hills on a naturally well-drained site. The surroundings are beautiful and restful, the grounds spacious and attractive. The peculiar natural advantages consist of a vegetable earth used for the mud pack or bath, and two mineral waters used in conjunction with the mud. One of these waters is an active diuretic; the other, a sulphosaline, has laxative properties. No recent analysis of the waters has been made.

For the mud bath, a thick layer of the heated vegetable earth is spread on a specially constructed cot on which the patient reclines. He is covered except head and chest in the pack and left for the time prescribed for him. He then goes under a warm shower followed by a short mineral-water tub bath. The pack is considered superior to any water bath in its power to relax and soothe the patient. The treatment is one of elimination and rest. This treatment is advocated for rheumatic affections, gout, arthritis of special forms, excepting the tuberculous and septic. It is said to be efficacious in most forms of eczema, and in psoriasis; and helpful in nephritis and diabetes.

Golf links, tennis courts, croquet grounds, and other sources of amusement are provided for the guests.

EMMA E. WALKER.

Mueller, Johannes Peter.—Born at Coblentz, Germany, July 14, 1801. Although his father was a simple shoemaker, he himself showed at an early age a decidedly studious turn of mind. In 1819 he began the study of medicine at the University of Bonn, and before graduating he wrote an essay on "The Respiration of the Fetus," which won for him the Faculty Prize. In 1822 he received the degree of Doctor of Medicine, and in 1824 he was made a Privatdozent in the university. The positions of Professor Extraordinary and Regular Professor were given to him in 1826 and 1830. In 1833 he was called to Berlin to fill the regular Chair of Anatomy and Physiology,

and at the same time to be the Director of the Anatomical Theater and the Anatomical Museum in the place of Rudolphi, deceased; both of which positions he held up to the time of his somewhat sudden death from heart disease April 28, 1858.

Pagel speaks of Mueller as the genial biologist, as one of the most distinguished creators of modern physiology, and as the originator of a well-defined school of biology. He speaks of his great work on physiology—"Handbuch der Physiologie des Menschen," Coblentz, 1833–1841—as one of the finest productions in German medical literature. The fact that in the course of thirty-four years Mueller published 267 separate writings (books, essays, etc.) affords sufficient evidence of the gigantic character of his labors. Further evidence, however, may be found in the following facts: When Mueller took charge of the Berlin Anatomical Museum it contained 7,000 items; at the end of twenty-five years he brought the number up to 12,380 items. The remarkably varied character of his learning may be appreciated when it is remembered that during a large part of this period he gave instruction in descriptive and comparative anatomy, in physiology, in embryology, and in pathological anatomy. According to the statements made by Waldeyer, who has written an admirable biography of this remarkable man, Mueller should be credited with the distinction of having been the first to formulate in precise terms the doctrine of reflex movements and that of sympathetic sensations, to expound the law of eccentric sensation, to furnish an exact demonstration of the truth of Bell's doctrine, to discover the analogy between the mauner in which tones are produced in the larynx and that in which they are produced in pipes provided with membranous tongues, etc. Among his pupils there were several who afterward became distinguished authorities in their respective branches of science—*e.g.* Schwann, Henle, Bruecke, E. Du Bois-Reymond, Remak, Virchow, and Helmholtz. A. H. B.

Mullein.—See *Scrophulariaceæ.*

Mummification.—See *Necrosis.*

Mumps.—(*Synonyms:* Cynanche parotidea; parotitis; parotiditis; Fr., *Oreillons;* Ger., *Ziegenpeter.*)

Mumps is an acute, infectious disease, self-limited, and characterized by inflammation of the parotid, and sometimes of the submaxillary and sublingual glands, with a tendency to involve the mammæ, testes, and ovaries.

Epidemic parotitis has a long history. The classical description left by Hippocrates has been little altered or amended for the better by modern writers.

Non-specific parotitis, often met with in acute and chronic infections or after surgical operations or injuries of the abdominal or pelvic organs, has little in common with the disease under discussion.

Nature and Etiology.—Mumps prevails widely as an epidemic, and also occurs in the sporadic form.

It is propagated by a specific virus the nature of which is unknown. Numerous organisms have been found in the blood, saliva, and other secretions by Bordas, Capitan, Charrin, Boinet, Bein and Michaelis, Pick (1902), but the cultures obtained have failed to stand the crucial test of reproduction by inoculation. The disease is communicated by contact with the infected, and by the intermediation of various substances to which the virus adheres. The contagious principle is supposed to be chiefly transmitted by the breath, and is capable of reproducing the disease from the beginning of the parotid swelling up to ten days or two weeks after the fever has subsided. It is highly contagious. When the disease breaks out in schools, children's hospitals, or other institutions where large numbers of young people are congregated, few escape, unless protected by a previous attack. The susceptibility is not the same in all individuals and the infectiousness of epidemics vary widely.

Mumps is quite rare in infancy and after the middle period of life, occurring chiefly in youth and early manhood. Hale White reports the case of a child and its mother who, on the sixth and the seventh day respectively after the parturition, developed a severe parotitic infection. Homans found, in the child of a woman whose labor came on in the eighth month as the result of mumps, a swelling of the left parotid on the day after birth. Such cases suggest the possibility of intrauterine transmission. Males are more prone to attack than females. Like the diseases of the class to which it belongs, it rarely occurs more than once in the same individual.

It is more apt to prevail during the winter and spring, but epidemics have been observed at all seasons. Bad hygienic surroundings and lowered personal vitality favor its diffusion.

Morbid Anatomy.—The opportunity for post-mortem examination in cases of mumps, for obvious reasons, is very limited. On this account pathologists differ as to the seat of the morbid process; some locating it in the gland proper, and others in the periglandular connective tissue. Among those who maintain the glandular origin, some hold that it is rather the fibrous stroma which supports the acini than the acini themselves, which are primarily involved.

The weight of authority is in favor of the initial lesion being a catarrhal inflammation of the gland ducts, but the local swelling which gives character to the disease is largely due to an infiltration of the surrounding cellular tissue. The swelling disappears by the absorption of the exudation, and only in very exceptional instances does suppuration take place.

Occasionally the glands remain enlarged for a considerable time, and, in rare instances, the enlargement and hardening are permanent. Atrophy of the parotid and other affected glands has been observed as an end result.

Symptoms.—The period of incubation varies greatly and is estimated by different authors at from seven to twenty days. Premonitory symptoms are, in most instances, either absent, or so mild as to attract little attention. When present they are those commonly met with in mild febrile attacks: chilliness, hot flushes, languor, anorexia, and sometimes vomiting and diarrhea.

Very exceptionally the initial symptoms assume a grave character, and the disease is ushered in with high fever, profound depression, persistent vomiting, and, in children so predisposed, with convulsions.

Pain and tenderness in the region of one or both parotid glands, if not present from the beginning of the illness, speedily make their appearance, and are never delayed longer than twenty-four or thirty-six hours. Swelling appears simultaneously with the pain and tenderness. It is at first noticed in the depression between the mastoid process and the ramus of the jaw, and is confined to the gland. The adjacent cellular tissue is soon invaded and the tumefaction extends forward on the face and downward and backward on the neck.

The degree of enlargement varies greatly, being, in some cases, moderate and confined to the parotid region, and in other cases involving a large portion of the face and neck. When both parotids are involved and the swelling is fully developed the configuration of the face is peculiarly altered, the lower half of the face being enormously widened and the outline of the chin lost in the edema of the neck. The swelling is firm, slightly elastic, and moderately sensitive to pressure. The head is fixed with the face directed straight forward, or, if but one parotid is affected, the head will be inclined to the diseased side. The skin usually preserves its natural color, but may be red

and glossy. Slight desquamation may take place after the inflammation has subsided.

More or less fever is always present, lasting, in cases of moderate severity, not more than four or five days, but occasionally is intense, protracted, and attended with delirium and prostration.

The edema generally extends internally, affecting to a greater or less degree the mucous membrane of the tonsils and pharynx. The saliva may not be materially altered in quality or quantity, but dribbles continuously from the half-open mouth.

Tinnitus aurium and earache are often experienced, and there may be a temporary or permanent impairment of hearing. The movements of the jaw are, of necessity, greatly impeded and painful. Speech is difficult, and the voice is husky or muffled.

Mastication and deglutition are almost entirely suspended, the patient enduring the pangs of hunger rather than undergo the suffering required to satisfy his wants. The affection may be limited to one parotid, but usually both are involved, though not simultaneously—the left is usually first involved.

Very often the submaxillary and sublingual glands are affected conjointly with the parotids. Dr. Penzoldt, of Erlangen, records an epidemic of mumps which fell under his observation, in which there were many cases in which the disease process was almost wholly confined to the submaxillary glands.

The swelling reaches its height in from two to five days, remains stationary about forty-eight hours, and then rapidly subsides, making the duration of the attack from ten to fourteen days.

Complications and Sequelæ.—These relate especially to affections of the nervous and glandular systems. The tendency for the inflammation to invade by so-called metastases other and remote glands is a singular and interesting feature of the disease for which no satisfactory explanation has been offered. As was originally pointed out by Niemeyer, it is probably not a true metastasis. The testes in males and the mamma and ovaries in females are the organs of special election. This complication is much commoner in males than in females, and less common in childhood than in adult life. Steiner has reported the only recorded case of complicating orchitis in a nursing child. When the testicle is invaded, it becomes swollen and painful, and there is often effusion into the tunica vaginalis, with edema of the scrotum. Some recent observations confirm the belief that the infection is often direct. The fingers conveying the contagium from the mouth to the penis which in this way reaches the testicle through the urethra. Bruising of the testes is said to invite the disease.

The migration may take place at any period of the parotid swelling, which then usually subsides, but occasionally the two inflammations run their course together. Sometimes the inflammation of the parotid disappears suddenly before the advent of the metastatic affection; in this event, alarming constitutional symptoms are liable to supervene. There may be high fever, headache, delirium, or profound collapse, which promptly disappear on the appearance of the local lesion. The new affection runs a course very similar to that of the original disease, and lasts about the same length of time.

Atrophy of the testicles sometimes results, or their function may become impaired from occlusion of the spermatic duct.

Meningitis is in evidence in a large percentage of the fatal cases; in the Index Catalogue six fatal cases are listed. Various diseases of the nervous system have been recorded as complications (insanity, neuritis, hemiplegia, facial paralysis), but in many, if not most, instances, they were mere coincidences.

Otitis media is not uncommon and occasionally terminates in permanent deafness. In a few cases a complete loss of hearing in one ear takes place without the slightest evidence of the presence of the inflammation in the corresponding middle ear; thus warranting the belief that the lesion—whatever may be its nature—must in these cases be located in the cochlea or in the auditory nerve at some point in its extralabyrinthine course.

Albuminuria with convulsions has been noted. Jacobs has recorded a case complicated with acute pancreatitis.

Prognosis.—Mumps is a mild though painful disease, and almost invariably runs a favorable course. The inflammation of the parotid rarely leads to the formation of an abscess, contrasting, in this respect, strongly with the non-specific form of parotiditis which occurs in the course of typhoid fever and other maladies.

Occasionally a hard, painless enlargement of the gland is left, which persists for a variable time and disappears, but which in very exceptional instances may be permanent.

The diagnosis is rarely attended with difficulty. The disease can scarcely be mistaken for any affection other than the non-specific inflammations of the parotid glands, which occur as complications of various constitutional diseases.

The comparative mildness of the general symptoms, the speedy resolution of the swelling, and the epidemic character of mumps, contrast strongly with the preceding severe illness and the inherent tendency to suppuration which constitute the clinical features of the non-specific or symptomatic parotiditis.

Treatment.—The treatment is purely symptomatic. The disease is self-limited and runs a definite course, uninfluenced by the administration of drugs.

The patient must remain indoors, preferably in bed, even in mild cases, until convalescence is assured.

On account of the difficulty in mastication, the diet should be exclusively fluid. If there should be high fever, a bath or surface sponging with tepid water will be of service. Pain and restlessness may be combatted with an anodyne, preferably Dover's powder. Refrigerant diaphoretics, such as a solution of bitartrate or citrate of potassium, or the neutral mixture of the Pharmacopœia will meet the indications. External fomentations to the neck are both useful and grateful to the patient. Soap liniment, to which deodorized tincture of opium may be added, warm olive oil, or the tincture of belladonna and glycerin (℥i.–℥i.), are eligible preparations for external use.

When metastasis to the testes or other glands takes place, the new affection should be treated in the same manner as if it had occurred independently of the parotid inflammation. The writer has obtained excellent results in orchitis from the inunction of guaiacol (℥i.) and lanolin (℥i.). When it is applied from two to four times daily the pain and swelling usually promptly subside. If the onset of the metastasis is heralded by great prostration, or by alarming symptoms of any kind, stimulants must be freely given and warmth applied to the body.

A course of tonics is advisable should convalescence be tardy.

W. J. Conklin.

Murchison, Charles.—Born on the Island of Jamaica, May 21, 1830. At the age of three he was taken to Scotland, and in 1846 he began the study of medicine at the University of Aberdeen. Later, he went to Edinburgh, and became (in 1850) one of Syme's assistants. In 1851 he received the degree of Doctor of Medicine; his graduating thesis bearing the title—"On the Pathology of Morbid Tumors." During the next few years he held several different posts: For a short time he was physician to the English Embassy at Turin, Italy; he next went to Dublin

(1852) to perfect his knowledge of midwifery; then from there he visited Paris, and in 1853 he entered the service of the East India Company, as an assistant physician; in 1855 he returned to England and became a member of the Royal College of Physicians in London; still later, he was appointed Instructor of Anatomy and Botany at St. Mary's Hospital; from 1856 to 1860 he was an Attending Physician at King's College Hospital, and gave up the position not long afterward in order to accept similar positions at the Middlesex Hospital and the London Fever Hospital. He continued active service at the former of these institutions until 1871, and at the latter until 1870. When the new St. Thomas's Hospital was opened in 1871 Murchison was appointed an Attending Physician and an Instructor of Internal Medicine. He died April 23, 1879, from the effects of an aneurysm of the aorta.

Murchison was a prolific contributor to medical literature, most of these contributions being in the form of lectures which he had delivered before the Pathological Society, of which he was made the President in 1877. Of his more important published writings the following deserve to receive special mention: "A Treatise on the Continued Fevers of Great Britain," London, 1862; "Clinical Lectures on Diseases of the Liver, Jaundice, and Abdominal Dropsy," London, 1868 (second edition in 1877); "On Functional Derangements of the Liver," London, 1874; and "On the Causes of Intermitting or Paroxysmal Pyrexia, and on the Differential Characters of its Several Varieties," in *The Lancet*, 1879.

A. H. B.

Murexide.—The murexide test for uric acid is performed as follows: If a little uric acid in substance is treated on a porcelain dish with a few drops of nitric acid the uric acid dissolves on warming and after drying on the water bath a red residue is obtained, which turns a purple red (formation of ammonium purpurate, or murexide, hence name) on the addition of ammonia.

F. P. U.

Murrina.—Murrina is a fatal form of equine trypanosomiasis met with on the Isthmus of Panama. The disease is known throughout the Republic by the names "murrina" (moreña de cadera) and "derrengadera," the natives believing that there are two distinct diseases, the one called murrina being a chronic disorder manifesting itself by edema and general weakness, while derrengadera is a disease which may be slow or rapid in its course, but in which there is always paresis of the hind legs and no edema.

The clinical features of this disease, briefly stated, are general weakness and droopiness, followed by progressive emaciation, the coat becoming rough and staring. At first there are febrile paroxysms and later an irregular or continued fever, reaching 104 or 106° F., rarely 107 or 108° F. A severe anemia develops, with ecchymoses and pallor or a muddy yellow color, of the nasal and ocular conjunctivæ. Toward the end of the disease in some animals a staggering gait was noticed. Extreme emaciation, edema of sheath, lower abdominal wall, or legs were features observed in some animals permitted to die of the disease.

The Pathogenic Agent.—The pathogenic agent is *Trypanosoma hippicum*, Darling, 1910. The typical trypanosome is sixteen to eighteen microns in length, two microns wide, the distance from kinetonucleus to the posterior tip about 1.75 microns, and the distance from the posterior tip to the middle of the trophonucleus is from 7.5 to ten microns. The flagellum may be short and not entirely free, for the attenuated process of the cytoplasm sometimes extends to the extreme end of the chromatin filament; but usually there is a free flagellum, reaching four microns in length. The trophonucleus is placed a little posterior to the middle, the relation being 1 : 2.8 to 1 : 2.4. The posterior tip is often rather blunt and usually obtuse, never being as attenuated as the posterior tip of *T. lewisi*. The cytoplasm usually contains numerous basophilic granules scattered throughout the cytoplasm or arranged in lines in the anterior and posterior halves. The granules are coarse and from 0.5 to one mikron or more in diameter. There may be sixteen to eighteen in number, most of them being placed, usually, in the anterior half. The lateral margin of the trypanosome may stain more deeply than the interior. Some of the longer forms contain few or no granules. A well-developed undulating membrane is present and the chromatin filament extends from the kinetonucleus to the anterior tip of the flagellum. When rapidly proliferating in the rat or mouse, some forms ap roach twenty-eight mikrons in length and become three to four mikrons in width. From this description it is quite evident that the trypanosome is different from *T. equinum* of mal de caderas and *T. equiperdum* of dourine, the only trypanosomes hitherto found in the New World. The former is autochthonous in South America, the latter was introduced from Europe.

The trypanosome morphologically falls into the Brucei group but the animal reactions are quite distinct in that cattle and deer are insusceptible.

Summary of Susceptible Animals.

Animal.	Infected.	Result.
Work horse	Yes	Died
Mule	Yes	Died
Saddle horse (experimental infection)	Yes	Died
Calf	No	Refractory
Pig	Yes	Recovered
Dog	Yes	Died
Raccoon	Yes	Died
Cat	Yes	Recovered
Kitten	Yes	Died
Monkey, *Cebus* and *Nyctipithecus*	Yes	Died
Rabbit	Yes	Died
Guinea-pig	Yes	Died
Rat, *M. rattus*	Yes	Died. Two recovered
Rat, *M. norvegicus*	Yes	Died
Rat, *M. alexandrinus*	Yes	Died. One refractory
Rat, albino	Yes	Died
Mouse, *M. musculus*	Yes	Died
Mouse, albino	Yes	Died
Opossum	Yes	Died
Agouti	Yes	Recovered
Coati	Yes	Died
Sloth	Yes	Died
Sloth	Yes	Died
Deer	No	No refractory

Deer, calf, pig, agouti, cat, and a few rats either proved refractory as in the first two animals mentioned, or recovered from a slight infection, while most of the mammals became infected and died of the infection.

Diagnosis.—The diagnosis is made by the detection of weak horses or mules "pulling back on the halter" or those with outstanding hind legs, animals temporarily off their feed, or those that in spite of sufficient food show steady physical deterioration. With these symptoms there may be conjunctivitis, anemia, and subconjunctival ecchymoses. As soon as such an animal shows a temperature of 101° F. or more, a blood examination will generally reveal the trypanosome; particularly if the elevated temperature is detected at the beginning of the access. During the latter part of the paroxysm, trypanosomes may not be demonstrable. The inoculation of very susceptible animals, such as mice, rats, monkeys, dogs, or guinea-pigs, will help in making a diagnosis in some of the

cases, or on some occasions when trypanosomes are extremely sparse in the peripheral blood. Autohemagglutination is invariably present in infected horses or mules.

In obtaining blood from the ear for diagnosis, no time should be lost before examining fresh cover-slip preparations, for occasionally the trypanosomes lose their motility within a few minutes after the blood is drawn, and can then only be detected in stained specimens. It has occurred not infrequently that what apparently were negative fresh preparations, contained trypanosomes after staining. Trypanosomes commonly remain for a time within a clump of red cells, which can be seen to be disturbed.

Duration of Disease in Mules and Horses.—Murrina is far more common among mules than horses. This has been undoubtedly due to the nature of the mules' work here, rendering them more liable to infection through cuts and galls. The duration of the disease is the same in mules and horses. The longest duration recorded is in a horse—247 days.

Pathological Anatomy.—When a mule or horse is sacrificed before the disease has run its course there may be very few gross lesions and none characteristic of the disease other than emaciation, edema of dependent belly wall, sheath, or legs, conjunctival ecchymoses, or some splenic enlargement. If the animal is permitted to die naturally there are lesions which are characteristic and usually well marked.

The spleen is enlarged, but its capsule, particularly the external surface, is dotted over with petechiæ limited to the capsule, usually one to two millimeters in diameter. The recent ones are bright red, while those somewhat older are reddish brown in color. The pulp is slightly increased in amount and the reticulum appears normal.

The kidneys contain petechiæ, one millimeter in diameter, distributed chiefly in the cortex, just beneath the capsule.

The endocardium and epicardium usually contain large and small hemorrhages. Favorite sites are the papillary muscle, mitral leaflets, and the epicardial fat along the coronary arteries, oftenest near the base of the heart.

The pleuræ and peritoneum in some cases have been the seat of numerous petechiæ.

The renal lymph nodes are usually enlarged, and one or two of the set are frequently the seat of extensive hemorrhages.

There are usually hemorrhages into the conjunctival or nasal mucosæ at some time during the disease.

Sometimes there is an excess of clear, serous fluid in the peritoneal, pleural, or pericardial cavities, but this is not constant, nor is the edema of the sheath, legs, hocks, or lower belly wall constant.

Other viscera show no changes.

The microscopic changes are fairly characteristic and constant. In the kidneys the focal hemorrhages and the acute glomerulitis, occasionally with necroses, make a rather striking picture. The spleen always shows the same appearance—phagocytosis of red blood cells and the presence of blood pigment in small and large clumps of refractile granules. In the liver the one unvarying feature is the presence of bronze-colored blood pigment in the endothelial cells of the sinusoids. There is a localized leucocytosis here and focal necroses. Renal lymph nodes usually show great engorgement, hemorrhage, and phagocytosis of red blood cells by large mononuclear phagocytes.

Mode of Transmission.—A study of this phase of the disease impresses one very strongly that it is carried mechanically by flies.

From a study of the epidemiology of an outbreak of murrina in the Commission corrals, it was found that mules and horses were equally susceptible to the disease; yet, when they were stabled together, mules developed the disease, but saddle horses never became infected.

After an investigation it was concluded that the infection was probably conveyed, not by definitive invertebrate hosts, such as tabanidæ, stomoxys, ticks, etc., but mechanically by flies in interrupted feedings visiting the excoriated patches on the skin of sick infected animals and transferring the virus on their mouth-parts or legs to fresh cuts, scratches, or galls on uninfected animals.

The mules, from the nature of their work frequently suffered from "scraper cuts," galls, and other injuries in which the skin became broken, while such injuries were rarely noted on the saddle horses.

Opportunity occurred for the collection of experimental data with a view to determining the mechanism of the infection by flies. First it was ascertained that *Musca domestica* could transmit or carry the trypanosome in the manner supposed. Three lots of *Musca domestica* were caught in biting jars and fed with blood from a guinea-pig infected with *Tr. hippicum*, the pathogenic agent of the disease, and, after an interval of about thirty seconds, the flies were placed over the shaved and scratched skin of three mules, where they remained for about five minutes. One of the three mules became infected in this way.

Out in the bush and in the native villages there may exist some true suctorial intermediary host in addition to other sources and means of infection.

One other mode of infection, impossible to investigate directly in the corrals, namely, the possibility of infection during coition, was tested experimentally by noting that *Trypanosoma hippicum* could pass through the intact mucous membranes of mules, vaginal, nasal, or oral.

Treatment.—*Prophylaxis.*—The likelihood of the assumption that the disease was transmitted by flies was borne out by the results of treatment which was instituted, and which resulted in saving the work horses from further infection. Twenty-three animals, at least, had been destroyed by this disease between April, 1909, and April, 1910.

The following recommendations were made and carried out with the result that the epidemic was completely wiped out:

1. Destruction in all infected animals and burial away from the corral to prevent flies becoming infected from blood at the time of shooting, if near the corral.
2. Routine daily (b. d.) temperatures for the detection of suspects.
3. The isolation in screened, vestibuled, fly-proof stables of all animals having a temperature above 100° F.
4. The detection of infected animals by blood examinations, and animal inoculations when necessary.
5. The disinfection of halters, instruments, etc., and the hands of attendants coming in contact with the infected animals.
6. All wounds, sores, galls, etc., on well, infected, living, or dead animals to be protected from flies by protective dressings, containing substances such as creolin, distasteful to flies.
7. Stray horses and mules are not to be impounded in or near corrals.
8. Sanitary inspectors and police are required to report all animals having this disease.

Arsenic medication by Holmes' method was not effective.

The disease, which has been eradicated in the Canal Zone, is still present in parts of the Republic of Panama, in villages and along the trails, and cases have been detected in native ponies near the Zone line. In those localities where biting flies other than the ones examined exist in numbers, it may be that the trypanosome has a true suctorial intermediary

host, but the inaccessibility and the sparseness of the native population render difficult at the present time an investigation of this part of the question.

SAMUEL T. DARLING.

BIBLIOGRAPHY.
Darling: Amer. Vet. Jour. Review, June 1, 1910.
——: Jour. Inf. Dis., 1911, viii., 467.
——: Jour. Exp. Med., 1912, xv., No. 4.
——: Jour. Med. Research, 1912, xxvi., No. 2.
——: Parasitology, 1911, iv., 83.
Laveran: Bull. Soc. Path. Exotique, 1911, iv., No. 3.

Mus.—The genus which includes the rats. These animals are important because they carry diseases. *M. rattus* and *M. norvegicus* are the two species which spread the plague by means of their fleas.

A. S. P.

Musca.—A genus of dipterous insects which includes the common house fly, *M. domestica*. These animals carry typhoid, cholera, and other diseases. See *Insects, Poisonous*, and *Insect Carriers of Disease*.

A. S. P.

Muscarine is a very toxic alkaloid closely related to choline present in the poisonous fungus, *amanita muscaria*, or fly-blown agaric.

Its relation to choline may be seen from the following formulæ.

Choline $CH_2OH—CH_2—N—(CH_3)_3—OH$

Muscarine $CH(OH)_2—CH_2—N—(CH_3)_3—OH$

Muscarine is a very strong base, in fact, stronger than ammonia, soluble in water, insoluble in ether and with many of the alkaloidal reagents fails to be precipitated. Doses of from three to five milligrams injected subcutaneously into man cause after a few minutes profuse salivation, increased frequency of the pulse, nausea, giddiness, confusion of thought and myosis, but no vomiting or diarrhea. The physiological actions of muscarine and atropine are to a great extent antagonistic. See also *Ptamaines*.

FRANK P. UNDERHILL.

Muscidæ.—A family of flies which includes a number of important disease-carrying genera. The body is stout; thorax short; arista plumose or pectinated; first posterior cell is only slightly open or closed at the border of the wing. The genera of medical importance are tabulated in the following key:

A. Proboscis long; adapted for biting.
  a. Palpi thin, shorter than proboscis.
    1. First posterior cell open—*Stomoxys*. Surra, infantile paralysis (?).
    2. First posterior cell closed—*Beccarimyia*.
  b. Palpi thickened, as long as, or nearly as long as the proboscis.
    1. Palpi cube-like, with only the tip thickened. Vertical diameter of head not greater than anteroposterior. Eyes oval—*Hematobia*.
    2. Palpi thickened from base to apex. Vertical diameter of head greater than anteroposterior. Eyes kidney-shaped—*Lyperosia*.
  c. Palpi strongly built everywhere, not thickened.
    1. Proboscis thick, less than twice the head length. Arista with few unbranched hairs. Median (fourth longitudinal vein) of the wings with sharp bends—*Glossinella*.
    2. Proboscis thin, more than twice the head length, swollen at the base. Arista with many branched hairs. Median with two sharp bends.—*Glossina*. Sleeping sickness, nagana in horses, etc.
B. Proboscis short, not adapted for biting.
  a. Midtibia without bristle on inner side.
    Musca. Typhoid, cholera, etc.
  b. Midtibia with bristles on inner side.
    1. Thorax blackish—*Calliphora*. Parasitic larva.
    2. Thorax black with whitish stripes—*Chrysomyia*. Parasitic larva.
    3. Thorax unicolored—*Lucilia*. Parasitic larva.

A. S. PEARSE.

Muscle.—Muscle is a special tissue which produces the various movements of the body whether under control of the will or not. It consists chiefly of cellular elements in the form of fibers of varying lengths and shapes. It constitutes the "flesh" and is classified in three varieties: (1) *voluntary striated*, or *skeletal*, (2) *involuntary non-striated*, or *smooth*, (3) *involuntary striated*, or *cardiac*.

Bowman's work in 1840 was the first satisfactory description of the structure of muscular tissue. His work was followed by that of Kölliker (1851 and 1867), W. Krause (1868), Hensen (1868), Merkel (1874), and Engelmann (1873). The latter did much in the way of using terms that are still retained and in the study of the effect upon the parts of the fibers during contraction. Further work was done by Hertzman (1873), Retzius (1881), Pallett (1885–86), McDougal (1897), Bernstein (1905), and Macdonald (1909) and Schäfer (1910). The later writers worked mainly upon the effects of contraction.

VOLUNTARY STRIATED MUSCLE.—Voluntary striated muscles are the most highly differentiated of the muscle tissues. These muscle fibers are arranged in masses called muscles and are usually provided with a tendon at each end for attachment to the periosteum of the bones.

Each *fiber*, or *cell* is a long, narrow cylinder and its cytoplasm constitutes a *syncytium*. A fiber averages about one inch in length, though in the Sartorius muscles they may reach five inches. The diameter, usually 25 to 80 microns, will vary in the same muscle. The largest fibers are about 100 microns ($\frac{1}{250}$ of an inch), while the smallest are about 10 microns. In the male, the fibers are thicker than in the female and in muscular individuals the diameter is greater (in the same muscles) than in other individuals. This difference in thickness in different muscles is not apparent during infancy.

Each fiber is composed of a large number of *fibrillæ* imbedded in a substance called *sarcoplasm*. These fibrillæ are surrounded by a delicate tubular sheath called the *sarcolemma* which is composed of a tough homogeneous substance that does not yield when the muscle substance ruptures. This sheath is more prominent, thicker and stronger in lower animals (fish, amphibian) than in mammals. Each fiber when viewed longitudinally shows light and dark bands, or lines running both transversely and longitudinally. These constitute the *striations*. The longitudinal striations are due to the alternation of the darker fibrillæ and the lighter sarcoplasm in which the fibrils are imbedded. Each *fibril*, or *sareostyle*, consists of a series of smaller rod-like parts. These small rods (*sareous elements*) are separated from one another at their ends by a clear space filled with sarcoplasm and containing a small body called *Dobie's globule*. The sarcoplasm is the passive substance of the muscle fiber and contains the glycogen. Holmgren described a trophospongium in the sarcoplasm of voluntary muscles, but Arnold later denied its presence.

The *cross striations* consist of comparatively broad, uniform, alternating dark and light bands that are usually more distinct than the preceding. The dark band is doubly refracting, or anisotropic, while the light band is singly refracting, or isotropic.

Each band averages about three microns in breadth. The dark band (*Brueeker's lines*) consists of a row of sarcous elements (rod-like parts of the fibrils) extending across the fiber and separated from each other by sarcoplasm. Not infrequently the middle of this band is marked a clear transverse line called the *disc of Hensen*. Upon careful examination each light band is seen to be crossed at its middle by a fine, usually dotted line. This is attached peripherally to the sarcolemma and is called *Dobie's line*, or the *membrane of Krause*. The parts of the light disc, above and below this membrane are referred to as the *lateral discs*. All parts of a

fiber embraced between two successive membranes of Krause constitute a *sarcomere*.

The *nuclei* of a voluntary muscle fiber are very numerous, often as many as one hundred. These are somewhat oval in shape and lie just underneath the

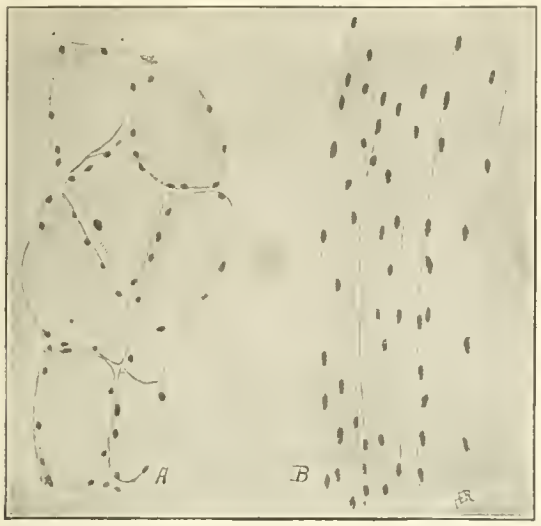


Fig. 4016.—Human Voluntary Striated Muscle. *A*, Cross-section; *B*, longitudinal section.

sarcolemma in mammals. In the frog the nuclei are imbedded in the substance of the fiber. They are more numerous at the tendinous ends of the muscle than in the middle. Each nucleus contains a network of chromatin and one or two nucleoli.

Upon transverse section a muscle fiber is seen to be limited by the sarcolemmal sheath; beneath this are seen the nuclei located at the periphery of the muscle substance. The fibrillæ are arranged in small, polygonal areas called *Cohnheim's areas*. These are separated from one another by a network of sarcoplasm. This network is made very prominent by treating muscle fibers with acid and gold chloride after the method of Cohnheim.

During contraction the muscle as a whole becomes shorter and broader. The changes in the appearance of the fiber during contraction have been studied by a number of observers. Merkel (1872) believed that the muscle substance diffused itself over the entire muscle compartment at first and then accumulated at the membrane of Krause, while the sarcoplasm passed to Hensen's disc, the substances thus becoming reversed. According to Engelmann (1873) when contraction begins, the membranes of Krause approach one another and the parts of each disc become indistinct, the striations are lost and the discs appear homogeneous. As the contraction progresses the striations reappear and the light disc becomes a dark band compared to the clearer disc of sarcous substance. In reality there has been no change of position of the discs as Merkel believed, but a change in refrangibility accompanied by a decrease in volume of the dark disc at the expense of the sarcoplasm. McDougall (1897) advanced the theory that the shortening of the sarcomeres in contraction was due to the absorption of water causing the sarcomeres to swell especially in the region of the dark discs. He later stated that he believed the absorption was due to the formation of lactic acid within or outside of the sarcomere. This has been criticised and has not been proven. The contraction must be due to the movement of the fluid within the sarcomere, that is from Krause's membrane to the sarcous elements. Huerthle attempted to photograph these changes. The cause of the movements of the fluids of the sarcomere during contraction was believed later by Engelmann to be due to the heat developed during contraction. Another view in the electrical change occurring at the adjacent surfaces of the dark and light portions of the fibers producing a change in surface tension at these points. MacDonald (1905) believed that the changes in the muscles are due to the alteration in relation of the protein molecules and electrolytes. He believes that the onset of the contraction is marked by the new appearance of potassium salts in the central portion of each sarcomere producing thus a difference in osmotic pressure.

There are two kinds of muscle fibers, red and white. The *white fibers* predominate in man and are poor in sarcoplasm and respond energetically when stimulated. The *red fibers* are rich in sarcoplasm, are usually thinner, respond more slowly to stimulation and possess more nuclei which may even be embedded in the fiber. In the rabbit these red fibers form entire muscles while in man they are scattered among the white fibers in the trapezius muscles.

A muscle consists of a definite collection of muscle fibers. The entire muscle is enclosed in a sheath of white fibrous tissue called the *epimysium;* this sends in septa that divide the muscle into large *secondary bundles*. The secondary bundles are composed of a number of *primary bundles*, or *fascieuli* each of which is surrounded by a sheath called the *perimysium*. From the perimysium fibers run between the individual muscle fibers forming a meshwork, *endomysium*, that supports the capillaries and smaller lymph channels and nerves. When the muscle fibers form the tendon, these fibers end bluntly and the nuclei are more numerous here than elsewhere. The tendon bundles begin abruptly and continue parallel to one another and the areolar tissue of the muscle and tendon is continuous.

Muscles are quite vascular. The *larger blood-vessels* enter the epimysium and send branches along the septa between the primary bundles and these branches run parallel to the long axis of the muscle.

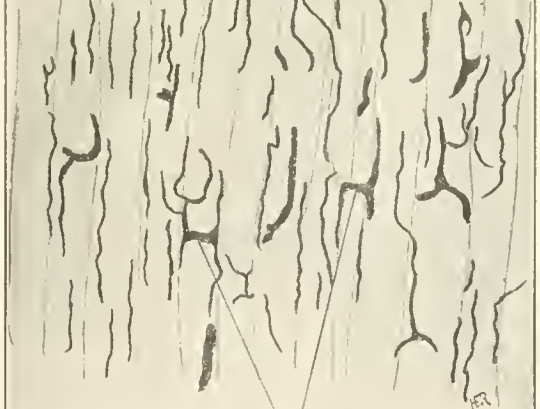


Fig. 4017.—Longitudinal Section of Muscle of Guinea-pig, injected, showing the course of the capillaries. *A*, Ampullæ.

Branches enter the primary fascieuli and form capillaries that also run parallel to the long axis of the muscle forming a long meshwork between the fibers. At intervals transverse connections between the longi-

tudinal capillaries are seen and these are the *ampullæ* that serve to take the tension off the capillaries during muscle contraction. As a rule the smaller the fibers the more abundant the vessels and the closer the capillary meshwork.

The nourishment of muscle fibers is not carried on in the usual way. Holmgren and Thulin, in their study of the tissues of insects, found special cells, *trophocytes*, present; these took from the blood and lymph the various nutritive substances and after modifying them, transferred the products to the tissue cells. These trophocytes are necessary to specialized tissues as muscle and nerve tissues. The relation of trophocytes to muscle cells has recently been studied by Nana Svartz, in the human tongue. The trophocytes are large granular elements that clasp the muscle cells. The granules are apparently nutritive in function resembling the tigroid bodies of nerve cells. They are arranged in rows and are passed into the muscle cells and during their contraction the granules dissolve. The trophocytes exhibit peculiar and characteristic changes in appearance, number of and arrangement of granules and the nucleus during the contraction wave of the muscle fiber. This seems to indicate that they are not indifferent cells. The direct passage of substances from the trophocytes to the muscle cells is demonstrable.

Lymphatic vessels are said to be absent in voluntary muscle. The lymph spaces between the fibers empty the lymph into the muscle sheaths and tendon. The *nerves* are large and enter with the vessels. They pass between the fasciculi and anastomose with one another. The exact mode of termination will be considered under *Nerve Tissue*.

Voluntary striated muscle is found as the skeletal and external ocular muscles, in the tongue, pharynx, esophagus (upper part), diaphragm, anus, larynx, external ear, and parts of the genital organs.

Involuntary Non-striated Muscle.—The involuntary non-striated, or smooth muscle is less abundant than the preceding and not so highly differentiated. The fibers, or cells are usually arranged in distinct layers and not in the form of muscles. They form the muscular coats of the hollow and tube-like organs. The fibers are usually united to one another by a small amount of intercellular cement that can be indicated by staining with silver nitrate. When spaces between the fibers occur, delicate intercellular bridges are seen connecting the various cells in the form of a syncytium, as pointed out by Barfurth. These bridges are regarded by N. Lenhossek, Schäffer, and others as artifacts. Each fiber is a small spindle-shaped element measuring from 40 to 200 microns in length and 3 to 8 microns in width. Larger fibers are seen in a pregnant uterus where the length is often 500 to 600 microns and the thickness also increased in proportion. The ends of the fibers may be branched as in the aorta and bladder. The muscle substance may show longitudinal striations due to the presence of coarser peripheral fibrillæ and deeper and more delicate fibrils. These are separated from one another by varying amounts of sarcoplasm. Each cell possesses a single nucleus that is long, rod shaped, and centrally located. It contains a chromatin network and one or two nucleoli. The sarcoplasm may contain granules at the poles of the nucleus. A centriole is usually present at the side of the nucleus. Each fiber is surrounded by a delicate membrane (not sarcolemma) that is probably a connective-tissue sheath that responds to special stains. These membranes are said to be fenestrated. The muscle fibers are collected into fasciculi of varying sizes that are usually arranged parallel to one another to form layers. In some organs, however, these fasciculi interlace. The fasciculi are attached at their ends either by connective tissue or by elastic fibers that split and attach themselves to the sheath of the muscle fiber.

Smooth muscle is found in the hollow viscera as the lower part of the esophagus, stomach and intestines, the trachea and bronchial tubes, the bladder, ureters, urethra, the oviducts, uterus and vagina, the blood-vessels, and lymph vessels, and in certain organs as the prostate, spleen, lymph nodes, and eyeballs.

The *blood-vessels* are less numerous than in the voluntary striated variety. The *capillaries* form plexuses around the fibers. The *lymphatics* follow the course of the blood-vessels.

Involuntary Striated or Heart Muscle.—The cardiac muscle resembles both of the preceding in some of its characteristics. It has both cross and longitudinal striations, is not under the control of the will, has branches and is found arranged more or less in layers. It is found only in the heart. A *cardiac muscle fiber* is a short, stubby, branched cylinder that measures 100 to 200 microns in length, 25 to 40 microns in diameter. Each cell has a branch that connects with that of another cell. A fiber shows both

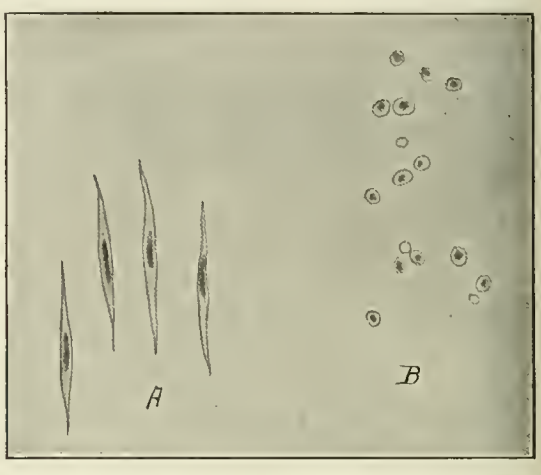


Fig. 4018.—Smooth Muscle Fibers. *A*, Longitudinal section from human aorta; *B*, cross-section from human uterus.

longitudinal and cross striations; the former are due to the presence of fibrillæ that have the same general structure as those of voluntary striated muscle and are surrounded by sarcoplasm. These fibrillæ, however, are not found in the region of the nucleus. They are usually arranged in radial groups. The cross striations are due to the presence of dim and light discs as in voluntary muscles. The fibrillæ seems to be continuous from cell to cell. The fiber is surrounded by a delicate membrane, but not a sarcolemma. Each cell possesses a single, large, oval nucleus that is centrally located: occasionally two nuclei may be present. The chromatin network is distinct and each nucleus is surrounded by an area of undifferentiated protoplasm in which granules and fat droplets are at times seen near the poles of the nucleus. Upon cross-section, the fibers show the radial arrangement of the fibrillæ.

According to some investigators, heart muscle represents a syncytium in which no distinct cell boundaries are to be detected. Others maintain that there are individual cells as above described as shown by special stain methods. After treatment with certain reagents, the muscle syncytium seems to be separated at fairly regular intervals by septa-like structures, the *intercallated discs*, which continue across step-like, or zigzag. Although some investigators consider these cell limits, these lines are very irregular as to form and position and indicate, according to those that uphold the syncytial character of heart muscles, a

"fixed phase of contraction wave" or are due to an irresistible strain condition. It is of interest to note that the fibrillæ continue through the intercallated discs from one so-called cell to another, seeming thus to indicate a syncytial nature.

Blood-vessels are more numerous in the heart than any other organ. The capillaries lie in close relation

Fig. 4019.—Human Heart Muscle. *A*, Cross-section; *B*, longitudinal section, showing the branches.

to the fibers and may even lie in grooves. In some animals the capillaries are seen imbedded in the muscle cells. *Lymphatics* follow the course of the vessels.

Muscle tissues are derived from those special portions of the mesoderm called the *myotomes*, or *muscle plates*. The cells that form the muscle fibers are called *myoblasts* and they multiply very rapidly. In the formation of voluntary striated muscles the myoblasts elongate and the nuclei increase in number. The myoblasts become separated by the mesenchymal cells, the latter forming the fascia and tendons. The protoplasm contains granules that are mitochondria according to Meves and Duesburg. Meves studied the development of fibrils in chick embryos and found that the fibrils developed independently of one another. During the second month, in the human embryo, the granules form peripheral, longitudinal striæ (future muscle substance) and a delicate membrane appears, derived probably from the mesenchyme. The nuclei lie in the central undifferentiated protoplasm. More striæ are formed and cross striations appear so that by the sixth month there remains but a small central core of unchanged protoplasm containing the nuclei. M. Heidenhain has recently investigated the formation of the fibrils in the trout embryos and found as Maurer did that the first fibril, by a radial longitudinal division, forms a peripheral ring of fibrils and these fibrils by splitting form the central fibrils. As the central protoplasm becomes differentiated into fibrils the nuclei migrate to the periphery or occupy the deeper portions according to the cell. The remaining undifferentiated protoplasm between the fibrils constitutes the sarcoplasm. Thus the white fibers are formed. In the red fibers fewer fibrils are formed and the sarcoplasm predominates. This variety represents an intermediate form between the myoblasts and the white variety.

Most of the smooth muscle fibers are derived from the myoblasts of the mesoderm; the exceptions are the the muscle of the sweat glands and the muscles of the iris which are of epithelial origin. In either case the

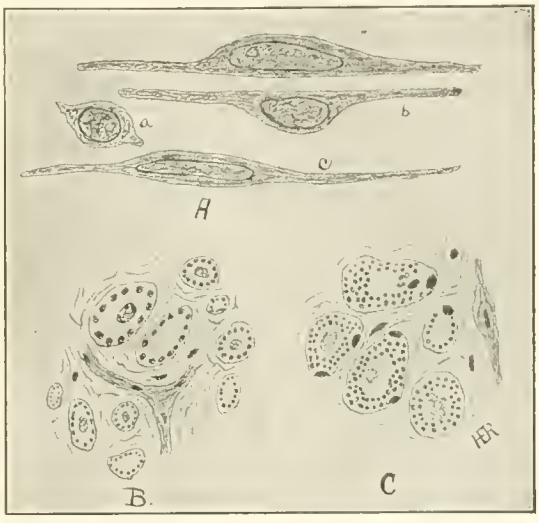


Fig. 4020.—Developing Muscle Cells of Pig Embryo. *A*; *a*, Myoblast; *b*, young spindle cell; *c*, older spindle cell. (After Bardeen.) *B*, Cross-section of voluntary striated cells of 45-mm. pig embryo showing the formation of fibrils at the periphery of the cells. *C*, The same of a 75-mm. pig embryo showing the increase in fibrils and the formation of the peripheral nuclei. (*B* and *C* after MacCallum.)

cells elongate and become spindle shaped while the nucleus elongates. The protoplasm gradually shows the formation of fibrillæ that soon completely occupy the entire protoplasm. McGill believes that smooth muscle starts as a syncytium and remains so throughout life.

The early stages of the cardiac muscle fibers is similar to the above. Later, however, these fibers seem to join to form a syncytium as pointed out in the study of the avian and mammalian hearts by Heidenhain and by G. Mann in the frog's heart. Later this syncytium becomes incompletely altered into individual cells.

After becoming completely developed voluntary striated fibers continue to increase in size to birth and from that time to adult life. They double their size in the last half of gestation and in the adult are about five times the size as at birth. The increase of muscle cells is due to the presence of myoblasts in the muscles, even in the adult.

Although formerly it was believed that muscle tissue does not regenerate it appears that diseased or cut areas are later joined by muscle tissue. Some consider it due to the presence of myoblasts but Schmincke states that the existing fibers bud from the end.

Pfitzner found that in artificially produced lesions of smooth muscle tissue regeneration occurs by the neighboring cells multiplying by karyokinesis.

H. E. Radasch.

Bibliography.

1. Bernstein: Pflueger's Archiv, cx., 1905.
2. MacDonald: Quart. Jour. Exp. Physiol., 1909, II.
3. Huerthle: Pflueger's Archiv, cxxvi., 1908.
4. Schäffer: Quart. Jour. Exp. Physiol., 1910, III.
5. Meves: Anat. Anzeiger, xxxiv., 1909.
6. Duesburg: Anat. Anzeiger, xxxiv., 1909.
7. McGill: Amer. Jour. Anatomy, ix., 1909.
8. Schmincke: Ziegler's Beitrage, xlv., 1909.
9. Holmgren: Arch. für mic. Anat., 1907.
10. Holmgren: Anat. Anzeiger, July, 1913.
11. M. Heidenhain: Anat. Anzeiger, July, 1913.
12. Svartz: Anat. Anzeiger, March, 1914.

Muscle, Pathology of.—Striated Voluntary Muscle.—From the pathological point of view, the important points to be considered in the structure of striated voluntary muscle are the amount of interstitial connective tissue, the size and shape of the muscle fibers, the striation, and the number and position of the nuclei. Normally the endomysium, or the connective tissue separating the individual fibers, is small in amount, while that separating the fasciculi is considerably larger in amount, varying in different portions of the muscle. The distinctness of the striation depends somewhat on the method of fixation and preparation of the tissue, but in well-fixed preparations the fibers show a distinct transverse striation, due to the difference of refraction of the fibrillar and interfibrillar substances of the fibers, the ultimate fibrils being anisotropic, while the sarcoplasm is isotropic. In cross-sections, the muscle fibers present irregular lighter and darker areas, due to the arrangement of the fibrils in columns, known as muscle columns, with a larger amount of sarcoplasm between the columns than is found between the individual fibrils. The muscle fibers are large, showing normally in cross-section a diameter of from 10 μ to 100 μ, while they often attain a length of twelve centimeters. Their free ends are usually pointed, while the end attached to tendon is rounded. The nuclei of white muscle fibers are situated immediately under the sarcolemma and are very numerous, a cross-section of a muscle fiber presenting from one to four or five nuclei. The nuclei of red muscle are situated in the sarcoplasm between the musele columns. Marked variations occur in the number of nuclei, however, as has been pointed out by Morpurgo and Bindi and others. In young muscles, the nuclei are more abundant and more uniformly distributed than in adult muscle. In small adult muscles the nuclei are more abundant than in the larger fibers, while in the large irregular fibers the number is very variable and much smaller than in the smaller fibers or the embryonic muscle. Hence growth of muscle is not accompanied by corresponding increase of nuclei, the small fibers with high coefficient of growth preserving the juvenile character of nuclear abundance. These are the fibers which change most in the process of activity hypertrophy, the abundance of nuclei corresponding to a greater reserve of growth energy.

Under different pathological conditions, any one of these factors may be materially altered. The connective tissue may be increased or diminish in amount. The muscle fibers may be larger or smaller than normal and may change their shape and their relation to each other. The striation may become indistinct or even be lost altogether, the fibers assuming a granular or homogeneous appearance, while the nuclei may be greatly increased in number and very irregularly grouped, so that some sections will contain large numbers of nuclei, while others contain none. The muscle fibers may segment into short discs, or may break up longitudinally into small slender fibrils, which may remain attached at one extremity, giving the appearance of a branching of the parent fiber. With some modifications I have made use in the following discussion of the classification suggested in the American Text-book of Pathology.

Most of the pathologic conditions in muscle are not primary, but are secondary to some general disease. In wasting diseases, there are many changes in muscle not proportional to the emaciation of the patient. These changes are alterations in size, shape, and staining reactions of the fibers, increase of nuclei, production of false giant cells, and increase of connective tissue. Fewer muscle changes are associated with acute general diseases and these consist of hyaline and granular changes and fatty degeneration, especially in diphtheritic toxemias and certain blood disorders.

Circulatory Disturbances.—Voluntary striated muscle has a very rich blood supply; numerous arteries break up into rich, long-meshed plexuses of capillaries, which surround the muscle fiber, each cell being in contact with several capillaries. The free anastomoses of these vessels easily compensate for any local obstructions, thrombosis, or embolism, and prevent any deleterious results, unless an infective embolus is the cause of the obstruction, in which case an abscess results. "In cachectic conditions, fevers, etc., in which the nutrition of the muscle is lowered, an anemic necrosis may result from arteriosclerosis, deficient heart action, local compression, infiltrations, etc. Such anemic infarctions are seen in senile gangrene, decubitus, etc." (Warthin.) Psoas infarcts, associated with bedsores, may result from long continuance of the recumbent posture, in which case the main arteries of the muscle may contain obturating thrombi or may show a proliferating endarteritis. In this condition, the entire muscle may undergo Zenker's necrosis, appearing white and translucent, but usually hemorrhages are scattered through the muscle and the necrosed area is surrounded by an extensive extravasation of blood. Scar tissue may replace the necrosed tissue, attempts at regeneration of the muscle fibers being frequently found; if the area becomes infected, however, a psoas abscess may result.

Anemia of muscle may result from general anemia or it may be local in origin, being caused by obstruction in the nutrient arteries, compression or arteriosclerosis. The muscle is pale and either soft, as when the affection is local, or dry, when the process is part of a general anemia. The muscle may, however, be brown from increase of pigment.

Hyperemia usually disappears shortly after death, the passive hyperemia occurring only in the rare cases of extreme vascular stasis, while the congestive form is found in the neighborhood of inflammatory areas. Edematous muscle is softer and moister than normal muscle, and on microscopic examination clear vacuoles are seen in the protoplasm of the muscle cells, while the connective tissue is much looser than under normal conditions, the connective-tissue fibers being separated by accumulations of clear fluid. In severe cases, the muscle fibers may undergo liquefaction.

Hemorrhages in muscle are far from uncommon; they may result from trauma, from convulsive contractions of the muscle, from increased blood pressure, or from degenerative changes in the vessel walls or in the surrounding muscle. Such changes are common in typhoid or typhus fever, in septic conditions, pernicious anemia, etc., while small hemorrhages are frequent in the acute infections, phosphorus poisoning, leukemia, and pernicious anemia. As a result of the hemorrhage, the muscle fibers are pushed apart and may be destroyed, if the hemorrhage is large. The muscle liquefies or undergoes a coagulation necrosis. Blood clot becomes organized and a pigmented scar remains, only a few regenerated muscle fibers usually replacing a portion of the connective tissue of the scar. The connective tissue may, however, develop into cartilage and bone, as in some of the cases of traumatic myositis ossificans.

Retrogressive Changes.—Changes in size of the voluntary muscle fibers are among the commonest changes met. Under circumstances of increased nutrition, whether from the general condition or from systematic muscular exercise, the muscle fibers increase in size and we have a true *hypertrophy* of the muscle, while under the opposite conditions of disuse or diminished use of muscle, or when the general nutrition is lowered, the fibers undergo *atrophy*, the diminution in size varying with the degree of the unfavorable conditions. These conditions of true hypertrophy and of simple atrophy are usually transient, the fiber being restored to its normal appearance on the restoration of the normal conditions. If, however, the exercise be continued too long or be carried to an excess, the hypertrophied muscle may

become atrophied, and simple atrophy may lead to degenerative changes. Simple atrophy, in its simplest form, occurs in old age, but it is also seen in cachectic states, such as tuberculosis, carcinoma, etc., and it may result from compression of the nutrient arteries. Macroscopically, atrophic muscles appear paler, dryer, and firmer than normal. A brown pigment, hemofuscin, probably a product of the sarcoplasm of the muscle fiber, may develop in the fibers, giving them a brown color. In some cases, the fibers undergo *hydropic degeneration*, serous atrophy, in which the muscle appears moist and soft.

The clinical aspect of the muscular atrophies will be treated under a separate heading. Regarding the pathological aspect of the muscular atrophies, we may say that atrophic degenerations may be neuropathic, depending on lesions in the spinal cord, or they may be primary or myopathic. In the former case, some of the most interesting changes are those which occur in the spinal cord; the cells of the anterior horn are atrophied and show degenerative changes and the pyramidal tracts are involved. The degeneration may even be traced to cells in the medulla and motor cells of the cerebral cortex. In the myopathic form of muscular atrophy, or the so-called muscular dystrophy, the nervous system shows no essential changes, although varied and irregular alterations are described by certain authors, such as atrophy of the posterior root ganglion cells, some cytoplasmic changes in the ganglion cells of the spinal cord, etc. None of these changes, however, is found uniformly in all cases of muscular dystrophy, and the disease is therefore believed to originate in the voluntary muscle and is probably due to some congenital anomaly of development. Atrophy of the motor cells is noted in many of the cases reported in the literature. This may readily be explained as the result of faulty development, and the development of muscles might well stop if at a certain age the motor nerve cells thus atrophied, while it is not unreasonable to suppose that the motor nerve cells might undergo secondary atrophy, as the result of this degeneration of the muscle fibers. The idea that the dystrophies could be differentiated by the fact that the atrophy was uniformly preceded and accompanied by hypertrophy of the muscle fibers has been practically overthrown by the recognition of the fact that in both the neuropathic and myopathic atrophies the atrophy may be preceded by hypertrophy, the fibers being enlarged to a variable extent before the atrophy sets in, and even at the height of the atrophic process some enlarged fibers may be found among the many atrophic cells. In neuropathic atrophy, however, the localization of the degenerative process varies according to the localization of the lesion in the cord.

In a case of traumatic transverse myelitis resulting from an injury to the cord in the lower dorsal region, the psoas muscles showed the most extreme degree of degenerative changes, while the lumbar muscles and the leg muscles contained bundles of extremely atrophic fibers, and the muscle cells of other bundles were normal in size, appearing hypertrophied by contrast with the atrophied fibers. In the psoas muscles, most of the cells were very small, appearing scarcely larger in cross-section than involuntary muscle cells. No transverse striation could be observed in any of the fibers and the cross-sections appeared either homogeneous or finely granular. Some, however, were vacuolated, some showing very little of the protoplasmic substance of the fiber, appearing to consist of nucleus and sarcolemma, the intervening space being clear. A few of these fibers in cross-section presented no nuclei; in the majority, however, one or two deeply stained, relatively large nuclei were seen near the end of the oval cell, while some showed a crescent or corona of nuclear substance at the periphery. Many cells were seen containing numerous nuclei, which were often hyperchromatic and appeared as a dense, fused mass of deeply stained chromatic substance. These giant cell forms or sarcolytes were especially numerous in some fields, while in others very few were found. In longitudinal sections, longitudinal and transverse cleavage could be observed, and in many areas long, narrow, spindle-shaped cells were seen, which contained long rows or chains of deeply stained nuclei. There was also a marked increase of connective tissue, often accompanied by a deposition of fat, especially in the increased connective tissue of the endomysium. This picture may be taken as the typical picture of muscular atrophy, varying in degree, but little in character. The increased connective tissue, the fibrillar forms mentioned, and the multinuclear, giant-cell forms have been the subjects of much discussion. Durante, Kroesing, and others, upholding the view of embryological development of muscle advocated by Hoffmann, Waldeyer, and others, that the striated muscle cell is a syncytium developed by the fusion of numerous spindle-shaped cells of the mesoderm, describe the longitudinal cleavage or fibrillation of the muscle fiber as a return to the embryonic condition. They state that these fusiform fibers may form new muscle fibers, but usually degenerate and mingle with the connective tissue, acquiring all its characteristics. To this tissue Kroesing gives the name myogenous connective tissue or connective-tissue state of the muscle fibers. He states that the increase of connective tissue in muscular atrophy is due to the formation of this tissue rather than to an increase of true connective tissue. In preparations stained by Mallory's differential stain for connective tissue, however, it may be plainly seen that this tissue gives the reaction of true connective tissue, so that we may conclude that, if it be derived from muscular tissue, it has acquired, not only the morphological, but also the chemical characteristics of connective tissue. It seems more probable, however, that the muscle degenerates on account of the poor nutrition of the tissue, and that the increase of connective tissue is due to the well-known tendency of connective tissue to replace lost tissues and to fill spaces where it is needed. The fate and significance of the multinuclear forms have been considered by many authors and have been generally regarded as attempts at regeneration. Fujinami, however, believes that in purely degenerative processes, cells morphologically identical with the myoblasts of regenerating muscle may be found, and that in these cases they should not be interpreted as having a regenerative significance, but rather as degenerative forms. While this point seems to need further investigation, Fujinami's view receives confirmation from the fact that these multinuclear forms are quite as numerous in the most extreme degree of muscular degeneration, where no tendency to repair seems to be present or is to be expected, as in areas less severely affected. Ishida found iron in the atrophied muscle fibers of these cases; the iron came, not from the blood, but directly from the muscle substance and he was able to obtain a similar condition in animals by nerve section. Muscles atrophied by nerve section also show an increase of phosphorus bound to protein but little change in the proportion of mono- and diamino-nitrogen.

Progressive muscular dystrophy, in its simple form, presents a very similar pathologic picture to that described for neuropathic atrophy. The pseudohypertrophic form, however, is characterized by a marked formation of adipose tissue, formed probably from the proliferated cells of the endomysium, although Kroesing states that it arises from a metaplasia of the muscular tissue into adipose tissue. This myogenous adipose tissue is distinguished from true adipose tissue by the presence of fragments of muscle or by remains of muscle structure or arrangement.

In this form of atrophy, as in the others, the muscle fibers are more or less atrophied although a true hypertrophy of the muscle may accompany the increase of connective and adipose tissue. Increase of muscle nuclei, vacuolation, and granular degeneration may also be noted in these fibers. Durante believes that the muscular hypertrophy is congenital or is developed in early life, while the degenerations and elephantiasis are probably of much later growth.

Thomsen's disease, or Myotonia congenita, is a special form of muscular dystrophy, which is hereditary and congenital and affects numerous members of the same family. It is characterized clinically by the occurrence of tonic cramps, when the patient attempts to move. A case described by Koch may be taken as typical of the affection. The patient was twenty-one years old and his musculature was well developed. The principal symptom of the affection was stiffness, slowness, and difficulty of motion, especially when first beginning to move but wearing off later as the effort was continued. This symptom had been noticed since early childhood. The cramps are usually painless and may affect the limb muscles, the eye muscles, and the muscles of mastication, but the extremities are the parts most involved. The involuntary muscles are spared. Cold and nervousness may cause an increase of the affection, while systematic muscular exercise is beneficial. The affection is rarely cured, although it does not endanger the life of the patient. Erb describes an increase of the interstitial connective tissue, with marked hypertrophy of the muscle fibers. The finer details of structure may also be slightly altered, the striations being less distinct than normal, the fibers appearing more homogeneous, but often vacuolated. Koch describes a longitudinal cleavage of the muscle fibers, causing an increased number of fibers. He states that amitotic division of the muscle nuclei was observed, resulting in the formation of the long, slender cells containing rows of nuclei, such as are observed in degenerative and regenerative processes.

Degenerations.—While the various forms of muscular degeneration have been variously classified, it may be noted that they all tend to occur together, wherever the muscle is exposed to unfavorable conditions. Progressive muscular atrophy, whether of nervous or of muscular origin, may be accompanied by any or all of the degenerative processes, while inflammations, injuries of muscle, and tumors are all, to a greater or less extent, surrounded by areas of degenerated muscle. One of the most common and at the same time the most serious degeneration affecting striated muscle is the *granular degeneration,* also known as *cloudy swelling.* The fiber is usually enlarged, the striations are less distinct, the cell appearing distinctly granular. The granules are not fatty, since they do not react to osmic acid nor dissolve in ether or chloroform; they dissolve in acetic acid. Durante distinguishes two forms of granular change—one, which we may regard as physiological, due to excessive activity of muscle, and analogous to the granular change in gland cells during secretion. The fibers are enlarged and the striations are indistinct on account of the thickened layer of granular sarcoplasm lying between the sarcolemma and the fibrils. This condition is usually transitory, the cell returning to its normal state as soon as the conditions which caused the change have been altered. If, however, the cause persists, the cell may undergo fatty degeneration or liquefaction or coagulation necrosis. The second type is a true degeneration, leading to the death of the cell, and occurs in cachexias, infectious diseases, myositis, and other muscular affections. A similar change in the structure of muscle may be seen in the beginning of autolysis. There is no sharp line of separation between necrosis and cloudy swelling; it has been suggested that the latter is due to aggregation of colloids without coagulation; hence the granules are soluble. Later when coagulation takes place, the granules are less soluble. (Wells.)

Hydropic degeneration of voluntary muscle occurs especially in suppurative inflammations, chronic edemas, etc., and is characterized by the presence of

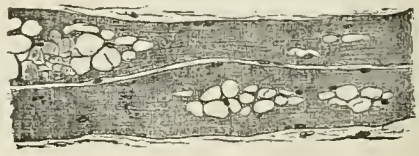


Fig. 4021.—Hydropic Degeneration of Voluntary, Striated Muscle. (Ziegler.)

clear vacuoles in the protoplasm. Fresh muscle thus affected appears pale and watery. It may be distinguished microscopically from simple edema of muscle by the fact that the muscle nuclei stain poorly in case of degeneration.

Fatty degeneration occurs in an extreme degree in cases of phosphorus poisoning, in diphtheritic toxemia (Wells) and to a less degree in tuberculosis, in fevers, intoxications, etc. The muscle cells show fat globules in their protoplasm, which therefore appears peculiarly reticular. These may merge into larger fat droplets. These cells stain poorly in eosin, so that a fiber undergoing fatty degeneration appears hazy and mottled, while, after treatment with osmic acid, the droplets show the characteristic black reaction. The muscle nuclei may also show the characteristic degenerative changes. True fatty degenerations seem to be much less common than is usually stated, but collections of fat droplets are frequently found near the nuclei, especially in advanced life. They are rare in childhood and almost unknown in animals. They appear to have little, if any, pathologic significance.

In cases of inflammations, fevers, intoxications, and in the neighborhood of malignant tumors may be found fibers undergoing *simple necrosis;* these are larger than normal, show no transverse striations and no nuclei, and the entire fiber takes an indifferent bluish-red color, when stained with hematoxylin and eosin. In chronic edema, suppurative inflammation, etc., the muscle fibers may undergo *liquefaction necrosis.* The fibers at first appear enlarged, vacuolated, or granular, and finally dissolve in the fluids in the surrounding tissues. Zenker has also described a *waxy or hyaline necrosis* of the muscle fibers, occurring in typhoid fever. It may also occur in any severe fever, in acute tuberculosis, in sepsis

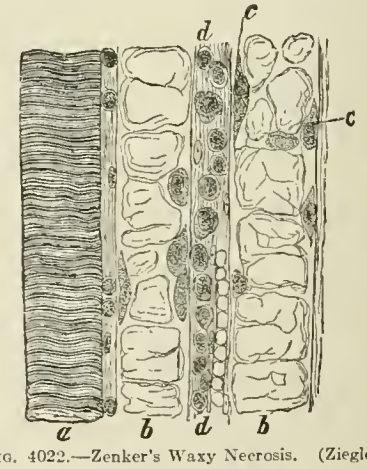


Fig. 4022.—Zenker's Waxy Necrosis. (Ziegler.)

and variola, and also in wounds, inflammations, and to a limited degree in all the pathological processes which may result in the degeneration of voluntary muscle. If the degeneration is of wide extent, the affected muscle is soft, white and translucent, resembling fish-flesh. The softening may lead to more or less extensive hemorrhages in the muscle. The muscles most frequently severely affected are the psoas, the abdominal muscles, and the muscles of the thigh. The muscle fibers are of irregular size and form, many of them being swollen. The cross striation is lost, at least in many areas, and a peculiar hyaline or waxy mass appears in the protoplasm, the fiber finally breaking up into irregular hyaline masses, which are afterward absorbed. The hyaline mass usually stains poorly with the ordinary stains, but may resemble fibrin in its reaction to Weigert's fibrin stain, while in the Van Gieson stain it may react like colloid. The hyaline mass may fill the entire cell or occupy only certain areas, these peculiar homogeneous areas being surrounded by granular sarcoplasm, while some areas may appear striated and quite normal. The nuclei may entirely degenerate, while in milder cases they may proliferate and lead to the regeneration of the muscle fiber. A leucocytic infiltration of the intermuscular connective tissue may precede or accompany this degeneration. This form of degenerative change usually results from the action of toxic substances and is undoubtedly due to increased accumulation of acid in muscles with diminished supply of oxygen. Wells was able to produce the appearance of Zenker's waxy degeneration by allowing weak solutions of lactic or other acids to act on the muscle fibers. The degenerated muscle fibers show a great increase of fat and water and also of sodium and calcium, while the potassium is diminished. In senile gangrene, decubitus, infective inflammations, burns, freezing, and in lowered nutrition of the skin and subcutaneous tissues, the voluntary muscles may undergo gangrenous changes, the muscles becoming brownish, black, or greenish in color, breaking up into shreds or liquefying, or, if exposed to the air, undergoing mummification. Microscopically, the muscle fibers present the picture of liquefaction or coagulation necrosis, the fibers losing their form and striation. A marked leucocytic infiltration accompanies this process, while blood pigment and crystals of cholesterin and triple phosphate are often found. In mummification, the cells shrink and lose their form and nuclei and finally appear like horn. Not unlike a liquefaction gangrene is the degenerative process described by Hoen as occurring in the striated muscle fibers of the uvula. This is characterized by a bleb-like change, associated with pigment formation and nuclear proliferation. The sarcolemma is raised by the vesicles, each of which contains a nucleus, so that the liquefying process seems to begin in the undifferentiated sarcoplasm surrounding the nucleus. Cross striation can still be seen in places, but the longitudinal striation is replaced by wavy and undulating lines, due to the twisting of the fibrillæ. The final stage of the degenerative process shows masses of large blebs, containing small, large, and misshapen nuclei, with pigment, through the middle of some of which runs a shadow suggestive of a muscle fiber. Even in such a mass, some fibrils may be found which still show striæ.

Fragmentation and Fibrillation.—In necrosis and in most of the degenerative and other pathological states of muscle, fibers may be found which are breaking up either longitudinally into long fusiform fibrils, or transversely into irregular plates or discs of muscle substance. Often the fibril can be traced to the point where it joins the parent fiber. The process results in the atrophy of the main fiber, while the fibril which has been split off may either develop into a new muscle fiber, as in the regeneration of muscle by the proliferation of its nuclei, or it may still further degenerate, either shrinking into threads so that the tissue closely resembles fibrous connective tissue, or undergoing fatty degeneration and forming a tissue resembling adipose tissue.

Amyloid Degeneration.—Warthin states that "*amyloid degeneration* of voluntary striated muscle is rare and occurs especially in the muscles of the tongue and larynx. The deposit begins in the capillary walls of the endomysium and may extend around the sarcolemma, causing an atrophy of the fiber. The atrophic fiber then appears as if surrounded by a glassy hyaline substance. Ultimately the fiber disappears and the confluence of the deposit leads to the formation of nodular masses."

After experimental nerve section, certain degenerative processes occur in voluntary muscle, due probably rather to disturbances of circulation and nutrition than to direct influence of nerve section. The nuclei undergo direct division, the new nuclei showing no tendency to lead to regeneration of the muscle. The muscle fibers show vacuolation and transverse cleavage, with diminishing of distinctness of striation and a slowly developing atrophy.

Schujeninoff has carefully studied the processes involved in the *calcification* of striated muscle, both experimentally in animals and by observation of men. He concludes that the lime salts are deposited in muscle under certain conditions, as after the suture of a wound in the muscle. The calcification takes place after the fibers have undergone a colloid degeneration. When the lime salts are absorbed, the calcified fiber disappears. The calcification of muscle is therefore a local, secondary process, which stands in relation with the local disturbance of circulation.

Regeneration of Voluntary Muscle.—In embryonic life, striated muscle fibers develop from mesodermic cells, each fiber being formed by endogenous proliferation of the nuclei of a single cell. This is the view advanced by Remak, Schultze, Kölliker, Zenker, and many others, who contend that the growth both in length and thickness takes place by this nuclear proliferation, while the protoplasm changes into the contractile substance of the muscle fiber. This view is opposed by Hoffmann, Waldeyer, Kroesing, Durante, and many others, who believe that the muscle increases in length only by endogenous division of the nuclei, while the increase in thickness is brought about by the apposition and fusion of numerous fusiform cells. Experimental degeneration of muscle has been brought about by tenotomy, by neurotomy, and by sectioning the muscle fiber itself. Numerous experiments have also been undertaken in the transplantation of portions of muscle taken both from the same animal and from other animals, even those of a different species. Salvia transplanted muscle from a rabbit to fill the space made by removing portions of a dog's muscle. He states that the result was perfectly satisfactory, as the new muscle replaced the old perfectly both anatomically and functionally. Others have claimed equal success in similar experiments, but Capurro, in a series of experiments recently reported, gained results which were only partially satisfactory. The result of transplanting free pieces of muscle was negative. By using only a portion and leaving a pedicle attached during the union, he was able to secure satisfactory functional results. He observed degenerative changes in the muscle, such as simple atrophy, Zenker's necrosis, fibrillation, increase of connective tissue, leucocytic infiltration, etc. In these cases, as well as in wounds of muscle, granulation tissue is first formed. The muscle nuclei proliferate, both by mitotic and by amitotic division, and buds of sarcoplasm containing the new nuclei grow out from the ends or body of the muscle fiber into the granulation tissue. These buds at first show no

striation, but contain many large nuclei and appear like epithelioid cells. Then in the sarcoplasm, fibrils are formed and thus the fiber becomes striated. Several new fibers may be formed from one bud or myoblast. In addition to these myoblasts, free multinuclear cells are formed, known as sarcolytes. These are not in connection with the original fiber, and while some may form new fibers or unite either with the old fiber or with new ones, most of them probably undergo fatty degeneration or necrosis. The sarcolytes may resemble the myoblasts in section and give the appearance of regenerative effort, even when the conditions are so unfavorable that no attempt at regeneration is to be expected. A perfect regeneration of muscle appears to be possible only when the contractile substance is but slightly injured and the sarcolemma and muscle nuclei are intact, as after freezing, after the degenerative changes of typhoid fever, sepsis, and trivial traumatic injuries in which but little of the contractile substance is lost. In more severe injuries the regeneration is only partial, muscle fibers growing out from the ends of the old fibers into the granulation tissue which at first replaces the destroyed muscle. (Warthin.) Volkmann states that regeneration is functionally important only after typhoid fever and freezing, while after injuries the regeneration is so slight that function is not restored unless the wounds are small. Larger wounds heal by the formation of scar tissue, which is muscularized from both sides and ends, but only for a short distance. Transplanted pieces of muscle degenerate and are replaced by sear tissue, which is in the same way muscularized for a short distance from the sides and ends. Kümmel, however, reports a case in which he sutured the ends of muscle which were from eight to ten centimeters apart, and secured almost perfect restoration of function after six months. The differences in the reported results may depend upon different nutritive or nervous conditions, but it would seem from the majority of the reports that, while voluntary muscle does regenerate by both mitotic and to a limited extent amitotic division, its power of proliferation is extremely limited and does not extend to the complete restoration of large areas of destroyed muscle fiber.

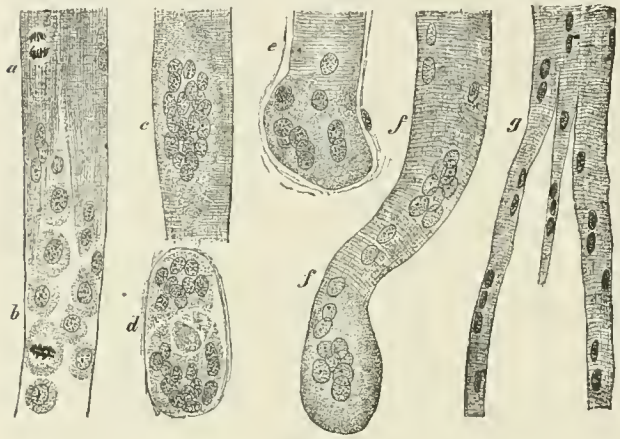


Fig. 4023.—Regeneration of Muscles, Myoblasts, and Sarcolytes. (Ziegler.)

Changes in the Muscular Nerve Endings.—The subject of degenerative changes in voluntary muscle can scarcely be fully treated without some consideration of the changes occurring in the motor and sensory nerve terminations in this muscle. I am not familiar with any work reporting the changes in the motor endings in human muscle occurring under pathological conditions, but Huber has reported the results of some experiments on rabbits, in which he crushed the posterior tibial nerves, afterward studying the motor and sensory nerve endings in the interossei muscles by means of the *intravitam* methylene-blue method. Till the end of the first day after crushing the nerve, the motor endings presented a normal appearance and the muscle responded to electrical stimulation of the nerve, applied below the point of injury. During the second day, changes began to appear in the motor endings, ushered in by relatively large, usually round or oval, deeply staining enlargements, or varicosities, varying in number, size, and shape, which were found on the arborizations of the motor endings. These changes did not affect all the motor endings at the same time; but when a majority of all the motor endings in the muscle showed the nodular enlargements, the muscle failed to respond to electrical stimulation. At the same time the nerve fiber showed degenerative changes at its distal end. Later, the arborizations disappeared or failed to stain differentially, although the so-called sole plate sometimes stained a faint blue. The regeneration of these endings was observed about thirty days after the experiment, beginning with the formation of fine, varicose fibers terminating in a small granule, and passing through various transition stages to an ending which is in every respect like the original. Not until numerous regenerated motor endings were found, did the muscle again respond to electrical stimulation. The neuromuscular nerve end-organs are the most interesting of the sensory nerve endings found in voluntary muscle and have been subjected to the most careful investigation. Sherrington sectioned the sciatic nerve, causing degeneration of the nerve fibers and complete atrophy of the muscle fibers, but found the intrafusal muscle fibers of the spindle well preserved and the striation retained 150 days after the section. Eichhorst reports the presence of fat globules in the intrafusal muscle fibers of neuromuscular spindles in a case of phosphorus poisoning. Grünbaum found the muscle fibers atrophied and surrounded by hyaline substance in some of the spindles in a case of pseudo-hypertrophic paralysis, while Gudden observed atrophy of the intrafusal fibers in a case of alcoholic neuritis. Batten examined the condition of the neuromuscular spindles in cases of infantile paralysis, tabes dorsalis, myopathy, progressive muscular atrophy, and peripheral neuritis, and found the muscle spindles normal, except in one of the three cases of tabes examined. After injury of the brachial plexus, however, which resulted in complete loss of motion and sensation, he found changes in the spindles one year after the traumatism. The spindles were small, the intrafusal fibers were atrophied and granular with indistinct striation, while the nerve fibers going to the spindles were poorly stained. Batten therefore concludes that after injury or section of the nerve, neuromuscular spindles undergo degenerative changes in time, but much later than the surrounding muscle fibers. Laslett and Warrington found the spindles unaltered in a case of lead paralysis examined by them. Batten, in a series of experiments upon animals, showed early degenerative changes in the nerve terminations within the neuromuscular end-organs, with later changes in the form, caliber, and arrangement of the intrafusal muscle fibers, but he was unable to reproduce the fatty change of the intrafusal muscle seen by him in the case of tabes dorsalis. Huber, in the experiments previously described, found that the myelin of the large sensory nerve fibers going to the neuromuscular and neurotendinous end-organs showed segmentation, and that the nerve fibers within the organs were broken up into irregular, deeply staining fragments, which gradually disappeared. The

changes in the sensory nerve end-organs did not, however, take place until the third day after the crushing of the nerve. No degenerative changes in the muscle fibers of the spindle were mentioned by him. Regenerating sensory endings were seen by him on the forty-first day after the experiment, but it was not until the end of the second month or the beginning of the third month that the nerve endings in these organs presented an appearance similar to that found in the normal organs. In the case of transverse myelitis previously described, the neuromuscular nerve end-organs showed edema, the layers of the capsule being widely separated by clear fluid, and the muscle fibres also being crowded apart. The muscle fibers of the spindle did not, however, show any marked pathological changes. In the neurotendinous nerve end-organs, also, Cattaneo and others have demonstrated early changes in the nerve endings.

Inflammations.—The inflammatory processes in voluntary muscle may be acute, subacute, or chronic. The true inflammatory conditions are largely interstitial, involving the connective tissue of the endomysium and perimysium and the capillaries, while the muscle fibers undergo degenerative changes as a result of the changed nutritive conditions brought about by the presence of the inflammatory exudate. The inflammations may be the result of the extension of an inflammation from neighboring tissues, or germs may be carried into the muscular tissue through the blood current. Traumatism, disturbance of nutrition, and vascular changes may also act as powerful indirect etiological factors. Myalgia or so-called rheumatic myositis or muscular rheumatism often affects the muscles of the back, neck, or the intercostal muscles. In some cases it is probably not a myositis but a neuralgia, due to slight twisting or laceration of some of the muscle fibers. Its one common symptom is pain in the muscles. E. C. Rosenow has described, however, cases of muscular rheumatism in which microscopic examination of pieces of excised muscle showed edema, marked degeneration of the muscle fibers, extravasation of blood and leucocytic infiltration. Cultures made from these bits of muscle gave colonies of streptococci closely resembling those obtained from the joints in rheumatism. A case which was treated with a vaccine of various strains of organisms from rheumatic patients recovered without suppuration in the muscles and without developing further lesions. He was also able to produce similar muscle lesions, with joint involvement and often endocarditis in experimental animals by injection of pure cultures of streptococci obtained from cases of muscular rheumatism.

In *acute parenchymatous myositis*, the muscle fibers show granular, hydropic, and fatty degeneration, Zenker's necrosis, fragmentation, fibrillation, etc. The endomysium contains large numbers of leucocytes and is edematous, while the capillaries and blood-vessels are distended and filled with blood cells. If the degenerative changes in the muscle fibers are not too severe, recovery usually takes place with complete restoration of structure and function of the affected muscle. This comparatively mild form of inflammation occurs after slight injuries, in disturbances of circulation, in typhoid fever, and in the neighborhood of new growths. Trichina cysts, anthrax pustules and other irritating conditions may produce similar processes in neighboring muscles. A similar form of myositis has been called by Froriep *monomyositis*. It arises on a traumatic or infectious basis and may lead either to muscular abscess or to an indurative interstitial inflammation which ends either in repair or in the formation of a muscle tumor. The course may be acute, subacute, or chronic. The symptoms consist of extreme pain in the affected muscle, generally preceded by chill and slight rise of temperature. There are swelling and edema of the skin over the affected part, with swelling and extreme tenderness of the affected muscle, which soon becomes very hard. There is also contracture of the affected muscle, with diminution of the electrical excitability. A more severe and generally fatal inflammatory affection is known as *primary acute polymyositis*. This is infectious in character and is accompanied by edema and marked swelling of the overlying connective tissue and hyperemia and even exanthema of the overlying skin. The clinical symptoms are fever, pain, tenderness, and loss of function in the affected muscles. These symptoms suggest trichinosis, and Hipp suggests the name pseudo-trichinosis. The resemblance indeed is at times so striking that a differentiation can be made only by removing portions of the affected muscle and subjecting them to microscopical investigation. This form of myositis is sometimes known as dermatomyositis, because of the simultaneous involvement of the skin and muscles. Polymyositis may also be hemorrhagic in character, since a marked extravasation of blood may be found between the muscle bundles. This usually runs a chronic course, death resulting from involvement of the heart. In certain septic cases a diffuse, purulent infiltration of various muscles may occur, this condition being rarely regarded as primary and terminating in gangrene of the muscle. Ziegler describes a case of phlegmonous inflammation of the subcutaneous and intermuscular connective tissue near the pectoral muscle, resulting from an infected wound. Skin phlegmons, erysipelas, decubitus, and purulent arthritis may also cause similar suppurative muscular affections. The muscle is swollen and softened and may be mottled yellow, brown, red, and greenish in color. The pus infiltrates the endomysium and may burrow along the sheaths of the muscles for considerable distances. Small, circumscribed abscesses, either single or multiple, are found throughout the muscle in various regions in case of hematogenous infection. These small abscess cavities are filled with pus and tissue débris, and are surrounded by edematous and degenerating muscle. These small abscesses may be absorbed or become encapsulated, while larger ones break and discharge their contents, being replaced by scar tissue, which gradually contracts and is partly replaced by new-formed muscle fibers. The scar tissue may undergo calcification, while the encapsulated forms may become either calcified or liquefied. On exposure to the air, this greenish-black, gangrenous muscle evaporates or undergoes mummification. Stierlin has described a case of septic total necrosis of muscles resulting from wound infection with obstruction of the artery and therefore interference with the nutrition of the part. The bacteria were gas-forming, putrefactive bacteria. Fragments of the necrotic muscle filled the abscess cavities. The entire process was limited to the musculature, the skin being unaffected. The connective tissue and lymph and blood capillaries were filled with innumerable cocci, forming a network around the muscle cells, which appeared in cross-section as homogeneous red discs in which no nuclei could be seen. Very few cocci had penetrated the muscle cells. An *acute interstitial or productive myositis* may also be distinguished; it is progressive in character and generally passes into the chronic form. It occurs in typhoid fever, chronic irritations, etc. The primary changes are in the connective tissue, which proliferates and causes a secondary degeneration of the muscle fibers.

Chronic Myositis.—In progressive muscular atrophy, whether neuropathic or myopathic there is a marked increase of the intermuscular connective tissue, so that the small muscle bundles are separated by thick bands of connective tissue, or the muscle may be entirely replaced by connective tissue. This constitutes the condition known as chronic interstitial

myositis or fibrous myositis. It may also occur in the neighborhood of chronic inflammatory or irritative processes, as ulcers, tumors, parasites, foreign bodies, etc. It may also attack the muscles in the neighborhood of inflamed joints, as in inflammatory rheumatism, gout, etc. Acute purulent myositis may be followed by a condition in which the abscesses are walled in by granulation tissue and we may speak of it as a chronic purulent myositis. This occurs most frequently in the psoas muscle. While the condition may follow an ordinary pyogenic infection, it is far more common after specific infections, such as tuberculosis, syphilis, actinomycosis, glanders, gonorrhea, leprosy, etc.

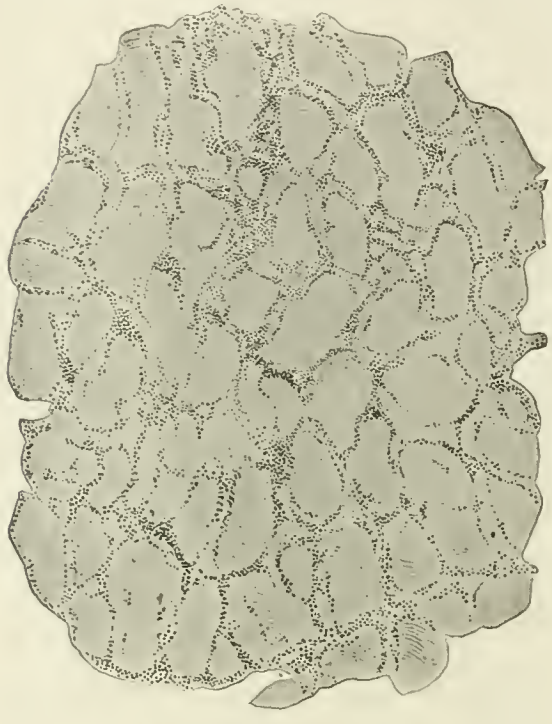


Fig. 4024.—Purulent Myositis, with Necrosis of Muscle. (Stierlin.)

Tuberculous myositis may and frequently does occur in muscles in the neighborhood of a tuberculous abscess or some focus of infection, the process extending directly into the muscle from the infected area, as in the muscles surrounding a psoas abscess or caseating lymph gland, or in the intercostal muscles in pyothorax and in miliary tuberculosis of the pleura. Primary or hematogenous tuberculosis of muscle is, however, rare—a fact which is explained by the bactericidal action of the muscular fluid, which, as Tria states, is more efficient in its action than the fluids of any other tissues. Cases of hematogenous tuberculosis of the muscles have, however, been described by Habermaas, Müller, Delorme, Reverdin, and Lanz and Quervain, and Steinthal, the latter having collected eight cases of primary tuberculosis of the abdominal muscles. The tuberculous nodules found in the intermuscular connective tissue present usually a caseated necrotic center surrounded by a zone of lymphocytes and epithelioid cells with some giant cells, and this is surrounded by a zone of connective tissue. Blood-vessels are poorly developed in these areas. The muscle in the neighborhood of one of these areas may be normal, but is usually atrophied, while the muscle nuclei are increased in number and surrounded by a clear zone; the protoplasm of the muscle diminishes as the nuclei increase in number, so that finally the sarcolemma appears filled with nuclear masses. As the muscle degenerates, it is replaced by connective tissue into which the tuberculous foci extend. Here they consist of lymphocytes mostly, with a few epithelioid cells. According to Petit and Guinard, the tuberculous process originates in the intermuscular connective tissue, the degeneration of the muscle resulting from the presence of cells called myophages, which send processes between the contractile fibrils and gradually destroy them. In none of these cases were the tubercle bacilli demonstrated microscopically, but the history of the case, the microscopic appearance of the tissue, and the positive results gained by injecting the contents into guinea-pigs made the diagnosis unquestionable. Tuberculous myositis must be differentiated from syphilitic myositis, interstitial myositis, actinomycosis, echinococcus, and benign and malignant tumors. A tuberculous abscess may also be found in muscle, consisting of muscular and cellular débris surrounded by a thin wall of granulation tissue poor in blood-vessels.

Syphilitic myositis may be diffuse or circumscribed. In the former case there is a primary diffuse infiltration of the connective tissue with a secondary degeneration of the muscle fibers. It occurs especially in the later stages of syphilis and attacks by preference the muscles of the extremities. It is characterized by a painful, indurated swelling of the affected muscle, which is easily differentiated from other muscular affections by its prompt response to antisyphilitic treatment. Muscle gummata, while not infrequent in the later stages of syphilis, have not often been described. They may, as in the case reported by Eger, develop many years after the syphilitic infection. If no regressive changes have taken place, they are usually indolent in their course, causing no pain, no disturbance of function, and no alteration in electric excitability, unless by their excessive growth they press upon nerves or blood-vessels. They are influenced more or less readily by the potassium-iodide medication. The large tumors may caseate, forming deep ulcers or abscesses, which heal readily but leave indurated scars, which may disturb the function of the muscle. In the earlier stages, the gummas consist of very vascular granulation tissue which may be mistaken for sarcomatous tissue, but later the characteristic three zones develop, the outer consisting of vascular granulation tissue, the inner caseated zone, and the intermediate zone of mature connective tissue. Giant cells may be present or absent. The rich blood supply, the absence of tubercle bacilli, and the response to antisyphilitic medication will readily differentiate these nodules from those of tuberculosis.

A case of *gonorrheal myositis* involving the latissimus dorsi has been described by Ware. The microscope revealed a picture of interstitial inflammation, with cloudy swelling of the muscle fibers, though in some places the striation was still distinct. There was some proliferation of the muscle nuclei, showing a possible tendency to regeneration of the muscle fibers. The connective tissue was so greatly increased that the muscle fibers were crowded apart and compressed. No germs were found except the diplococci. This form of myositis is characterized by the intense sclerotic process, which is so marked a feature of gonorrheal inflammation in other localities. The process generally heals by the formation of connective tissue, which usually undergoes resolution, although cases have been reported of ossification of the affected muscles. If an abscess forms, it is probably due to a mixed infection. The localization of gonorrheal myositis is probably generally due to extension from neighboring joints and bones, though it may sometimes result from metastasis.

Leprous Myositis.—Fujinami describes the changes

which take place in voluntary muscle in cases of leprosy. The muscle is crossed by white strands consisting of connective tissue containing many fat cells and numerous brown pigment granules arising from degenerated muscle fibers. The muscle fibers are atrophied, showing either a very irregular arrangement of the striation or a granular and pigment degeneration. The nuclei are increased in number, enlarged, and very irregularly arranged, while many of them take the stain intensely and show indistinct outlines, so that they appear as fused, hyperchromatic masses. The changes are similar to those observed in muscular atrophy, in the neighborhood of tumors, in inflammatory processes, and are probably due, not to the direct action of the bacilli, but to disturbance of the nutrition of the muscle, perhaps brought about by chemical changes in the lymph caused by the growth of the bacilli. Colonies of leprosy bacilli are seen between the atrophic muscle fibers and in the connective tissue, and they are sometimes seen within the connective-tissue cells or leucocytes.

Actinomycotic myositis is not at all common, but in rare cases a focus infected with the ray fungus may, either by direct extension or by metastasis, lead to an infection of voluntary muscle. The infection results in the formation of nodules of granulation tissue, which may undergo fatty degeneration or suppurate and form abscesses. The healing of these nodules leaves areas of induration which are not easy to distinguish from the scars of syphilitic myositis. An inflammatory affection of muscle may also be due to an infection with the *glanders* bacillus. This leads to the formation of many small, grayish abscesses, containing a thin fluid in which the germs are found. The muscle may become infiltrated with pus and chronic ulceration or abscess may result.

Animal Parasites.—Varieties of chronic myositis may also result from the presence of certain animal parasites, one of the commonest of which is the *Trichina spiralis*. When found in muscle, it is in the encysted stage of its development, which is known as a measle. The poorly cooked measly pork is eaten, the capsules dissolve in the gastric juice, the embryos develop in the intestine six or seven days after the ingestion of the meat. These pass into the muscles, showing a preference for the diaphragm, tongue, intercostal muscles, neck, larynx, and thigh muscles. The worm penetrates the muscle fiber, which degenerates, the fibrillæ appearing swollen, granular, and with indistinct striæ. The worm is soon surrounded by a clear, homogeneous capsule, which later becomes calcified. There are at first evidences of acute interstitial inflammation in the intermuscular connective tissue, which later disappear. The clinical symptoms consist of irregular fever, gastrointestinal disturbances, typhoid symptoms, edema of ankles, pain and tenderness in the muscles. Brown notes a marked leucocytosis in acute cases, the eosinophile cells being most markedly increased, reaching 68.2 per cent. of all the white blood cells present. Muscular changes take place similar to those in chronic myositis—increase of connective tissue, fibrillation and segmentation of the muscle fibers, with granular and hydropic degeneration of the muscle fibers, proliferation of nuclei and thickening of the sarcolemma are the most marked changes noted. Death may result in the acute stage of trichinosis, or the worms may become encysted within calcified capsules and create no further disturbance, remaining innocuous during the life of the individual. The diagnosis of trichinosis depends on the history, the onset with more or less severe gastrointestinal symptoms, followed after a variable time by swelling, pain, and tenderness in the muscles. These symptoms may be accompanied by fever, sweats, abdominal pain, edema of face and ankles, leucocytosis, and eosinophilia. All doubt may be removed by microscopic examination of the stools, bits of excised muscle, and remnants of suspected food for ova and parasites.

This disease is one which can be prevented by proper prophylactic measures. These are in the main of three kinds: (1) the elimination of the disease in swine; (2) inspection of meat and rejection of all "measly" or trichinous meat; (3) thorough cooking of all meat, especially pork. If it is discovered early that infected meat has been eaten, the stomach and intestines should be thoroughly evacuated by the use of emetics and purgatives. Glycerin and turpentine have been given in order to destroy the worm. The constitutional and muscular symptoms are treated by the usual measures for relieving pain, producing sleep, and maintaining the strength.

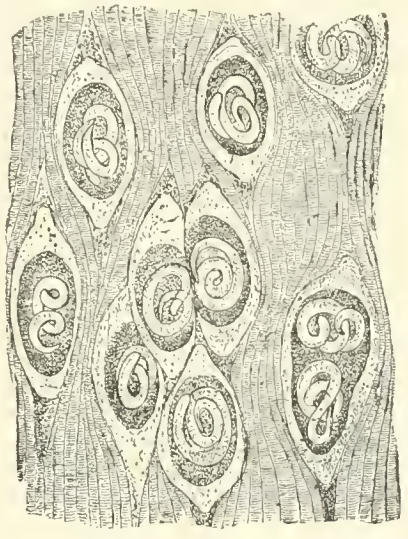


Fig. 4025.—Trichinæ Encysted in Voluntary Muscle. (Ziegler.)

The *Cysticercus cellulosæ* may sometimes be found encysted in muscle, the cyst being surrounded by a firm fibrous capsule, the whole being surrounded by a zone of inflamed muscle tissue. The *Echinococcus* may be encysted in muscle, although it is far more prevalent in the liver and lungs. The capsule is dissolved in the gastric juice, the embryo developing and making its way through the wall of the stomach or intestine and either passing through the portal circulation to the liver and thence to the heart and lungs, which are the regions infected in sixty-five to seventy-five per cent. of all cases, or wandering actively to the muscles and other regions. Gerulanos has collected from the literature 214 cases of muscle echinococcus, 195 of which were single, while nineteen were multiple. Most of these were, however, very limited in number, while the cysts in the case described by Gerulanos were very numerous, varying in size from a pinhead to a man's head. Some of the largest had suppurated and contained masses of pus, while others showed scolices, and others contained nothing except a clear yellowish fluid. The tumors were white, opaque, and either smooth or lobulated, surrounded by a fibrous capsule. The question of the origin of the multiple cysts is one of considerable importance. It is claimed by some that each cyst develops from a single embryo, by others that one cyst, containing an embryo, is formed from which daughter cysts are given off; others believe that the rare cases of multiple echinococcus cysts are due to rupture of a fertile cyst and hence a reinfection of the surrounding tissues. Gerulanos, however, thinks that in his case at least the multiple infection was due to an active wandering of the embryos, which follow the paths of the loose

connective tissue surrounding the large vessels, in the neighborhood of which these colonies were usually found. In the case reported by Scholtz, however, the hydatids were found on the outer side of the thigh, far removed from the great vessels. In several of the cases reported, trauma was described as an etiological factor, but probably, as Gerulanos suggests, the trauma has simply called attention of the patient to a latent tumor which has existed for a long time. The diagnosis of this condition must be based on the presence of an elastic, fluctuating, dense, slightly sensitive tumor. The sensitiveness will of course depend on the exact location of the hydatid. It must be differentiated from neoplasms and cold abscesses. The elasticity and fluctuation indicate fluid contents, while the lobulated, multilocular feeling and the history of the case will generally distinguish the echinococcus cyst from the cold abscess, although the cyst may also sometimes be smooth and spherical. The treatment consists in extirpation of the tumors.

Myositis Ossificans.—Myositis ossificans, as its name implies, is a disease in which an inflammatory affection of the muscles terminates in ossification. Long regarded as a pathological curiosity, it is still a comparatively rare disease, the character and etiology of which are not beyond controversy. Cases of pathological ossification naturally divide themselves into two great classes: those in which bone is formed in connection with bone, an abnormal activity of the cells of the periosteum being the apparent causative factor, and those in which bone is formed in the softer tissues, having no connection, primarily at least, with the skeletal bones or their periosteum. Myositis ossificans occupies a very prominent position in this second group of cases. Two types of this disease are sharply differentiated—a progressive and a localized form. The progressive type, known as myositis ossificans progressiva, is distinguished

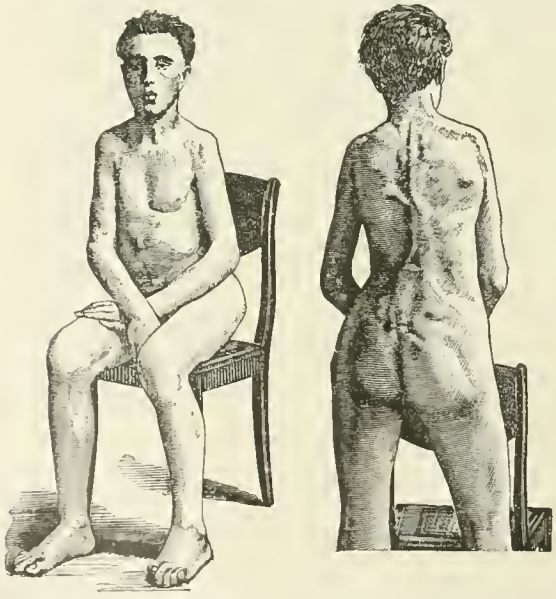


Fig. 4026.—Myositis Ossificans Progressiva, Showing Multiple Osseous Tumors, Forming an almost Continuous Ledge along the Spinal Cord, Fixation of the Head, Microdactyly, etc. (Brenosohn.)

from the localized form by the facts that many series of muscle groups are attacked, that it begins in youth and advances with occasional periods of apparent repose followed by exacerbations, which may or may not be attributable to any known exciting cause. This type is much more easily recognized than the others, so that most of the cases mentioned in the literature belong to it. The earliest cases of myositis ossificans progressiva were reported in the Philosophical Transactions of 1740. In the same journal in 1741, Copping gives the following graphic description of a case: "Das ganze Rückgrat war ein zusammenhängender Knochen, von dem sich ein scharfer Rand erhob, der wie eine Handhabe aussah, woran man das Skelet halten konnte. Es waren ihm jedes Jahr aus den Fersen Hörner gewachsen, wie die Sporen bei den Hähnen und die Ueberwüchse von Knochen waren in so grosser Menge da, dass es eben so schwer sein würde sie zu zählen als die Stalactiten in der Grotto der Calypso." In 1869 Münchmeyer, giving to the disease the name suggested by von Dusch, myositis ossificans progressiva, described the disease so accurately that little has been added to his description by later writers.

He declares the disease to be a constitutional affection of slow course with periodical exacerbations followed by periods of apparent repose. The first disturbance of the muscle tissue begins with a marked infiltration of the intermuscular connective tissue, so that the name myositis ossificans interstitialis which has been suggested is not inappropriate; the second stage, that of connective-tissue induration, consists of an excessive growth of intermuscular connective tissue with destruction of the striated muscle as a result of pressure atrophy or fatty degeneration. The third stage is that of ossification, which begins in the center of the affected muscle in the connective-tissue ground substance. The disease begins in youth with local swelling and later loss of function and ossification. Sometimes local and radiating pain is associated with it and also slight febrile reaction. The skin may be of higher temperature than normal and the connective tissue may be edematous. The swelling may disappear after from two to four weeks, leaving the muscle hard and ossified, a condition which is sometimes temporary, but generally spreads to the origin and insertion of the muscle and remains permanent. With very few exceptions, the disease makes its appearance in the muscles of the back, especially in those of the upper portion of the back or of the neck. In connection with the neck muscles, the ligamentum nuchæ becomes ossified and the long muscles of the back generally form one mass of bone; later, the muscles of the scapulæ and the latissimus dorsi are involved; afterward the anterior muscles of the neck are attacked and then the deltoid and the muscles of the axial space. The final result is usually complete fixation of the head, immobility of the entire spinal column and ankylosis of the joints of both shoulders in the position of adduction, with fixation of the scapulæ. Still later, the muscles of the arm and forearm may become inflamed and the elbow-joint ankylosed; the muscles of the hand, however, possess almost complete immunity. In the further course of the disease the muscles of the pelvic girdle, the glutei, and then those of the lower limbs become involved; only at the last and in very severe cases does the disease extend to the muscles of the jaw and of the palate, while the face muscles usually remain intact. Münchmeyer notes the complete immunity of all muscles which are not attached to bone at both extremities, hence of heart muscle, of the diaphragm and sphincters, the muscles of the eye, of the tongue, the facial muscles, the muscles of the genital regions, and the muscles of the abdomen. This immunity is not, however, absolute, since Münchmeyer notes the occurrence of bony tumors in one case on either side of the chin, the location of which coincided with that of the triangularis menti. The disease rarely advances steadily; it is quite characteristic that there should be pauses which may last for years, the renewal of the process being either spon-

taneous or the result of some injurious influence. Deformities of a more or less severe degree, involving the position of the head, of the spine, and of the extremities result from the fixation of the joints, from the degeneration and loss of function of the muscles, and from the increase and subsequent contraction of the connective tissue. Münchmeyer closes his detailed description of this rare and terrible disease with the following vivid picture: "At first deprived of only a few not very necessary motions, the patient after a time can no longer carry food to his mouth, the hip and knee on one side become immovable, and finally walking becomes impossible. And during this whole long time, there is a constant alternation of hope, as each tumor disappears and as each pause occurs, and the sad feeling of bitterest disappointment as each new symptom appears, until finally all hope is gone, the mouth can no longer be opened, the food can be introduced only through an opening artificially made between the teeth; even swallowing and speaking become at times extremely difficult. The mental condition in a few cases indicates perfect resignation, but generally deep psychic depression prevails."

Although the disease is a comparatively rare one, a careful study of the literature has resulted in finding seventy-eight cases, most of which have followed the typical course which has been described. Exhaustive study of the literature of this disease has been made by Münchmeyer, Pinter, Pincus, Roth, and others, the results having been carefully tabulated by Pincus.

Little is known regarding the etiology of the affection. It occurs very generally in youth, with very few exceptions under fifteen, often in infancy, but Kronecker reports a case beginning at fifty-four. Males seem to exhibit a certain predisposition to the disease, nine of Münchmeyer's twelve cases being males and thirty of Roth's thirty-nine. Many factors are mentioned as predisposing to the disease, such as cold, damp, poor hygienic surroundings, insufficient nutrition, rheumatism, and other constitutional affections. A congenital predisposition is naturally suggested by the fact that it so universally occurs in early childhood, that it is so generally symmetrical in its development, and also by the fact that it is often accompanied by a curious congenital malformation. This is microdactyly, an ankylosis of the phalanges of the thumb, and a lack of one phalanx of the great toe on both sides. This malformation was first noted by Florschütz in 1873, since which time it has been observed in about seventy-five per cent. of all cases reported. While this is the most common abnormality noted in connection with this affection, other anomalies are mentioned, such as hallux valgus and other malpositions and incomplete development of the testis and other organs. Lexer has described quite minutely the microscopical appearance of sections taken from several tumors removed from two cases of myositis ossificans progressiva. Near the periphery of his preparations he finds quite normal muscle fibers. Near the center, the muscle fibers are more or less degenerated, the cross striations lost, the muscle nuclei increased, so that the fibers in many cases resemble giant cells; the fiber is broken up, while the intermuscular connective tissue is increased and infiltrated with leucocytes, especially in the neighborhood of the capillaries. The connective tissue contains many cells of different forms, arising from division of the connective-tissue cells, which may be regarded as fibroblasts, while in some places may be seen cartilage cells with formation of hyaline cartilage. Nearer the center the ground substance becomes denser, the former connective-tissue cells lie in small angular spaces, and the formative cells lie in rather regular rows on the dense tissue which comprises the osteoid trabeculæ. Later these become calcified and thus bone is formed. The fact that these tumors consist of true bone, often with all the structure of compact bone, is noted by many authors, who have not given so detailed a description of their findings as has Lexer. The degeneration of the muscle fibers, the increase of the connective tissue, and its infiltration with leucocytes are noted by all who have examined these tumors microscopically. Kissel, however, reports a case in which no osseous tissue was found, although the clinical picture was typical of the disease. The tumors showed only young connective tissue with remains of altered muscle. In his case some of the tumors disappeared, leaving no trace, while others broke down and a puriform liquid was discharged. This case improved somewhat under treatment and was regarded by Kissel as an incipient stage of the disease.

The *prognosis* in this disease is undeniably very bad. The course is, however, very slow, interrupted by many pauses of longer or shorter duration, and death directly assignable to the disease is very rare. As a usual thing, the disease drags its slow course along, the patient becoming more and more helpless, all vital functions unimpaired, until some pulmonary complication or some other intercurrent affection closes the scene.

Treatment seems practically useless; yet, as in all hopeless diseases, many remedies are tried, partly in hope of relieving the most painful symptoms, and perhaps partly in the hope that the diagnosis may be wrong. Among the remedies suggested are thyroid extract, phosphoric acid, and sodium salicylate. In a few cases, extirpation of the tumor was attempted in the earlier stages. So unanimous is the opinion regarding the bad prognosis in this disease that we may well be doubtful of the correctness of the diagnosis in those cases in which cure or permanent improvement is noted.

The disease has something in common with muscular rheumatism, with the muscular dystrophies, with polymyositis acuta, and with the multiple osteomata, but the history of the case, the order of advance of the disease from one series of muscles to another, the symmetrical nature of the affection, with the characteristic deformities resulting from the progress of the disease, make the diagnosis easy, especially in the later stages.

Cases of myositis ossificans confined to single muscles or groups of muscles are less frequently noted in the literature, either because the disease is less easily recognized or because it seems less striking and worthy of note. A careful study of the literature has resulted in finding thirty-five cases. Some of these cases followed a single severe injury, as in the four cases reported by Cahen, in which the growth resulted from the kick of a horse. Other cases resulted from repeated injury or strain, under which heading we may include the ossification of the deltoid and arm muscles in soldiers and of the thigh muscles in riders. This perhaps includes far the largest number of this class of cases. Then we have ossification of muscles occurring in the course of a chronic inflammatory process, which may be rheumatic, syphilitic, or tuberculous.

Cahen describes a case in which, six weeks after a kick had been received, a bony tumor was found about twelve centimeters long on the left thigh, corresponding to the position of the biceps. After the failure of other modes of treatment, the tumor was excised; after a short time the tumor returned and was again removed, this time with the periosteum, to which it had become adherent. The sections from these two growths present somewhat different appearances. At the periphery of the section of the first tumor and crowded by connective tissue containing many blood-vessels and large spindle cells, he finds muscle fibers which have undergone many degenerative changes—hyaline degeneration, increase of nuclei of sarcolemma, loss of striation, etc. Near the center of the tumor, he finds irregularly arranged trabeculæ of bone, with an epithelium-like lining of osteoblasts,

with many lucunæ and giant cells, and the spaces filled with a marrow extraordinarily rich in blood-vessels and connective-tissue cells. All through the preparation are scattered bits of muscle, the relation being so intimate that single muscle fibers are completely embedded in bone. In the sections from the second tumor, no muscle fibers are seen. There are three distinct zones: a zone of greatly increased connective-tissue cells, then a zone of small-celled hyaline cartilage, which, by ingrowth of blood-vessels and giant cells, is changed into bone. There is no distinct boundary between the cartilage and bone, the cells becoming smaller and losing their capsules while the intercellular substance becomes denser, more opaque, and stains bluish red in the hematoxylin-eosin double stain. The development of bone in all cases investigated stood in direct relation with an increase of the intermuscular connective tissue.

Lehman describes the case of a woman of thirty-six years, who presented herself with a tumor in the thigh which had been developing at irregular intervals since her seventeenth year. The tumor was extirpated and with it the greater part of the biceps,

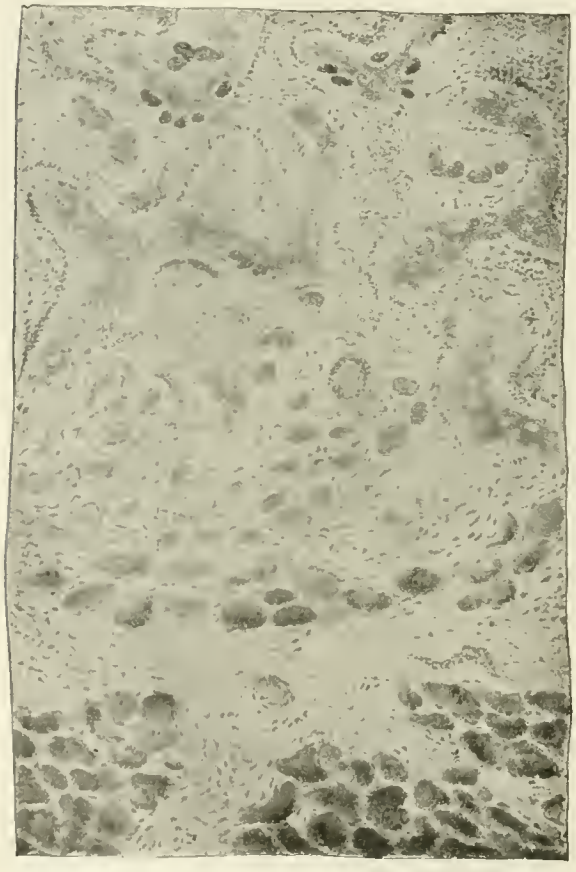


Fig. 4027.—Microscopic Appearance of Muscular and Osseous Tissue, Removed from one of the Tumors in a Case of Myositis Ossificans. (Cahen.)

which was involved in the tumor mass. Microscopic examination showed a large amount of adipose tissue, permeated by bands of altered muscle.

The author has reported two cases of myositis ossificans limitata, one being that of a farmer, aged twenty-three years, the cause of whose death was pulmonary and laryngeal tuberculosis. His clinical history presents nothing of interest in this connection until six weeks before death, when he complained of pain in the left leg. On examination the left leg and foot were found swollen, soft, and edematous. The thigh was also swollen, although less than the leg. No tumor was detected, however, and a marasmic thrombus was believed to have caused the edema. The autopsy showed a very general tuberculous process. In the left saphenous vein was found an old obturating thrombus, which extended through the femoral, the left external iliac, and into the left common iliac and the abdominal vena cava. Around the wall of the femoral vein there was an area of hyperemia and infiltration, originating apparently from an enlarged lymph gland near by. This gland on section showed infiltration and caseation. The microscopic appearance was as follows: Both femoral vessels were nearly or quite filled by thrombi in various stages of organization. The entire section showed marked hyperemia, all the smaller vessels and even the capillaries being distended and packed full of blood corpuscles. The connective tissue surrounding the large blood-vessels, as well as that around the smaller ones, was infiltrated with leucocytes, this being especially marked in the intermuscular connective tissue and around the capillaries of the endomysium. Many of the leucocytes showed degeneration and in some portions of the sections larger or smaller necrotic, abscess-like areas were found. Surrounding these necrotic areas, and indeed in many portions of all the sections, attempts at repair were noticeable. The inflammatory tissue had been replaced by a new granulation tissue, rich in small, thin walled blood-vessels and in large plate-like cells with little fibrous tissue. The most marked changes, however, were in the muscular tissue. In addition to the alterations in the intermuscular connective tissue already noted, various degenerative changes in the muscle were observed. The cross

Fig. 4028.—Section through Thrombosed Femoral Vessels, Muscles, Fat, Connective Tissue, and Granulation Tissue Containing Plates of Bone. *m*, Muscle; *b*, bone; *c*, calcification; *t*, thrombus. Drawn under the dissecting microscope, with aid of camera lucida. Magnified about eight times. Reduced to one-half size of drawing. (DeWitt.)

striation was lost and in some even the longitudinal striation seemed lost or very indistinct, so that the fiber appeared finely granular or entirely homogeneous. In some places a muscle nucleus, with a fusiform fragment of sarcoplasm, was separated off from the rest of the cell, and often a small fragment of muscle containing many nuclei, or even a mass of nuclear substance in which the nuclear outlines were very indistinct was seen. Small, isolated fragments of muscle could be seen in the granulation tissue and even in and near the inflammatory, necrotic areas, containing numerous nuclei embedded in homogeneous-appearing protoplasm, producing the appearance of giant cells. These may be interpreted as attempts at regeneration of the degenerated muscle

fiber, although probably many of the forms, especially those in the necrotic areas, were degenerating sarcolytes. In addition to the simple atrophy, fatty degeneration and Zenker's waxy necrosis were noted.

In the granulation tissue, which seemed to have replaced the larger inflammatory areas, were irregularly branching and anastomosing trabeculæ of osteoid tissue consisting of a dense matrix, enclosing rather large cells usually not surrounded by a capsule. The spaces between the trabeculæ were filled with very vascular granulation tissue, somewhat resembling bone marrow. Many of the large cells of these areas were arranged on the trabeculæ, like the layer of osteoblasts on the trabeculæ of developing bone. Most of the osteoid tissue had undergone calcification, at least in the central portion, so that, according to Ziegler's definition, it represented a true ossification process. These ossified masses were found, not only immediately around the femoral vessels, but also extending out in all directions between the degenerating and regenerating muscle fibers, wherever a sufficiently large area of granulation tissue was found. The relation of the plates of bone to the other tissues in the section is represented in Fig. 4028. In the marrow spaces were often seen bits of degenerated muscle, atrophied, non-nucleated, and appearing homogeneous.

The changes in the tissue indicate that the intermuscular inflammation, the changes in the muscle, and the bone formation antedated by a considerable period the thrombosis, which was probably secondary to the other changes.

The microscopic appearance of the two cases was identical and an obturating thrombus was found in the femoral vein in both. The fact that in these two cases the ossification was not discovered until the autopsy had been made and the tissues examined microscopically is of interest as suggesting the possibility that pathological ossification of muscle after injury or inflammation may occur much more frequently than is generally supposed or than can be gathered from the literature, since such an ossification, if limited in extent, may not excite any symptoms that would lead to the diagnosis of myositis ossificans. When the diagnosis is made and the disturbance is sufficient to warrant it, operation seems to offer great hope of recovery. In the cases reported by Cahen, Lehmann, Munro, and others, entire extirpation of the tumor, with the periosteum in cases in which the bone had become adherent to the periosteum, resulted in perfect recovery. Much difference of opinion has arisen as to the true character of the bone formation. Virchow places the disease on the border line between inflammation and new growth and is supported by Lexer, Bollinger, and many others. Mays asserts that it is a true tumor and is supported by Kümmel, Pinter, Helferich, Pincus, Partsch, Cahen, and others. Cahen bases his assumption on the microscopic appearance, especially on the fact that new connective tissue, cartilage, osteoid tissue, and bone are found in the same section, thus showing the characteristics of an atypical growth. They consider the inflammatory phenomena and muscle degeneration to be secondary to the tumor formation. Pincus, after a most exhaustive study of the literature and of his own cases, arrives at the conclusion that myositis ossificans progressiva is not a disease, but undoubtedly a tumor belonging to the multiple osteomata and exostoses of Virchow. He states that the process begins in the periosteum, the muscle degenerating secondarily, and that an inborn, not hereditary, constitutional anomaly lies at the foundation, the constitutional anomaly consisting of an excessive productivity of the periosteum and connective tissue of the locomotor apparatus. The disease needs for its development an external cause, which may be trauma or rheumatism. The apparently spontaneous cases arising in early life are really of traumatic origin and due to intrapartum injuries. Nicoladoni advances the hypothesis that it is a trophoneurosis, comparable to progressive muscular atrophy and pseudohypertrophy of muscle. Electrical tests, however, indicate the absence of any neuropathic factor and the disease is probably myopathic, and either primarily inflammatory in character or having the primary characteristics of a neoplasm. In the progressive form of the disease many of the tumors are probably neoplasms, while others, as would seem to be indicated by Lexer's description, are developed on an inflammatory basis. In consequence of the diffuse interstitial myositis, an indifferent granulation tissue arises, which may change either into scar tissue or into cartilage and bone. In the myositis ossificans limited to single muscles or groups of muscles the primary condition is an inflammatory process in the intermuscular connective tissue resulting in the degeneration of the muscle fibers, either from simple pressure atrophy or from fatty degeneration, so that the name myositis interstitialis ossificans seems not inappropriate. Processes of repair are then established, granulation tissue rich in fibroblasts and small blood-vessels, in which white fibrous and yellow elastic fibers are sparingly developed, is formed. Instead of changing to mature connective tissue, however, a portion of this granulation tissue changes to trabeculæ of osseous tissue, and the rest into bone marrow which fills the spaces between the trabeculæ. This is not unusual since, as is well known, the different members of the connective-tissue group change with great readiness to other forms of connective tissue. Cold, unsanitary surroundings, trauma, either single or repeated, irritation, or chronic pathological processes may act as the direct causes of the development of the disease. This might be satisfactory on the etiology of the affection, were it not that the exciting cause is often so slight and trivial that we cannot believe it sufficient to produce the disease in a normal individual. This is especially true of the

Fig. 4029.—Section through a Few Trabeculæ of Pathological Bone Formation, with Marrow Spaces, Surrounding Granulation Tissue, and, at the Periphery, Degenerating Muscle Fibers. *b*, Bone; *m*, degenerating muscle; *g*, granulation tissue; *s*, marrow spaces; *v*, capillaries surrounded by connective tissue infiltrated with leucocytes. Drawn with the aid of the camera lucida. No 2 eyepiece; one-sixth inch objective. Reduced to one-fourth. (DeWitt.)

progressive type, while in the stationary form of the disease the irritant cause which has operated on hundreds of cases has produced ossification in very few. The explanation of these facts has opened a large field for conjecture and speculation. Virchow believes that in these individuals there is an ossifying predisposition, either hereditary or congenital, which he calls diathesis ossificata sive ossea. Maunz suggests as a predisposing causative factor a disturbance of embryonic development. He says: "In the 'Anlagen' of musculature, where in later life pathological bone formations occur, osteoblastic nuclei enter. These nuclei remain dormant so long as they are held in check by the physiological resistance of the neighboring tissues. If, however, this be weakened, the bone Anlagen develop into the pathological bone formation." He explains in a similar way the occurrence of exostoses and osteophytes which are so frequently found in conjunction with the muscular ossification. Those who favor the view of embryonic disturbance cite the frequent occurrence of microdactylie in this disease as an evidence in favor of their hypothesis. Atavistic influence, misplaced periosteal buds and osteoblasts, etc., have been suggested. Direct heredity, however, seems from the history of the cases reported to have very little influence. Atavistic influence seems to be contraindicated by the fact that in the hand and foot, where splint bones are most common in the lower animals, these osseous growths rarely occur. In the progressive myositis ossificans, beginning in early life, it may be necessary to admit the hypothesis of a congenital condition consisting of an abnormal activity of the osteoblastic, or, if we accept the Weismann theory of embryonic development, the persistence of indifferent, undifferentiated mesenchymal cells, which, under the requisite conditions of nutrition, develop abnormally into nodules of fibrous connective tissue, cartilage, and bone, sometimes in connection with the skeletal bones, sometimes in fascia, tendons, ligaments, or intermuscular connective tissue. In the localized form of the disease, however, no such hypothesis seems to be necessary. In these cases granulation tissue is formed, a new connective tissue, whose cells may therefore revert to the undifferentiated, indifferent, embryonal cell type, mesenchymal cells, which may develop into fibrous tissue, cartilage, or bone according to the prevalent nutritive conditions.

Wounds and Injuries of Muscles.—Injuries of muscle may be of the most varied degree of severity, from a slight strain or sprain, twisting, or laceration of a few fibers of the muscle, which results in the so-called myalgia, to complete severance of all the fibers of the muscle.

Myalgia is a temporary condition of pain in the muscle, which is usually neuralgic, and which is caused by a slight traumatism, with possibly an inflammation of the muscle, or may arise from an acute infectious disease, from syphilis, or from some toxic agent, as mercury, alcohol, or lead. The affection is usually but trivial, and is cured spontaneously, especially if the affected part is put at rest by the use of splints or strapping. Local applications of heat and anodyne solutions are useful, and the pain may at times be so severe that hypodermic injections of morphine may be necessary. If the muscle fibers are weakened by disease or degeneration, or if the strain upon the muscle is too great, either from an external force or from too violent and sudden contraction, the muscle may be fractured, either completely or partially. Fractures and lacerations of healthy muscle are rare except in cases of sudden, unexpected, or unusual contractions. Such accidents are more common among soldiers. Certain diseases, however, such as typhoid fever, yellow fever, scarlet fever, and other severe fevers weaken the resistant power of the muscle, which may undergo various degenerative changes which make it more brittle. The rectus abdominis, the rectus femoris, the adductors of the thigh, the calf muscles, the psoas, and the flexors of the forearm are the muscles most frequently fractured. The symptoms of fracture of muscle are quite characteristic, consisting of sudden sharp pain, with a sensation of giving way and powerlessness of the muscle. In case of complete rupture, a gap is immediately formed between the broken ends of the muscle by the contraction of the parts, and this gap, which can easily be palpated, is a characteristic feature of the affection. It is soon filled, however, by an extravasation of blood, which may form a hematoma of greater or less extent and hence a prominence in place of the depression. The skin becomes discolored usually from the extravasation of blood. Wherever muscle is lacerated, whether the tear is large or small, blood extravasates into the tissues, except in those cases in which the injury is very near the tendinous extremity of the muscle, where the vascular supply is poor. The interference with the function of the muscle depends upon the extent of the laceration, the use of the muscle being lost in cases of complete rupture. If only a few fibers of the muscle are broken, recovery is usually rapid and complete and the function of the muscle may be quite well restored even when the injury is quite extensive. In these milder cases the only treatment usually necessary is perfect rest of the affected part. If, however, the muscles are completely torn across, it is usually necessary to suture their ends; and where there is a considerable gap between the ends, it may be well to fill in the interval with the muscle from an animal (muscle grafting), or with sutures of chromicized catgut or kangaroo tendon to act as a framework for the reparative material. The interval is at first filled with granulation tissue, even the engrafted muscle undergoing degenerative changes; later a scar tissue is formed, penetrated in places by the regenerated muscle fibers. In spite of the experimental work on muscle grafting previously mentioned, the consensus of opinion among surgeons and pathologists seems to show that, while the function of the muscle may be fairly well restored, muscle fibers are not regenerated in sufficient numbers to fill the intervening space. At times the injury results in the formation of bone in the granulation tissue, following the law of the metaplastic tendencies of the connective tissues. In some cases the muscle remains intact, while the overlying fascia is torn, generally as the result of the imperfect healing of some former wound. In these cases the muscle may protrude through the opening in the fascia, forming a muscle hernia. Féré collected thirty-one cases of muscle hernia in epileptics, fifteen of which were symmetrical, a finding which would seem to indicate a certain nervous influence as a possible etiological factor in these cases. The hernia is distinguished from a neoplasm in the muscle, from an aneurysm, etc., by the fact that it disappears entirely or diminishes in size when the muscle is at rest, becoming prominent during the contraction of the muscle. Generally the opening in the fascia can be felt through the skin. The condition may often be attended by considerable inconvenience, pain and loss of function of the affected muscle. Rest and bandaging are usually sufficient to effect a cure in recent cases. In cases of long standing it may be necessary to freshen the edges of the rent and unite them by stitches. It is distinguished from fracture of muscle by the fact that the symptoms usually develop more gradually than those of fracture. It affects the adductor muscles by preference. Muscle may also be more or less completely crushed by external violence. The results of this as well as of other injuries of muscle depend upon several factors. Apparently identical injuries may in one case cause only temporary disturbance of function, in another ossification, and

in another paralysis. Young tissues tend to heal more readily than old. The condition of the muscle at the time of the injury, whether at rest or contracted, has a marked influence on the effect of any traumatism. The nerve fibers which may be cut, injured, or compressed, may have a vital bearing on the permanency and severity of the functional disturbance. Single or repeated injuries of muscle may have a real or fancied relation to the development of malignant tumors, a fact which may be explained by the assumption that embryonic tumor-tissue germs are latent in the muscle, which are either excited to activity by the irritation produced by the traumatism or permitted to grow because the normal resistance of the tissues is removed or diminished as an effect of the injury.

Involuntary Muscle.—Involuntary muscle has a wide distribution, occurring in the walls of the digestive tract, blood-vessels, skin, in the capsules of many organs, and making up the greater part of the structure of the uterus, bladder, and other organs. Its structure is far simpler than that of voluntary striated muscle, and its pathological changes are therefore less complicated and have received less attention and research. It consists of mononuclear, fusiform cells, cemented together to form bundles or membranes, which are separated by a larger or smaller amount of connective tissue. The pathological processes in non-striated, as in striated muscle, consist of inflammations, degenerations, and tumors. Certain abnormalities may be noted occasionally, such as the presence of striated muscle fibers among the involuntary muscle fibers of the uterus. These may be due to the metaplasia of non-striated into striated muscle or to the misplacement of embryonal cells.

The pathological processes occurring in involuntary muscle have not attracted the attention of investigators as have those of voluntary muscle. This may be explained, in part at least, by the fact that any disturbance in the function of voluntary muscle causes unmistakable symptoms, while in most cases the symptoms of change in involuntary muscle are masked and indefinite and the pathological processes in it are often not recognized until after the death of the patient. In most cases of muscular atrophy, whether neuropathic or myopathic, and in other muscular degenerations the statement is made either that the involuntary muscle was normal or that it was not examined. Certain regressive changes, analogous to those which occur in striated muscle, are, however, observed, having been described especially in connection with inflammations and tumors of the myomatous type. Edema of non-striped muscle is frequently noted. Kenntmann described a case of myometritis edematosa, in which the muscle fibers of the uterus became so soft and edematous that the uterine wall was perforated by a sound. Microscopic examination of the myometrium in this case showed the muscle bundles separated by large clear spaces, equal in size to the muscle bundles themselves. This condition was especially marked in the vascular middle layer, in which the blood-vessels presented thickened walls, the connective tissue of the intima being especially thickened. The muscle cells appeared cloudy and in places atrophied. Near the vessels the muscle fibers appeared especially narrowed, even the nuclei being atrophied. Large areas were found in which the muscle had undergone pathological degeneration. No solid strands or bundles were found, and the single fibers were so small that they gave the impression of being reduced to fine fibrils, whose single thicker part, we might almost say whose single dimensional part, consisted of the degenerated and poorly stained nucleus. The connective tissue was probably somewhat increased, but not markedly so; still in places where the muscle was most degenerated, some increase of connective tissue could be observed. Similar degenerative changes are frequently observed and described in myomata of the uterus, which have undergone myxomatous or edematous degenerative changes.

Atrophy of involuntary muscle occurs under conditions similar to those of atrophy of voluntary muscle. A neuropathic form of atrophy of involuntary muscle—although a form which may be considered neuropathic has been mentioned in connection with vitiligo and other skin diseases—has not, so far as I have been able to find, been described. The atrophies are largely due to circulatory disturbances, as in the case above described, or to pressure of a fluid or cellular exudate, as in inflammations. No better picture of atrophy of involuntary muscle has been given than that by Kenntmann. Similar atrophy of the involuntary muscles of the skin in skin diseases has been described by Unna, Pospelow, and Lelois and Vidal.

Hypertrophy of non-striated muscle frequently occurs and may be physiological or pathological. The best example of the physiological hypertrophy is that found in the pregnant uterus. Pathological hypertrophy occurs as a result of stenosis or obstruction of the intestinal canal and other ducts. This is regarded by Herczel as a true hypertrophy, without increase of the number of cells, although many authors regard it rather as a hyperplasia accompanying the hypertrophy. Hypertrophy of the skin muscles was also described by Unna in keratosis suprafollicularis and in pityriasis rubra and other skin diseases. In elephantiasis streptogenes he found the non-striated muscles enlarged, but not increased in number. Calcification of involuntary muscle was noted by Meslay and Hyeme and others, and Brunings reports a case of fatty degeneration of a myoma, the process corresponding to that in progressive muscular atrophy. True ossification of uterine myomata has also been noted. Liquefaction necrosis of the dermal muscles was noted by Unna in abscesses and a collaginous degeneration of these muscles in erysipelas. Gangrene and other forms of necrosis have also been observed in myomatous tumors, as well as cystic degeneration. Nuclear degenerative changes have also been noted, such as atrophy, vacuolation, granulation, and karyolytic changes. The question of the *regeneration* of involuntary muscle is one which has been considerably discussed, and upon which authors are still at variance. Vignolo-Lutati, in his experimental study of the pathological conditions in the skin muscles, was never able to find karyokinetic division figures, but frequently, especially after the less severe injuries, he found appearances which he interpreted as direct nuclear division. Ziegler states that "there is a new formation of smooth muscle fibers and also a regeneration after traumatic, toxic, and chemical injuries, as well as in the hypertrophic new formations of muscle, as in tumors; that this process begins with the karyokinetic division of the nucleus of the muscle cell. However, it is shown by experiment as well as by observation of men that there is very little reproduction of the non-striated muscle fibers, as in the healing of wounds and areas of degeneration, the regeneration soon ceases and the loss of substance in the muscular coats of stomach, intestine and bladder is replaced mostly by connective tissue. The new muscle tissue is formed probably entirely from pre-existing muscle tissue." Moleschott and Piso Borne and Busachi support these conclusions, while Arnold, Aeby, Frey, Neumann, and Virchow favor the view that it may originate from connective-tissue cells, and Kölliker and Förster believe that it develops from embryonal germ cells or formative cells. Tizzoni also found a zone of proliferation near the diseased area in typhoid ulcer of the small intestine; and Baumgartner in cases of tuberculosis found mitoses in the muscle tissue of the arteries, veins, and bronchi near the affected area. Herczel and Baumgartner were unable to find signs of proliferation after

their experiments, while Vignolo-Lutati found only direct nuclear division in the skin muscles in his experiments. From all this work we may conclude that regenerative changes occur in non-striped muscle as in striated muscle, both by mitotic and by amitotic nuclear division; but that the result is only a partial replacement of the destroyed muscle tissue, the main portion being replaced by scar tissue.

Inflammatory processes in smooth muscle are exceedingly common, although generally secondary to similar processes in the neighboring tissues. Vignolo-Lutati reports the development of inflammatory changes in the involuntary muscle of the skin as the result of the injection of bacteria and also of chemical, thermic, and mechanical irritants. With some variations in degree, the pathological picture in all these experiments was essentially the same. The intermuscular connective tissue was infiltrated with leucocytes, which were either diffusely scattered through the tissue or formed small nodes. The blood-vessels were distended and filled with blood, while the whole tissue appeared edematous. The muscle fibers were swollen, vacuolated and hydropic, and crowded apart by the exudate. The muscle nuclei were either granular or vacuolated and karyolytic figures were noted in some of the experiments. After the simpler mechanical injuries the nuclei showed direct division, which the authors regarded as preliminary to regeneration of the muscle fibers. Purulent inflammation of the non-striated muscle of the uterus is a very frequent occurrence, while Aristoff notes a case of syphilitic inflammation of the muscle coats of the stomach, extending from the mucosa. Tuberculous nodes have been noted in the non-striped muscle of myomas of the uterus, as well as in involuntary muscle in other localities.

Heart Muscle.—The muscle of the heart is a peculiar kind of striated, but involuntary muscle, differing histologically from voluntary as well as from involuntary muscle. It forms a syncytium of branched and anastomosing fibers, containing centrally placed nuclei. In the normal heart, the amount of interstitial connective tissue is small. It is, however, greatly increased in many pathologic conditions of the heart. The pathologic changes in the heart muscle are similar to those in other types of muscle. Perhaps the most common change is hypertrophy. The muscle fibers become enlarged and the entire heart is greatly increased in size and in the thickness of its muscular wall, generally as a result of increased activity of the heart muscle in overcoming obstruction in the peripheral circulation. Atrophy of cardiac muscle is also not at all uncommon especially brown atrophy in which the fibers show a yellow-brown pigment around the nuclei. Later in these conditions, deficient nourishment causes degeneration of the heart muscle fibers with weakening of the wall, dilatation and incompetence. Various pathologic conditions may cause the same symptoms and different symptoms may be caused by the same pathologic condition so that the symptomatology may be no index of the condition of the heart. Both fatty and fibroid changes in the heart generally occur in people past middle life. We find two distinct types of fatty heart. In the first, the fat is superimposed on the heart, but sometimes penetrates between the muscle fibers, impeding their action mechanically. In true fat degeneration, the muscle fibers themselves are replaced by fat as a result of obstruction or inflammation of the coronary arteries. Acute fat degeneration may be caused by phosphorus and by toxins of various infectious diseases. The chronic form may result from chronic disease of the kidneys and anemia.

In fibroid degeneration the connective tissue of the heart, usually in limited areas, is greatly increased, the muscle fibers atrophied or degenerated and replaced by fibrous tissue. Certain regions of the heart as the interventricular septum or the papillary muscles are frequent seats of this fibroid degenerative process. This usually results from inflammation and, when acute, is generally septic and when chronic is either a continuance of the acute process or a result of rheumatic endocarditis. The most important symptoms of cardiac degenerations are irritability of temper, pain over the precordium, palpitation of the heart, dyspnea, changes of the pulse and slight edema of the ankles. The general treatment for cardiac degenerations consists of general and heart tonics, avoidance of excessive exercise, regulation of diet, correction of all injurious habits and treatment of any causative disease.

Acute and chronic inflammatory affections of the heart muscle also occur and are classed as myocarditis. The acute form may be interstitial or parenchymatous. In the former, the connective tissue is swollen and infiltrated, while the muscle fibers are degenerated. The parenchymatous myocarditis occurs in fevers and in endocarditis and pericarditis and is characterized by turbidity and softness of the muscle fibers. A rheumatic myocarditis has also been described in which nodules consisting of large cells, are found in the muscle tissue. These nodules were found by Fraenkel in nearly all cases of rheumatic arthritis and in one case of chorea but not in acute infections. Rosenau has shown that the type of streptococcus which was associated with rheumatic myositis also produces myocarditis.

Since 1845, another form of muscle fiber, known as Purkinje's fiber, has been recognized in the heart. In 1893, His, Jr., found also a bundle of small muscle fibers in the posterior wall of the right auricle. In 1906, Tawara showed that such a bundle was present in all species of animals examined and that it sent a

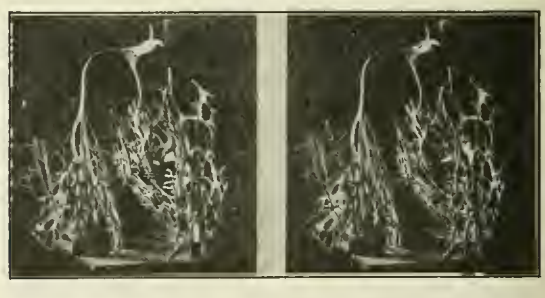


Fig. 4030.—Stereoscopic Photograph of a Model of the Connecting System in the Cat's Heart. (DeWitt.)

main branch to each side of the heart, this breaking up into a complicated system of terminal fibers, known as Purkinje's fibers. These fibers differ from all other types of muscle fibers and are found in the subendocardium and myocardium. The author also has studied and modeled this so-called sinoventricular system (see Fig. 4030). Its function is no doubt conductive, preserving the correlated rhythm of auricles and ventricles. This muscle system is subject to the same pathologic changes as other muscle—hypertrophy, atrophy, hemorrhage, necrosis, etc. The most common condition is atrophy with increase of connective tissue, which may result in complete interruption of the bundle. When the bundle is interrupted, either experimentally by clamping, or by increased connective tissue, by gummata, or by tumors, we have a changed rhythm of the heart, the ventricle beating two or three or more times as often as the auricle. This is the condition found in the well known Stokes-Adams disease, which is no doubt due to some pathologic change in the bundle. Complete heart block may result from complete interruption of the bundle.

Tumors of muscle are treated under a separate

heading and the reader is referred to the article on *Myoma*. LYDIA M. DEWITT.

BIBLIOGRAPHY.

Adami: Principles of Pathology, vol. i., 1908.

Batten: Experimental Observations on Early Degeneration Changes in the Sensory End-organs of Muscles, Brain, 1898, xxi., 388.

Cahen: Ueber Myositis Ossificans. Deut. Zeitschr. f. Chir., 1891, xxxi.

DeWitt: Myositis Ossificans. Am. J. of Med. Sci., 1900, cxx., 295.

De Witt: Sino-ventricular System. Anatomical Record, 1909, ii, 424.

Huber: Observations on Degeneration and Regeneration of Motor and Sensory Nerve Endings in Voluntary Muscle. Am. Journ. of Physiology, 1899–1900, iii., 339.

Ingals: Myocardial Degenerations. J. Am. Med. Assn., 1912, lviii., 1269.

Ishida: Ueber das Auftreten Mikrochemisch Nachweisbaren Eisens in quergestreiften Muskels. Arch. f. path. Anat., 1913, ccx., 67.

Koch: Zur Histologie des myotonisch hypertrophischen Muskels der Thomsen'schen Krankheit (Myotonia congenita). Arch. f. path. Anat., 1901, clxiii., 380.

Lexer: Das Stadium der bindegewebigen Induration bei Myos. ossif. progress. Arch. f. klin. Chir., Berlin, 1895, l., 1.

Münchmeyer: Ueber Myos. ossif. progress. Zeitschr. f. rat. Med., 1869, xxxiv., 9.

Rosenau, E. C. The Etiology of Acute Rheumatism. J. of Infectious Diseases, 1914, xiv., 61.

Ware: Gonorrheal Myositis. Am. Journ. Med. Sciences, 1901, cxxii., 40.

Warthin: Pathology of Voluntary Muscle. Am. Text-book of Pathology, 1901.

Wells: Chemical Pathology 2nd edition, 1914.

Muscular Atrophies, Progressive.—The presence of muscular atrophy at once suggests to the clinician one of two possibilities, namely:

1. The atrophy is a *symptom*. As such it may indicate injury, hemorrhage, inflammation, or new growth, affecting more or less acutely the oblongata, the spinal cord, or peripheral nerves; or it may be one expression of joint disease and then be due to reflex trophic disturbance in the cord.

2. The atrophy is a *disease*. In other words, it is sufficiently regular in its evolution and constant in its associated symptoms to merit a definite place of its own in our nosology. The scope of the present article is limited to this second group of muscular atrophies, those of the first group being treated under appropriate headings elsewhere in this work.

Our knowledge of muscular atrophy as a clinical entity dates from 1850, when Aran[1] published the first account of what we now recognize as progressive spinal muscular atrophy, although he considered it a disease of the muscles primarily. The disease was elaborated upon by Duchenne a few years later, whence the name "Aran-Duchenne Disease."[10]

The muscular atrophies which are classed as distinct diseases are divisible pathologically into two types, namely:

1. The myopathies or progressive muscular dystrophies; also known as "idiopathic" muscular atrophies, which are characterized by slow premature dissolution of muscle fibers from inherent vital defect. This is a long-recognized tissue condition for which Gowers has recently given us the convenient and expressive term "abiotrophy."[2]

Abiotrophy of the myon would be a concise statement of the pathologico-anatomic status of this group.

2. The myelopathies or "spinal muscular atrophies," characterized pathologically by the same process (premature dissolution) in the spinal motor nerve elements (anterior horn cells or lower motor neurons). Since, however, these same changes often occur also in the cerebral motor neurons (pyramidal motor cells) or in other cases are apparently limited to the peripheral nerves, a more comprehensive designation would be *neuronic muscular atrophy*. *Abiotrophy of the motor neurons*, therefore, would express the pathologico-anatomic nature of this group.

While this classification serves to define the great majority of cases, a series of mixed forms or so-called "connecting links" between the two main groups is becoming numerous in the literature as experience in their recognition increases, *e.g.* cases which present symptoms of myopathy and myelopathy combined. These serve to illustrate the anatomical and physiological fact now well recognized, that the entire motor tract from the cortex cerebri to cord and from cord to muscle fiber constitutes a continuous functionating unit, and cannot suffer long in one part without in some degree impairing others.

There seems no good reason, however, to the writer for the use of the term "connecting link" for these cases. The coincident or consecutive involvement of one more segment of the motor tract is all that is necessary to the evolution of these mixed forms, and this may be reasonably postulated in any given case.

Accepting the pathological grouping into myopathic and neuronic, therefore, as the best at present available, we proceed in the order mentioned to consider the individual diseases in each group. The accompanying diagram shows at a glance the anatomical location of the pathological process in the several clinical types (Fig. 4031).

The myopathies or primary atrophies are divided clinically into several "types," somewhat arbitrarily perhaps, since there are good reasons for the view held by many that they are all due to the same pathological processes, differing mainly in location. An exception to this statement, however, must be made in the case of the "pseudohypertrophy," which is a prominent feature in one form.

They are all characterized, moreover, by certain clinical features in common, of which the chief are:

1. Hereditary or familial tendency.
2. Onset before puberty.
3. Preponderance in the male sex.
4. Loss of myotatic irritability, and in consequence loss of "tendon reflexes."
5. Electrical changes of reaction of *quantitative* character (diminished response to galvanism and faradism), and absence of typical R. D.

The recognized types of myopathy are:

A. PSEUDOHYPERTROPHIC MUSCULAR ATROPHY.—*Causation*. The disease begins in childhood; in two-thirds of the cases before the sixth year (Gowers). Heredity is traceable in three-fifths of the cases (Dana). The hereditary influence is strongest through the mother's side, though the *male members* of the family are more frequently affected. Church explains the transmission by the female members of affected families by the fact that the disease renders the males impotent.

The disease is frequently preceded by some acute infection—diphtheria for instance, which probably favors its onset in those already predisposed.

Symptoms.—Weakness in the legs of gradual onset, accompanied by a "waddling" gait and frequent stumbling without evident cause are the earliest symptoms. These are usually noticed about the fifth year and are often attributed to carelessness or stupidity on the part of the child. Later, a noticeable enlargement (pseudohypertrophy) of the leg muscles, especially of those of the calves, appears. This may extend to the thighs and gluteal muscles; and the infraspinati are also frequently enlarged. The enlargement of muscles may be slight in some cases, but even in these an undue firmness with lack of elasticity is noticeable on palpation. The shoulder girdle muscles are affected later, while those of the face, forearms, hands, and feet escape for a long time, but are probably affected eventually in most cases that survive a sufficient length of time. Thus in two cases, brothers, aged fourteen and nineteen, seen recently by the

writer, through the kindness of Dr. W. E. Lewis of Cincinnati, one presented marked weakness of facial muscles, and the occipitofrontalis could not be made to act at all, though the patient could frown at command. In this same patient as well as his brother, aged nineteen, the hands were markedly involved, the grasp registering by the dynamometer only nine (right hand) and ten (left) in the younger; and nineteen (right) and fifteen (left) in the elder, both showing a reduction in power estimated by me at seventy-five per cent. or more. Moreover, in the elder of these brothers there was marked wasting of the thenar group of right hand, as well as *fibrillary twitching*, though both cases were typical myopathies in their development and most other respects.

Peculiarities of posture and gait due to the muscular weakness are developed in time. Lordosis is commonly present when the patient stands. The gait is waddling and clumsy. Frequent falls result from the lack of muscular power and irregular control of movements, so that contusions and abrasions are frequent accompaniments of the disease. Ascending stairs is particularly difficult, and the patient arises from the prone or supine position in a characteristic manner by pushing with his hands upon the front of each thigh, to steady the legs. Thus he is said to "climb up his own legs." (See Plate XLVIII.)

While the statement is commonly made that the face is unaffected, nevertheless the facies of most of these patients, according to the writer's observation, is characteristic in some degree of defective muscular action. A blank, expressionless countenance is the rule, or again a marked senile aspect is present after the disease has progressed for a few years. In one case this facial involvement notably affected the smile, the mouth extending horizontally in a straight line, without the usual curves, a pathological "*risus sardonicus.*"

In addition to lordosis, which is common, other forms of spinal curvature appear late in the disease. Contractures are also a feature in the extremities, talipes equinus often resulting therefrom.

Apparent lengthening of the neck, due to the drooping of the shoulders consequent upon weakening of the trapezii (Brissaud) is noted.

Fibrillary twitching in the affected muscles is commonly absent, but there are numerous exceptions to this rule. Notably in the two brothers just cited, the elder presents marked fibrillation in the lower portions of the pectoralis major, as well as in the thenar muscles of the right hand.

Sensation is usually unaffected. The writer has noted one case in which a constant "prickly" sensation was complained of throughout the trunk and limbs, but most accentuated on the anterior chest wall.

The tendon reflexes are progressively diminished and finally lost, as the muscular structure disappears.

The cases without pseudo-hypertrophy are separated from the preceding form by that circumstance and from each other mainly by differences in distribution of the atrophy. Two forms appear to require recognition, clinically speaking.

B. The Scapulo-humeral Form, Erb's "Juvenile Type" (Fig. 4033).—This begins as a rule between the ages of fifteen and thirty-five, though a range of from two to sixty years in ages of patients is recorded (Gowers).

The shoulder, scapular, and upper-arm muscles are first affected, though the deltoid often escapes (Gowers.) The pectoralis and latissimus dorsi commonly waste in their lower portions. The supinator longus is commonly involved. As the disease progresses, the muscles generally are invaded.

Fibrillary contractions and R. D. are said to be absent.

C. The Facio-scapulo-humeral Form, or Landouzy-Dejerine Type.—Also called the "infantile variety." In this the face is the part first attacked, but the ocular muscles and those of mastication escape,

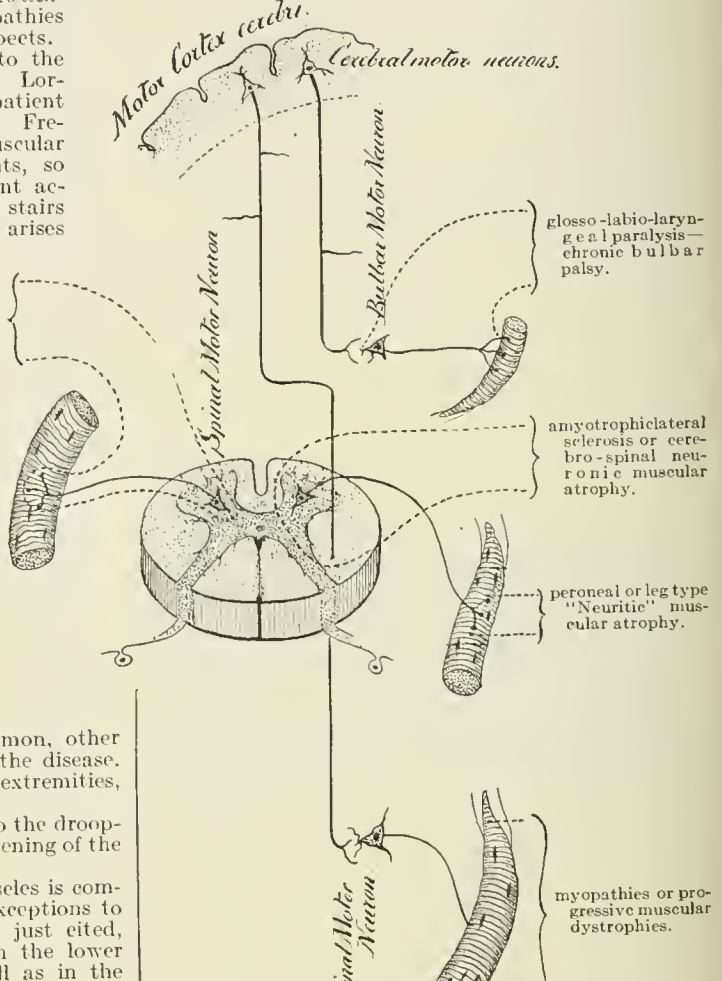


Fig. 4031.—Diagram of Motor Tract from Cortex Cerebri to Muscles, Showing Sites of Initial Degenerations in the Progressive Muscular Atrophies and Dystrophies.

The shoulder and upper arm are invaded later.

The disease begins earlier as a rule than the two preceding forms, though marked exceptions to this statement are recorded.

For instance, in two cases reported by Hoppe,[3] one began at twenty-three, and was alive at fifty-five. In the other, a daughter of the first patient, the disease began at about the twenty-eighth year. These cases are also anomalous in the fact of R. D. being present as follows: In the mother's case, in the thenar and hypothenar muscles of both hands. In the daughter, in the *opponens pollicis* and *flexor brevis pollicis* only.

Fibrillation was not present in either case, and the mode of onset and distribution were regular in all respects.

D. Distal Form of Myopathy.—Gowers[9] applies this term to a case recently described by him, which differs from the other myopathies chiefly in the fact of the atrophy beginning in the hands and feet, although the sternomastoids and tongue were also involved.

The disease began at ten or twelve, and at eighteen the patient still had good power in the peroneal groups and calf muscles as well as in the thighs.

The trunk muscles apparently escaped; of the shoulder-girdle muscles the trapezius only was affected, and that slightly.

Electrical response was diminished to both currents.

Another case referred to at the same time combined the features of this type with those of the scapulohumeral (form B).

As that author remarks, this is only another link in the chain of evidence which favors the essential unity of all types of myopathy.

Fig. 4032.—Pseudohypertrophic Muscular Atrophy. (From Dana, after Erb.)

Pathology and Morbid Anatomy.—These are practically the same in all forms of myopathy.

The process is a degenerative atrophy, with irritation and swelling of muscle fibers and proliferation of nuclei in the early stages. Later, there is atrophy of the muscle fibers with disappearance of their transverse striæ. Increase of connective-tissue elements follows the disappearance of muscle fibers, causing a "myosclerosis" with, in the pseudohypertrophic forms, a lipomatosis in addition. Along with the atrophy and pseudohypertrophy a number of observers have noted an apparent *true* hypertrophy in some fibers.

The spinal cord and nerves are normal with rare exceptions, which are found in the "irregular forms" of the disease.

The *diagnosis* of the myopathies in general is simple. The age of onset (usually under puberty), the slowly increasing weakness, the waddling, stumbling gait, the muscular atrophy without R. D., and the absence of fibrillary twitching sufficiently separate the myopathies from the neuronic or "spinal muscular atrophies." The diagnosis of the different "*types*" of myopathy from each other is mainly a question of the place of beginning and order of distribution of the muscular atrophy, as already noted (see Fig. 4035).

Prognosis and Treatment.—The disease being dependent on inherent defect in tissue vitality, the most that can be hoped for from treatment is to retard its progress and promote the comfort and general well-being of the patient. As already seen from some of the cases cited, the disease is not always incompatible with a moderately prolonged life. From ten to twenty-five years, however, expresses the usual range of duration in ordinary cases.

The usual treatment recommended consists of nutritional and tonic measures. Strychnine is spoken highly of by Gowers.

The glycerophosphates of lime and soda and other phosphorous compounds would seem indicated in young and developing patients.

Exercise, massage, and electricity have been recommended by most authors. Overuse of these agents may do harm. Orthopedic measures, such as division of tendons, are useful in the contractural disabilities.

The Spinal Progressive Muscular Atrophies or Myelopathies.—These are the atrophies of neuronic

Fig. 4033.—Juvenile Type of Scapulohumeral Muscular Atrophy. (C. L. Dana.)

origin, and imply primary degenerative disease of motor neurons of the cord, or cord and brain combined.

A. Progressive Muscular Atrophy Proper, or Aran-Duchenne Disease, "Wasting Palsy."—*Defi-*

nition.—A chronic progressive disease of the spinal motor neurons (ventral horn cells), characterized by fibrillary contractions, slow atrophy, and gradually increasing weakness of voluntary muscles, with R. D.

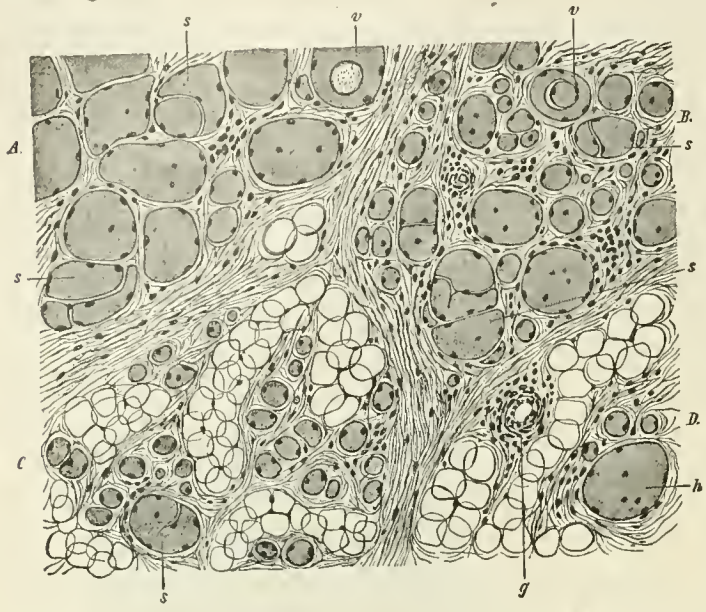


Fig. 4034.—Pathological Histology of Pseudohypertrophic Muscular Dystrophy. (Partly diagrammatic; after Erb.) *A*, Hypertrophied fibers; *B*, mixture of hypertrophy and atrophy; *C*, *D*, atrophy and fatty deposit; *v*, vacuolization; *s*, splitting of fibers; *h*, hypertrophy of fibers; *g*, thickened blood-vessel.

Causation.—Direct heredity is rare. The neuropathic diathesis is presumably the chief predisposing factor. Adult age (twenty-five to forty-five), the male sex, exposure and fatigue, typhoid fever, rheumatism, gout, syphilis, and lead poisoning are credited as additional causes. The actual exciting cause, if such exists, is unknown. Why certain "systems" of neurons should die in some persons and not in others, after the operation of the preceding causes, is a problem which can be solved at present only by assuming a "potential insufficiency" in the nerve elements, an "abiotrophy" (Gowers), only fully developed by the action of some profound and persistent nutritional drain.

Pathology and Morbid Anatomy.—Degenerative atrophy of peripheral motor neurons (ventral horn cells) is the essential lesion. As a result of this, sections of the cord in affected areas show shrinkage and disappearance of cell bodies, with corresponding degeneration and diminution in their processes (dendrites and anterior root fibers). These changes are naturally most marked in the cervical enlargement, since the disease begins in the upper extremity in typical cases.

The posterior horns, together with the columns of Goll and Burdach, as well as the direct cerebellar tracts are normal, excepting in the rare cases of muscular atrophy supervening upon tabes dorsalis, of which the writer has seen two well-marked instances. In this case two diseases are present, according to our present nosology. It is probable that the first actual destructive changes occur in the neuron endings (muscle plates) of the affected muscles (see diagram, Fig. 4031). Following closely upon this impairment of their neurotrophic organs the muscles degenerate, fiber by fiber, into granular and fatty material, the transverse striæ disappear, while the adjacent connective tissue at first proliferates and later undergoes fibroid changes and contraction. Distention of blood-vessels is also described.

The pyramidal tracts of the cord are usually affected in some degree. In fact, so experienced an observer as Gowers[4] remarks that he has not seen a single case in which they were unaffected.

This, as the same writer aptly puts it, is "the visible expression of a tendency to decay of the whole motor path from the cortex of the brain to the muscles."

Clinical History.—The disease begins with weakness and wasting of the thenar and hypothenar muscles of one hand, usually the right. This may be preceded by dull aching pains in the corresponding limb and cervical region. Otherwise sensory changes are absent. The nutrition of the bones and skin is not affected. The wasting advances slowly to other muscle groups, notably the interossei and lumbricales, producing the characteristic longitudinal furrows between the metacarpals, especially noticeable on the back of the hand. The wrist flexors and extensors may go next, or the deltoid and biceps may be affected before the forearm. In this case, as the writer has seen, the patient may present the anomaly of a powerful grasp, with inability to abduct the arm to a right angle.

The spinal extensors are commonly affected early, producing lordosis and allowing the head to droop forward in extreme cases.

The upper portion of the trapezius escapes, which

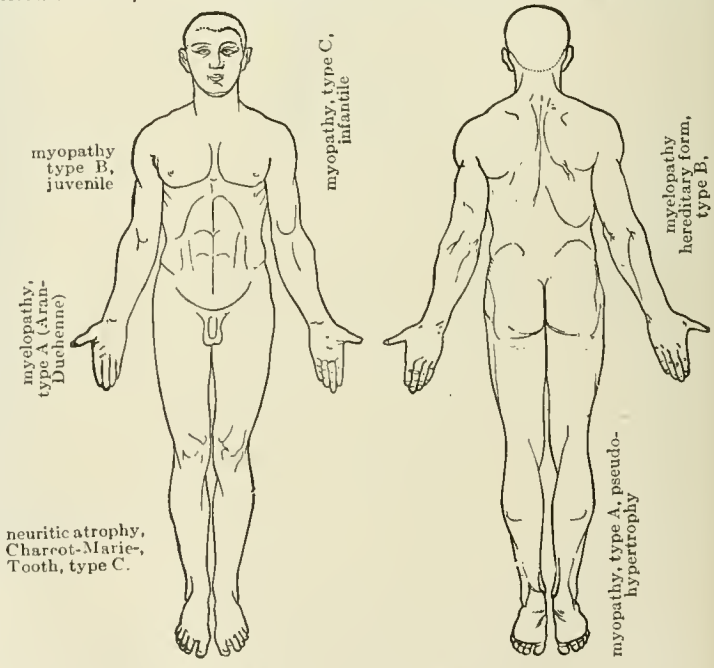


Fig. 4035.—Clinical Chart of Distribution of Muscular Atrophies. The shaded portions indicate the initial locations of muscular wasting in the different forms. (From C. L. Dana.)

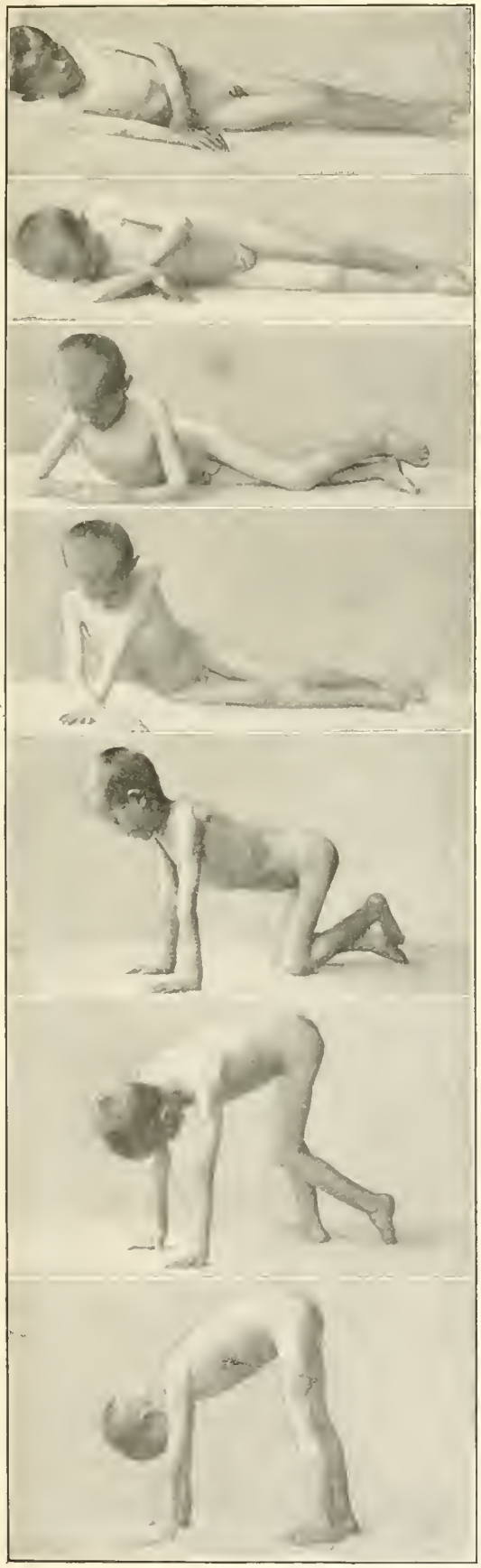
EXPLANATION OF
PLATE XLVIII.

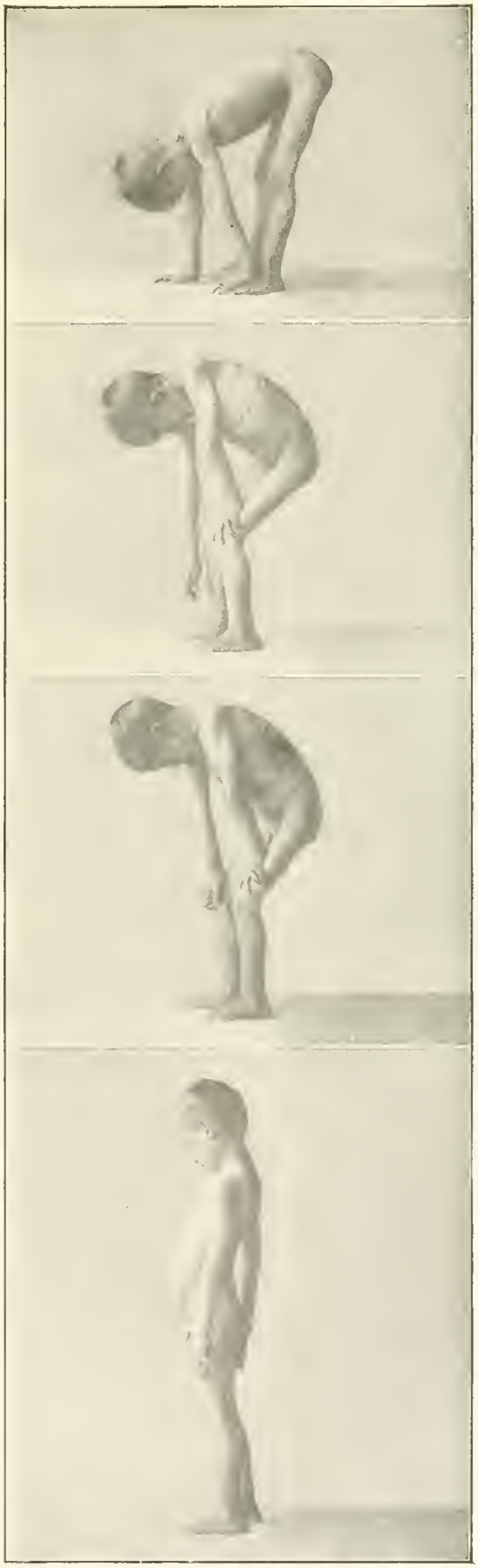
EXPLANATION OF PLATE XLVIII.

Serial kinetographs illustrating the characteristic method of arising from the recumbent position in progressive muscular dystrophy, the patient "climbing up his own legs." (From Curschmann.)

Beginning at the top of left-hand column the figures are to be read downward; then begin at top of right-hand column. The successive utilization of the muscles of the upper extremities to assist the more atrophied ones of the legs and back is evident.

The weakness of the back muscles is also well indicated by the drooping head, counterbalanced by the lordosis. The figures represent a case of myopathy with little if any pseudohypertrophy.





PROGRESSIVE MUSCULAR DYSTROPHY

(Curschmann)

may be a diagnostic sign of importance, as between this disease and the myopathies.

The disease extending downward involves the hips and thighs, impairing locomotion. Marked weakness of the legs proper also exists, often without atrophy, but with more or less spasm and heightened muscle jerks. The explanation of this is the involvement of the upper neuron for the legs, with escape of the lower. In those cases in which the lower leg is atrophied, however, the peroneal group suffers most, thus corresponding to the same process in the "peroneal" type (to be considered later); and also to the atrophy in multiple neuritis.

This distribution contrasts with the myopathies, which affect more markedly the calf muscles.

Fig. 4036.—Case of Spinal Progressive Muscular Atrophy of the Arm Duchenne Type. (From the Neurological Department of the Cincinnati Hospital.)

If the disease extends upward, the upper cervical segments and the oblongata may be invaded, giving rise to respiratory and bulbar symptoms of grave import, such as dyspnea, dysphagia, dysphonia, dysarthria, irregular heart action, glycosuria, etc. The facial muscles usually escape, but not always.

Fibrillary tremor is a characteristic symptom and is almost continuous in the affected muscles so long as any contractile substance remains. The mechanical irritability of the muscles is increased, light taps producing marked contractions.

The deep reflexes diminish gradually and finally disappear.

Electrical changes in the affected muscles are marked and constant. Early a quantitative reduction (diminished response) to both faradism and galvanism may be noted. Later, reaction of degeneration in varying degrees from simple sluggish response to complete polar reversal, *i.e.* the muscle contracts more readily (or to a weaker current) with the anodal (positive) closure than with the cathodal (negative) closure.

The presence of this R. D. is an important diagnostic sign in excluding the myopathies or "idiopathic" atrophies.

Contractions and deformities due to unequal wasting of opposing muscles are common. The "claw-hand" or "main en griffe," lordosis, and talipes equinus are examples.

The sphincters escape as a rule.

Sexual power is commonly lost.

Eventually the patient presents an extreme degree of generalized emaciation, the "living skeleton" type.

Pulmonary complications, bulbar palsies, bedsores, and septic infection are of serious import.

Diagnosis.—From the myopathies, the age (adult) at time of onset, the initial affection of the hands, the presence of fibrillary tremor and the R. D. are sufficiently distinctive. The onset in one hand and the extremely slow progress separate this from other neuron diseases, such as multiple neuritis, lead neuritis, and poliomyelitis, acute or chronic. The absence of pains and cervical deformity distinguish the affection from pachymeningitis cervicalis hypertrophica. Syringomyelia is excluded by absence of the "dissociation" sensory symptoms and of cutaneous trophic lesions.

Prognosis.—Arrest is said to be possible in rare cases. Remissions are more likely to occur. To retard the progress of the disease and improve the "compensation" in the remaining muscle tissue is as much as can be reasonably expected from treatment.

The duration is commonly prolonged, varying from two to thirty years (Dana). The fatal outcome is due to complications, pulmonary or laryngeal, resulting from involvement of the respiratory muscles.

Treatment.—Strychnine nitrate, administered hypodermically in doses gradually increased from gr. $\frac{1}{30}$ to gr. $\frac{1}{15}$, is highly commended by Gowers, who has seen the disease apparently arrested by its use.

General hygienic measures, careful diet, avoidance of fatigue are important. The phosphorus compounds (lecithin, glycerophosphates, etc.) should be tried.

Electricity, massage, and gymnastics should be used with caution, and any excess or fatigue should be avoided.

Mercurials and iodides are *never* indicated and may do harm.

B. Hereditary or Familial Type of Progressive Spinal Muscular Atrophy.—This is a rare form of neuronic atrophy described by Werding[5] and Hoffman. It is characterized by heredity, by early onset (under two years), beginning in the hips and back; by rapid progress to complete helplessness and a fatal termination at or before the sixth year. R. D. is present, and wasting of the ventral horn cells has been found. Beevor[7] records one case which began *in utero*. F. E. Batten and Gordon Holmes;[11] and Leonard Parsons and Douglas Stanley[12] have reported well-marked cases—verified by microscopic findings.

Diagnosis.—This is distinguished from the ordinary spinal atrophies (Aran-Duchenne type) by the hereditary element, early age, rapid progress, and absence of fibrillary twitching; from the myopathies, by the absence of hypertrophy, the presence of R. D. and the early termination.

Treatment has not influenced these cases appreciably.

C. Amyotrophic Lateral Sclerosis.—This is practically a progressive spinal muscular atrophy (type A) plus involvement of the upper neuron (pyramidal tracts of cord) to a marked degree (see Fig. 4031). The clinical difference consists in the marked spasticity, causing a stiff-legged gait, with toes tending to dig into the ground. There is also a rather more marked

tendency to bulbar involvement, and the lower half of the face may be affected. The affection does not differ materially from type A as regards the prognosis and treatment.

D. Glosso-labio-laryngeal Paralysis.—*Chronic Progressive Bulbar Palsy.*—This may occur primarily, or may indicate an extension upward of ordinary spinal muscular atrophy (type A). As a primary affection the degenerative process is limited to the bulbar neurons.

Patients are usually at the degenerative period of life. In many respects the disease appears to indicate a localized presenile change.

The chief *symptoms* are hoarseness, aphonia, dysarthria, dysphagia, sialorrhea, atrophy and fibrillation of the tongue, glycosuria, cardiac arrhythmia, and dyspnea.

Pseudoemotional symptoms, as causeless weeping or laughter, are frequent accompaniments. The palate reflex is absent in advanced cases.

The *diagnosis* must be made from bulbar apoplexy (small hemorrhage, thrombosis) by the sudden onset of the latter, with sensory defects of face frequently present; from cerebral lesions in the bulbar motor path (pseudobulbar palsy) by the sudden onset of the latter, with absence of sensory defects, of atrophy of the tongue, and also of accompanying hemiplegic symptoms; from asthenic bulbar palsy (bulbar palsy without anatomical findings) by the absence in the latter of muscular atrophy and twitching and by the frequent remissions which occur.

The progress is toward a fatal termination from inanition or respiratory complications in from one to seven years. Treatment is similar to that of other neuronic muscular atrophies—viz., rest and attention of hygiene and nutrition. Electrical treatment may add to the comfort of the patient and prolong life.

E. Neuritic or Leg Type of Progressive Muscular Atrophy, Charcot-Marie-tooth Disease.—This variety of the "neuronic atrophies" differs from the typical (spinal) form (type A):

(1) In its hereditary character.

(2) In its onset in the legs and feet (peroneal group of muscles).

(3) In its slower course.

(4) In the circumstance that the prospects of prolonged life are better.

It is a rare disease in this country, Burr[8] recording but five known cases up to 1897, including one reported by himself.

Pathologically a degenerative neuritis has been found. The disease therefore affects the distal extremities of the lower motor neurons.

Treatment is similar to that of the other neuronic forms. F. W. Langdon.

References.

1. Aran, F. A.: Recherches sur une maladie, etc. Arch. Gén. de Méd., Paris, 1850, iii., 5, 172.
2. Gowers, Sir William R.: A Lecture on Abiotrophy. Lancet, April 12, 1902, p. 1003.
3. Hoppe, H. H.: Zwei Fälle von Dystrophia Muscularis Progressiva mit Entartungsreaction. Centralblatt für Nervenheilkunde und Psychiatrie, October, Heft, 1892.
4. Gowers and Taylor: Disease of the Nervous System, third edition, London, 1899, vol. i., p. 550.
5. Werding: Arch. für Psychiatrie, 1891–94, quoted from Gowers' third edition.
6. Hoffmann: Deutsch. Ztsch. für Nervenheilk., 1893–97, quoted from Gowers' third edition.
7. Beevor, C. E.: A Case of Congenital Spinal Muscular Atrophy (family type), and a Case of Hemorrhage into the Spinal Cord at Birth, giving Similar Symptoms. Brain, 1902, p. 85.
8. Burr, C. W.: A Case of Progressive Neurotic Muscular Atrophy. Journal Nervous and Mental Disease, October, 1897.
9. Gowers, Sir W. R.: A Lecture on Myopathy and a Distal Form. Brit. Med. Journal, July 12, 1902, p. 89.
10. Charcot, J. B.: Contribution à l'étude de l'atrophie musculaire Progressive—Type Duchenne-Aran. Paris, 1895.

This work contains a digest of the French literature on the subject, with especial reference to the clinical and pathological distinctness of the Duchenne-Aran form (type A), and the amyotrophic lateral sclerosis form (type C), which Charcot (the younger) considers well established. The work is beautifully illustrated.

11. F. E. Batten and Gordon Holmes: Brain, 1912, vol. xxxv.
12. Leonard Parsons and Douglas Stanley: Brain, 1912, vol. xxxv., quoted for Pract. Med. Series-Patrick and Barroe, vol. x., 1913, p. 136, etc.

Musk.—See *Moschus.*

Mustard.—See *Sinapis.*

Musser, John Herr.—Born in Strasburg, Pennsylvania, in 1856. He studied medicine in Philadelphia and obtained the degree of Doctor of Medicine from the University of Pennsylvania in 1877. During the later years of his life he held the Chair of Clinical

Fig. 4037.—John Herr Musser.

Medicine in the same university, and he was also connected with the Philadelphia, University, and Presbyterian Hospitals. In 1904 he was President of the American Medical Association. He died suddenly from heart disease, April 3, 1912, at his home in Philadelphia.

Dr. Musser was especially noted as a diagnostician, and had made a number of valuable contributions to this branch of medical literature. He came from a long line of practitioners, not only his father, but his grandfather and great-grandfather having been physicians. A. H. B.

Mussey, Reuben D.—Born in Pelham, New Hampshire, June 23, 1780. He studied medicine at the

Fig. 4038.—Reuben D. Mussey.

University of Pennsylvania, and received the degree of Doctor of Medicine from that institution in 1809.

Up to 1814 he practised his profession at Salem, Mass., and then accepted a call to Dartmouth College, New Hampshire, to fill the Chair of Materia Medica and Therapeutics. From 1814 to 1838 he was also Professor of Obstetrics and from 1822 to 1838 he filled the Chair of Anatomy and Surgery in the same college. From 1838 to 1852 he was Professor of Surgery in the Ohio Medical College, and from the latter date to 1860 he held the same position in Miami Medical College. In 1830 he proved (what Sir Astley Cooper had said was impossible) that intracapsular fractures could be united; and he was the first person to tie both carotid arteries.

In 1837 he removed the entire scapula and clavicle of a patient who was suffering from osteo-sarcoma, the first operation of the kind on record. In 1860 he removed to Boston, Mass., and died there on June 21, 1866. A. H. B.

Mutter, Thomas Dent.—Born in Richmond, Virginia, March 9, 1811. He received his medical education at the University of Pennsylvania, Philadelphia, and was given the degree of Doctor of Medicine in 1831. After graduation he went to France and frequented the hospitals of Paris. Upon his return to this country he established himself as a practitioner in Philadelphia. From 1841 to 1856 he occupied the Chair of Surgery in the Jefferson Medical College. His death occurred March 16, 1859.
A. H. B.

Myatonia Congenita.—See *Amytonia Congenita.*

Mycetoma.—*Synonyms:* Madura foot; fungus disease of the foot.

Clinically, there are two varieties of the disease, (1) that known as *black* or *melanoid* mycetoma, and (2) that known as *white*, *pale*, or *ochroid* mycetoma. The disease has been longest and best known as the Madura foot of India. This is a form of the black or melanoid variety. Kaempfer, in 1712, called it "hypersareosis ulcerosa pedum." It was first adequately described by H. Vandyke Carter in his elaborate monograph published in 1874.

Etiology.—The infecting fungus which causes the common black Madura foot of India is now known to be one of the true or perfect spore-bearing moulds belonging to the order Ascomycetes, genus Madurella. It is correctly classified as *Madurella mycetomi*, Laveran, 1902. Another variety of black mycetoma, found in Algeria and Tunis, is caused by *M. tozeuri*, Nicolle and Pinoy, 1908. There are other Ascomycetes which produce white mycetomas. These belong to the genus Indiella. Among them are *Indiella mansoni*, *I. reynieri*, and *I. somaliensis*, Brumpt, 1906.

The order Hyphomycetes, embracing the imperfect, non-sporing moulds, includes the genus Nocardia. Several species of this genus cause mycetoma. The white or ochroid mycetoma is most commonly caused by an invasion of *Nocardia maduræ*, Vincent, 1894. This is the so-called ray fungus long known as *Streptothrix maduræ*. It is now assigned to the genus Nocardia along with the ray-fungus which causes actinomycosis, long known as *Actinomyces bovis* and now called *Nocardia bovis*. Beside *Nocardia maduræ*, the common cause of white mycetoma in Asia and Africa as described by Vincent, there are other species of *Nocardia* which produce closely similar disease conditions when they invade the tissues, notably *N. pelletieri* in Senegal, and *N. braziliensis* in Brazil.

Mycetoma is endemic in many of the provinces of India. It is found sporadically in tropical and subtropical countries all around the world. It has been seen in Canada. No natural habitat outside of the tissues of man has been discovered for any of the causative fungi. The infection is doubtless always introduced through some slight wound in the skin, which may heal promptly and attract no attention at the time. Of 100 cases in India collected and analyzed by Bocarro, all were dwellers in the country and ninety-one were tillers of the soil; ninety-two cases were in men and eight in women.

Pathology.—In Bocarro's series the disease was located in ninety-three cases in the foot, three in the hand, two on the leg, one on the shoulder blade, one over a sacroiliac joint. In the two cases on shoulder and sacrum the disease was of the melanoid variety and there was no doubt about the diagnosis. As in actinomycosis, the disease extends in the affected part by contiguity, disregarding anatomical boundaries. There is no metastasis along blood and lymph channels, and the infection remains localized. The fungus, once implanted in the subcutaneous tissue, sets up a reactive inflammation which surrounds the focus of infection with a zone of proliferating cells and fibrous tissue. Around the foci in the bones this forms a tough membranous capsule which can sometimes be enucleated entire. In a late stage of the disease the bones, as well as the soft parts, are riddled with such foci and their connecting sinuses. A mycetomatous foot or hand in an advanced stage shows a greasy surface, and on section the soft parts are found to have lost their anatomical characters and to be blended in a nondescript, pultaceous, oily mass; and the bones have become rarefied and partially absorbed. The foci vary in size; some are no larger than pinheads, some may be as large as a walnut. They are filled with an oily purulent fluid containing the peculiar granular or mulberry-like concretions characteristic of the disease, these concretions or "grains" having a black, gray, or pink color according to the species of the infecting fungus. These grains or granules have an appearance which has been compared to fish roe. In rare cases they are absent, the sinuses and cysts being filled with the oleaginous purulent fluid only.

Symptoms and Course.—Many of the patients will refer the beginning of the disease to a fester following the prick of a thorn or to some other slight injury. Early in the case a localized tenderness is followed by swelling and inflammation with the formation of a small central nodule. The overlying skin becomes inflamed and adherent. "The ball of the thumb or of the great toe, or the pads of areolar tissue and fat, along the bases of the fingers and toes are favorite initial seats of the disease" (Bocarro). As infiltration and swelling of these tissues progresses, the toes are tilted upward or apart, and the plantar tissue bulges downward, obliterating the arch of the foot and giving it a shapeless or "globose" appearance. The disease is never so superficial as to involve the integument only. The soft parts, especially the padding of areolar tissue and fat, sometimes with the muscles, are first implicated, and later the bone and cartilage are invaded. The progress of the disease is slow. In from six months to two years the growth softens and a sinus opens spontaneously through the skin, discharging a seropurulent fluid containing the yellow or pink roe-like granules of the white variety or the black granules of the melanoid form. In the course of from two to ten years or more, the process extends through the affected member till its natural form and the normal character of the tissues are no longer recognizable, and the part is riddled with foci and communicating sinuses, from twenty to fifty of which may open externally. Probes pass easily into the mass from different directions and meet each other. The affected part is elastic to touch and does not pit on pressure. Sensation is preserved in the skin, but there is no pain in the part, no constitutional disturbance, the patient complaining only of the inconven-

ience of the heavy useless mass. The leg muscles are usually much atrophied, exaggerating the apparent enlargement of the foot.

Diagnosis.—Mycetoma has been mistaken for *sarcoma* and for localized *tuberculosis*. Such mistakes are not likely to occur where mycetoma is endemic. The gross clinical diagnosis can be made almost with certainty from the appearance and the characteristic yellow, pink, or black granules which can be expelled from a sinus by manipulation and pressure, or demonstrated in masses by incision into one of the larger foci. This material is, as Manson says, "unlike anything else in human morbid anatomy." The identification of the species of fungus present can be accomplished in the laboratory by culture and microscopic study.

Prognosis.—This is favorable. Surgical treatment in Bocarro's cases, collected in 1893, resulted in complete cure of ninety-eight per cent. of the cases.

Treatment.—Beyond advising that shoes or sandals be worn to protect the sole of the foot, no rule of prevention can be laid down. The disease is almost confined to the barefoot poor. There is no tendency to spontaneous cure, and after an imperfect attempt at eradication the disease recurs and extends. The only treatment for the black forms of mycetoma is a radical surgical treatment which removes the diseased part completely. This may be effected, in the case of a very limited involvement, by incision, curettage, and antiseptics, or by a partial amputation. In the majority of cases amputation of the entire foot is required, and it must be done well above all infected tissue. The white forms of mycetoma also require amputation, usually. Benefit has been reported, however, in some of the white or ochroid cases, from the administration of potassium iodide. From the effect of this drug upon *Nocardia bovis* infections (actinomycosis), it would seem reasonable to hope for some success with potassium iodide in a case of mycetoma if one of the species of Nocardia has been identified as the infecting fungus. J. F. Leys.

Myelitis.—The term myelitis means literally inflammation of the spinal cord. It was formerly used to include a number of conditions which to-day on account of increased knowledge of anatomical localization and clinical symptomatology are described under separate names. Even now, however, sharp differentiation is not always possible and some authors prefer to describe under the heading "transverse lesions" a number of dissimilar conditions which have their chief symptoms in common but vary both in causation and in anatomical basis.

By the word myelitis in the restricted sense we understand an inflammatory condition affecting all the elements of the spinal cord either in its cross-section (transverse myelitis) or disseminated in small areas throughout the cord.

Myelitis is usually considered as a comparatively rare disease, though Oppenheim dissents from this opinion. It is not confined to any one age, though it is relatively rare in children, in whom that form of specific affection limited to the anterior horns of the gray matter (or relatively so) "poliomyelitis" is very common.

Etiology.—The older ideas which attributed myelitis to such causes as exposure to cold, overexertion, sexual excesses, and strong emotions, are received with considerable skepticism to-day, though as contributing causes it cannot be denied that these factors may play a part. They are certainly of vastly less importance than the intoxications and infections whose rôle in the production of myelitis is amply proved by clinical and experimental evidence. Cases of myelitis have been observed in connection with variola, scarlatina, influenza, measles, erysipelas, pneumonia, pertussis, dysentery, typhoid, cholera, diphtheria, tonsillitis, septicemia, endocarditis, gonorrhea, malaria, tuberculosis, and rabies (particularly after protective inoculations), while it is now known that the causal agent of infantile paralysis is by no means always limited in its action to the anterior horns of the spinal cord but may affect the whole cross-section, so that it is not improbable that some cases of myelitis of obscure etiology may be due to this agent. After poisoning by such agents as illuminating gas, sulphide of carbon, chloroform, and nitrobenzin, pictures suggesting myelitis have been observed, while in occasional instances of intoxication by lead, mercury, phosphorus, and alcohol there have been found diffuse changes in the spinal cord as well as neuritis. Meningitis from any cause may be accompanied by myelitis. Hemorrhage into the cord produces a softening (myelomalacia) which often seems to be the starting point for inflammatory changes. When this is not due to trauma or to some blood state, it almost always depends upon the rupture of a vessel affected by syphilitic arteritis. Spinal syphilis usually begins in the meninges but spreads to the cord itself, setting up a myelitis and in cases of myelitis our first care must usually be to confirm or to exclude syphilis. The influence of trauma has already been alluded to and it is a matter of experience that myelitis is specially frequent among porters, longshoremen and others who have to do heavy lifting. Falls, blows upon the back, or strains would be particularly apt to cause rupture of diseased vessels.

In divers and in others who work under greatly increased atmospheric pressure, too rapid return to normal pressure is often followed by paraplegia and other symptoms of spinal cord disease ("caisson disease") which is attributed to the sudden liberation of the gases of the blood into the tissues with resulting laceration which may be followed by an inflammatory reaction, a myelitis. Lastly, experimental shutting off of the blood supply from the cord—by clamping the aorta—has been found to cause a local softening and secondary reaction and it is assumed that the same thing may occur through embolism or thrombosis of the arteries supplying the spinal cord.

Pathological Anatomy.—The changes of myelitis may affect the whole cross-section of the spinal cord for one or more segments, or may be diffused in small areas throughout a number of segments.

If the area is sufficiently extensive the cord may here feel soft to the touch. Upon section the distinction between gray and white matter is more or less obliterated, the cord may be softened to a creamy consistency, is of a reddish or yellow color and swells up on the cut surface. If the inflammation is less intense, the consistency is firmer and the inflammatory areas appear as fine red points. If the process has reached the chronic stage, areas of a whitish yellow color show where the parenchyma has been replaced by connective tissue. Upon microscopic examination, congestion of the vessels, small hemorrhages and infiltration of the tissues by small round cells are found, while the nerve cells and nerve fibers are in all stages of degeneration. Small cavities may occur as a result of the disintegration of the nervous tissues, while elsewhere there is neuroglia proliferation. As to the character of the infiltrating cells there is some discussion, some authors considering them as leucocytes, while others hold that they are proliferated neuroglia cells. Some of them are phagocytic and on account of their tendency to invade and destroy both cells and fibers they have been called by Marinesco, "neuronophages."

Various bacteria have been found in myelitis, especially streptococci, staphylococci (both albus and aureus), and pneumococci.

If the focus has been large and the inflammation intense, the cord at this point may be destroyed; if

less intense, the cross-section may be changed into connective tissue. Regeneration of tissues in the spinal cord once destroyed, appears impossible, so that in myelitis the function of the cord is permanently impaired. A meningitis not infrequently complicates acute myelitis.

Abscess formation has occasionally been observed in the spinal cord, but according to Oppenheim this is exceedingly rare apart from the direct introduction of purulent material from without from a bed-sore, from vertebral disease or by direct trauma.

Myelomalacia or softening of the spinal cord results most frequently from disease of the vessels leading to embolism, thrombosis or hemorrhage. The area affected may appear red if there has been hemorrhage, white if there is simply death of the tissues. If the patient survives, the products of disintegration are eventually absorbed and the destroyed area is filled in by neuroglia. These sclerotic areas are apt to be very irregular in outline, and vary in size. When the blood supply is cut off, the neurones in the affected region undergo degeneration, the nerve cells swell, then disintegrate, the nerve fibers are also greatly swollen, distend their sheaths then later disappear, so that under the microscope the white matter presents a cribriform appearance.

Though myelomalacia cannot be considered as an acute inflammation, the degeneration of the parenchymatous elements and their replacement by neuroglia produce sclerotic areas in no way differing from those resulting from myelitis.

Whenever in a transverse section of the spinal cord there is destruction of the nerve fibers, there occur secondary degenerations which follow the direction in which the fibers conduct impulses, that is away from their cells of origin, hence are descending below the lesion, ascending above it. So, in a lesion in the midthoracic region the posterior columns (Goll and Burdach), direct cerebellar and Gower's tracts would be degenerated above it, the anterior and lateral pyramidal tracts would be affected in the lower thoracic, lumbar, and sacral regions, while the shorter fiber tracts, both ascending and descending, would show changes for a few segments on either side of the lesion. (See further under *Spinal Cord, Diagnosis of Local Lesions of the.*)

Symptomatology.—The onset of myelitis may be rapid with fever and symptoms of grave constitutional disturbance when due to infection, quite sudden when a hemorrhage serves as its starting point. When it supervenes upon an infectious disease the picture is of course colored by the symptoms of this disease. Again the symptoms may develop more slowly during a week or ten days, while in a very few cases it is chronic from the start. In cases which are not fatal, the subsequent course is always slow and recovery takes place with more or less defect, dependent upon the localization and the extent of the disease process. Upon this localization depend the symptoms also.

The most common and characteristic variety is transverse myelitis. This affects the cross-section of one or more segments of the spinal cord. Ability to localize its seat presupposes familiarity with the functions of each segment, which will be discussed under the head of diagnosis of spinal cord diseases.

Dorsal Myelitis.—A favorite seat of transverse myelitis is in the midthoracic region, so a discussion of the symptoms of a lesion at this point may well serve to introduce the subject, the symptoms found in other localizations being later compared with those from this region. At the start there is usually some pain and stiffness in the back, numbness and tingling in the legs, with increasing heaviness and disability.

In myelitis, conduction through the spinal cord in either direction is speedily impaired so that both motor and sensory functions suffer.

Motor Symptoms.—As the lateral and anterior pyramidal tracts—as well as the other descending fibers—are cut across at the level of the lesion, voluntary impulses can no longer be transmitted from the brain to the lower extremities (or in partial lesions only imperfectly), so that in dorsal myelitis there is paraplegia (or paraparesis), and since through these tracts also, the inhibiting influence of the brain is transmitted, the paralysis is of the spastic variety, the reflexes and the muscular tonus being increased. In the early stages the legs are usually in extension while in the latter they are often contracted in a position of flexion. Quite frequently they are the seat of involuntary contractions which jerk the legs about from time to time, often a distressing symptom. The reflex irritability is greatly increased so that a slight touch, or even a breath of air, may suffice to set up a more or less painful spasm. The knee jerk is greatly exaggerated, a clonus often being elicitable, there is ankle clonus and abnormal extension of the great toe on stroking the sole of the foot or the periosteum of the tibia (Babinski and Oppenheim reflexes). If however, there is complete destruction of the cord in the affected region, there is loss of reflexes and a flaccid paralysis.

Sensory Symptoms.—There is partial or complete loss of sensation—generally for all qualities—over the trunk and limbs below the injured segments, while just above this area there is usually a band of hyperesthesia and girdle pain is often felt. This disturbance of course varies with how complete the interruption of conduction is and may be different on the two sides.

Bladder and rectal functions are removed from the influence of the will so that there is incontinence of urine and feces. The patient is no longer able to appreciate the degree of fullness of the bladder so that the urine is usually retained until there is a certain amount in the bladder and then is involuntarily discharged (intermittent incontinence). Priapism is not uncommon.

The inability of the patient to change his position in the bed, together with the loss of sensation and constant soiling with urine and feces are important factors in the development of bed-sores, though we can hardly deny that the cutting off of trophic influences may be also at fault, since in no condition do bed-sores come on more rapidly, not infrequently over night. They often spread with extreme rapidity and may form large and deep ulcers extending down to the bone and even eroding it and opening up the spinal canal. The lesions occur chiefly on the back over the sacrum, over the trochanters and on the heels. They open a ready way to infection which the patient is little able to resist and frequently determine a fatal issue. Other skin affections as vesicles, etc., are occasionally found over the paralyzed parts, while vasomotor and secretory disturbances are sometimes noted, for instance edema of the paralyzed limbs, hyperidrosis, or anidrosis. The muscles of the limbs though paralyzed do not undergo atrophy nor show reaction of degeneration. On the other hand those muscles, the nuclei of whose nerves are involved in the disease process—in this instance particularly the abdominal muscles—do show such changes.

Lumbosacral Myelitis.—Next in frequency to myelitis of the dorsal region comes that of lumbar or lumbosacral seat. In this, the paralysis of the legs is flaccid and the muscles undergo atrophy with reaction of degeneration. The skin and tendon reflexes are lost, the anesthesia extends up to the groins or below this, there is no girdle pain, but pains may shoot down into the limbs. The bladder and rectal paralysis is more marked. If the disease focus is above the midlumbar region the knee jerk may be lost, while there is ankle clonus and the Babinski reflex. The bladder paralysis is a flaccid one and the incontinence permanent. On the other hand if the lesion is low in

the lumbar or in the sacral region the knee jerk may be retained or even exaggerated. If the conus medullaris is alone affected, there is paralysis of the bladder and rectum, impotence, anesthesia of the region of the anus, perineum, scrotum, penis and the inside of the thighs with finally degenerative paralysis of the muscles of the sciatic distribution.

Cervical Myelitis.—Myelitis of the cervical enlargement gives the following symptoms: Atrophic paralysis of the arms, spastic paralysis of the legs, anesthesia over the arms and of all the trunk, and in lesions of the last cervical segment oculopupillary phenomena (Horner's symptom complex, narrowing of the pupil, ptosis, sinking in of the eye-ball), with the other symptoms mentioned for dorsal myelitis. If the lesion is higher up, the respiratory muscles may be affected, a special danger, especially should a bronchitis or pneumonia supervene.

If the lesion is above the cervical swelling, the arm muscles will be spastic instead of flaccid, while the diaphragm will be paralyzed and the neck muscles will show flaccid paralysis and bulbar symptoms may supervene. This dangerous form is fortunately excessively rare.

In the picture described it has been supposed that the whole cross-section of the spinal cord was involved. In practice, however, a greater or lesser number of the fibers usually escape, so that the loss of function is less complete, the muscles may be only partially paralyzed and the loss of sensation may be unequally distributed and incomplete. Sometimes one-half of the cord may be preponderantly involved, in which case we find the Brown-Séquard symptom-complex (paralysis on the side of the lesion, loss of sensation on the opposite side). Usually, however, all the symptoms of transverse lesion are present though unequally developed. The sensory symptoms are generally far less marked than the motor. The disease focus is by no means always limited to a few segments, but may extend over a number of them, perhaps nearly the whole dorsal region, or parts of the dorsal and lumbar cord may be involved. It may also tend to descend or to ascend and involve the bulb, which last tendency is said to be specially marked in myelitis during pregnancy (Oppenheim). Bing has described a case of "migrating myelitis."

Disseminated Myelitis.—Instead of affecting the cross-section of a certain number of segments the myelitic process may be distributed in small areas throughout the cord and even in the brain (encephalomyelitis). This variety of myelitis has been brought into the closest connection with infectious diseases as variola, measles, pneumonia, diphtheria, endocarditis, rabies, etc., and syphilis also has been found in some cases to cause similar lesions. Apart from the fact that the poliomyelitic virus sometimes produces such foci, disseminated myelitis is decidedly more frequent in children. The symptomatology is naturally very variable and is often complicated by manifestations of cerebral involvement so that it is practically impossible to construct a clinical picture that will represent even an average case.

Diagnosis.—In a case presenting the symptoms of transverse lesion, we have to consider specially the mode of onset and the previous history of the patient. If he has, or has just had, an infectious disease or if the trouble begins with fever and constitutional disturbance we may suspect a myelitis. If the onset is sudden during apparent good health especially after some trauma or overexertion, a hemorrhage may be suspected. In all cases it is necessary to consider the probability of a syphilitic origin and to take steps to confirm or to eliminate this disease, through the history and by the Wassermann and Noguchi or Nonne-Apelt tests. In the cases of slow onset, if syphilis can be excluded we would next consider the possibility of a tumor either in the cord, or compressing it from outside, and of some disease of the vertebral column which secondarily involves the cord. In tumor there is usually a long period of severe pain affecting the region innervated from the affected segments and the detection of a growth somewhere else would speak in favor of a tumor, for primary tumors of the cord are comparatively rare. Disease of the bones of the vertebral column will usually be manifested by some deformity or will be shown in the *x*-ray picture.

A spastic paraplegia of primary origin is described and this symptom can also be produced by bilateral brain disease, but in both these conditions there is no sensory involvement. Multiple sclerosis often manifests itself for a long time as a spastic paraplegia alone and we may have to wait for the onset of the other characteristic symptoms to clear up the diagnosis. The disseminated form of myelitis would be particularly apt to resemble multiple sclerosis but the latter disease is usually chronic in its course while disseminated myelitis is acute and generally directly connected with an infection. Nevertheless we cannot eliminate an infectious origin in multiple sclerosis and some cases begin with acute symptoms so the differentiation may be impossible at the start.

Prognosis.—The prognosis of myelitis is always serious. Some of the more acute cases, especially those in the cervical region, speedily perish from involvement of the respiratory muscles, while others with rapidly developing bed-sores succumb to sepsis and exhaustion. In those cases which survive there is a long period during which the disease remains in a more or less stationary condition and then begins slowly to improve. The degree of recovery depends entirely upon the extent and the location of the disease process. It is an axiom that cells and fibers completely destroyed do not regenerate, but at the start many of these are put out of function by swelling of the part, though they are not destroyed, so that there may be a very considerable return of function. In some of the acute cases recovery may be complete or practically so, but in the majority of instances we have to expect at least a certain degree of impairment of function. The patient may have return of sensation in the affected legs and can get around with a cane while control over the bladder and rectum are regained in part or entirely.

Infectious cases are more likely to recover than those from hemorrhage. The more complete the anesthesia, or on the other hand the greater the pain, rigidity and spasm, the worse the outlook. Bed-sores and cystitis impair the prognosis and may be the cause of a fatal issue. Myelitis of the cervical region is the most dangerous, while that of the lumbosacral cord is most likely to be complicated by cystitis, urinary infection and bed-sores. That of the dorsal region is most apt to recover. Even after quite complete paralysis there may be gradual improvement and power to walk may be regained. For even as much as two years there may be hope of improvement, after this little or none.

Treatment.—In cases of syphilitic origin prompt administration of salvarsan followed by mercury and iodide of potassium or of the latter drugs alone if the salvarsan is for any reason contraindicated, should be at once resorted to. Outside of this we have no specific treatment of myelitis though it is recommended to give salicylates in cases of infectious origin. In the acute stages absolute rest in bed should be enforced, the patient even passing his evacuations in this position. He should be placed at once upon an air or water bed, his position being changed frequently and care being taken to protect the bony points from pressure. Absolute cleanliness and frequent bathing the skin with antiseptic and hardening lotions—as tannic acid gr. 10, alcohol 1 oz.—and subsequently powdering with stearate of zinc and acetanilid or talcum powder will do much to prevent bed-sores. If these form nevertheless, they should be treated antiseptically and

dressed with zinc oxide or balsam of Peru ointment. In some obstinate cases organic preparations as beef extract have seemed to favor healing. If there is retention of urine, catheterization must be carried out under the most careful antisepsis. Administration of hexamethylenamine, grs. 10, two or three times a day may prevent cystitis, but if this develops the bladder should be washed out twice a day with a saturated solution of boric acid. In the cases coming on after infection Oppenheim recommends diaphoresis by packing in wet cloths under a woollen blanket or by introducing hot air under the bedclothes by suitable apparatus. The application of the actual cautery along the back is contraindicated on account of the great tendency to form bed-sores.

The bowels should be regulated by the use of suitable laxatives followed by enemata when needed. The painful spasms of the muscles may be relieved by the application of warm cloths or hot water bottles, being careful not to blister the skin which is frequently anesthetic. Bromides or very minute doses of hyoscin internally may be of service in this connection. After the acute stage is passed warm baths may be applied with advantage and after partial recovery a cure at some of the thermal springs may aid. When improvement begins, exercises of the muscles carried out at first in the bath, later outside, massage and warm or tepid douches may be of advantage. When the patient begins to walk he should be guarded against over-fatigue and falls. Rubber heels and soles take off the shock and graduated exercises may favor the return of muscular power. In some cases skilfully applied orthopedic apparatus may aid in reducing contractures, etc. Electrical treatment is contraindicated throughout the earlier stages but after convalescense is established, direct application of galvanism along the spine and the use of either current to stimulate the paretic muscles is in place, especially to those muscles which are flaccid and tend to atrophy, while a residual bladder paralysis may also be benefited by such applications. Where the paralysis is entirely or largely cleared up and there remains impairment of sensation the faradic brush applied over the affected region may hasten the return of the latter.

CHARLES LEWIS ALLEN.

Myeloma.—A myeloma (from μυελός, marrow, and ωμα, a suffix denoting a tumor) is a tumor, or tumor-like growth, arising in the bone marrow. In the earlier literature the term myeloma has been given a variety of meanings, of which the following are the most important. (1) A tumor or enlargement of the brain or spinal cord; (2) any tumor resembling marrow in its consisteney; (3) a giant-celled sareoma or any sarcoma containing giant cells, such as the giant-celled fibrosarcoma of the jaw; this use of the term still persists although the noun is usually changed to an adjective as in such phrases as *myeloid sarcoma;* (4) more recently the term myeloma has been somewhat closely restricted to a group of cases exhibiting a peculiar disease of the bones. These cases have enough in common to warrant a consideration of the affection as a clinical entity, and to this condition alone may the term myeloma now be properly applied. In a general way these cases are characterized by the occurrence of multiple primary growths in the bone marrow, with pain, some fever, an increasing anemia and the presence of the Bence-Jones body in the urine, but without marked changes in the white blood cell count and without giving rise to metastases.

Because the growths are primarily multiple, the condition of myeloma is usually described under the term *multiple myeloma*, or *myeloma multiplex*. *Myelomatosis* is another synonym which has much to commend it. Cases have been recorded under a large number of terms, such as malignant osteomyelitis, myelogenous pseudoleukemia, medullary pseudoleukemia, lymphadenia ossium, sarcomatous osteitis, myelosarcoma, sarcoma multiplex ostium, angiosarcoma, lymphosarcoma of bone, general lymphadenomatosis of bone, plasmoma malignum, and erythroblastoma, so that both the literature and the pathological conception of the disease have become exceedingly complicated.

The earliest authenticated case of myeloma is the one reported by Bence-Jones in 1846. His attention was called to this case by the occurrence of an unusual body in the urine and his careful description leaves no doubt as to the nature of the disease which was classed as an example of "mollities ossium" or "osteomalacia fragilis rubra." A second case was reported by Weber in 1867 and the term "myeloma" was introduced by Rustizky in connection with a third case in 1873. After describing the disease condition, Rustizky made the observation which follows in free translation. "The previously described types of bone tumors, formerly grouped together as osteosarcomas but more recently, through greater precision in investigation, identified as true sarcoma of the bone, myeloid, medullary osteoma, osteoid chondroma, etc., are other and more complicated structures than the above-described tumor. In none of these classes can the latter be placed in respect to its tumor-architecture; rather do its microscopical and macroscopical peculiarities justify us in placing the above-described tumor in a distinct group and in giving it the name 'myeloma' in order to indicate its structural identity with the bone marrow."

For many years after Rustizky's report only occasional cases were recorded but in the last decade the number has been increasing very rapidly. In 1912, Stumm found about 50 cases in the literature and numerous additions have since been made to the list of the reported cases. Thus, it is evident that this condition is by no means as rare as was at first supposed. A realization of the diagnostic importance of the urinary findings has much to do with the rapid increase in cases in the last few years.

OCCURRENCE.—Multiple myeloma is especially a disease of middle-aged males. Shennan found about seventy-five per cent. of the reported cases in males in the fifth and sixth decades and practically all the cases have fallen between the ages of thirty-six and seventy. One typical case, however, has been reported at the age of seventy-two. As yet, no definite conclusion can be drawn in regard to etiology.

GROSS PATHOLOGY.—The occurrence of multiple tumors, arising primarily and simultaneously in widely separated bones, characterizes the condition of multiple myeloma. These growths take place usually, perhaps always, in the red marrow; and the vertebræ, ribs, and cranial bones are those most frequently affected. The multiple foci of the disease appear as grayish-red or yellowish-red tumor masses, the differences in color depending upon blood content and degree of necrosis. When highly vascular or hemorrhagic the color may be dark red. If the central portions of the various foci of growth undergo necrosis they may be readily recognized, but it is often quite impossible to differentiate exactly between the periphery of the atypical tissue and the surrounding bone marrow. The growth of the areas of myeloma is by expansion and the bone often disappears with the advance of the process until the tumor mass appears beneath the periosteum. In this situation it may form a readily palpable mass if it presents at an accessible point. The rapid and extensive absorption of both spongy and dense bone is often a remarkable phase of the disease and may be manifested not only by the appearance of subperiosteal tumor masses but also by spontaneous fractures, sometimes several such fractures taking place in the same case. The growths may also break through the periosteum and grow freely in the nearby structures, but it is very

doubtful whether metastasis ever occurs in pure cases. A few such instances have been reported, but in at least one case it has been shown (Shennan) that the apparent metastases did not result through embolism from cells of the new formation but were due to simultaneous transformations of other foci of hematopoietic tissue already present in the organs or to direct local extension. The possibility of metastatic extensions must be left open, but it can be safely said that this occurrence is at least very rare.

Histological Pathology.—The myeloma is a very cellular newgrowth made up in most cases of cells resembling myelocytes or premyelocytes. These cells are large, from fifteen to twenty microns in diameter and lie closely packed together in the meshes of a fine reticulum. Usually spherical, they may become polygonal through pressure. The protoplasm of the cells is relatively large in amount as compared to most round-celled sarcomas, and neutrophilic granulations may or may not be present. The nuclei are usually large, round, and vesicular and often eccentrically placed. A nucleolus is usually readily demonstrable by proper staining methods.

All who have reported cases of multiple myeloma emphasize the fact that in each individual case there is always a great uniformity in cell type. Among the various cases, however, there is no readily apparent similarity, and at least five different cell types have been recognized.

1. *True Myelocytes.*—These are large mononuclear cells, twelve to eighteen microns in diameter. A large lightly staining nucleus is often eccentrically placed and the chromatin in some cases appears to be more densely arranged toward the periphery of the nucleus. In the protoplasm neutrophilic granulations may be emonstrated.

2. *Myeloblasts.*—The myeloblasts are premyelocytes and differ from the preceding type chiefly in the absence of granules.

3. *Plasma Cells.*—In some cases the cells have been described as closely resembling plasma cells in that the nuclei have coarsely clumped chromatin somewhat radially arranged, and that the cytoplasm is basophilic. Wright was the first to call attention to this cell type among the myelomas, and several others have since described cells of similar appearance in this disease. To examples of this group such names as "plasmoma" or "plasmocytoma" have been applied.

4. Some authors have described the cells in cases of multiple myeloma as resembling large lymphocytes, and such cases have been called "lymphocytomas."

5. A single case has been described by Ribbert in which the cells seemed to correspond to megaloblasts, and to this the term "erythroblastoma" was applied.

Much of the controversy in regard to cell type seems to have been due to differences in technical methods in respect to both fixation and staining of material studied, for Shennan has shown that in certain cases the new growth could be thrown with the plasmomas or with the myeloblastomas according to the method of procedure employed. We may feel certain that many of the distinctions which have been made have depended upon such artificial appearances. On the other hand, it must be borne in mind that in multiple myeloma we do not have to deal with an ordinary hyperplasia of the bone marrow, for in any given case only one cell type is characteristically involved in the process; and in the present stage of our knowledge of the disease we have no reason for thinking it impossible that at one time one cell type and at another time another may be concerned. In general, however, it is to be expected that further study will reduce rather than increase the number of cell types found in the various cases of myelomatosis.

The close relationship between multiple myeloma, especially of the lymphocytoma type, and chloroma has been noted by several. In chloroma, however, there are, characteristically, marked changes in the blood picture and secondary foci of proliferation may be numerous. The resemblances between the two are largely those of cell type, yet it is rather an attractive view to regard multiple myeloma, chloroma, and leukemia as a group of closely allied conditions in which there is a progressively greater tendency, as we pass from one to the other, for the characteristic cell type to become less fixed in its habit and more prone to freely invade the blood stream.

Symptomatology.—Severe deep-seated pain in the affected area is most frequently the initial manifestation of the condition of multiple myeloma. The pain is intermittent in character and is increased by muscular exertion or by pressure. There may be extension of the pain into the extremities. Gastrointestinal disturbances are also common and there is frequently a moderate rise in temperature. With the advance of the disease the tumor masses may become the most striking feature, but it must be borne in mind that some cases never have any externally demonstrable lesions. Fractures, occurring either spontaneously or with relatively slight trauma, may take place and kyphosis or other evidence of distortion of the vertebral column is not unusual.

The urinary findings are also of great importance, for in a typical case of multiple myeloma the *urine*

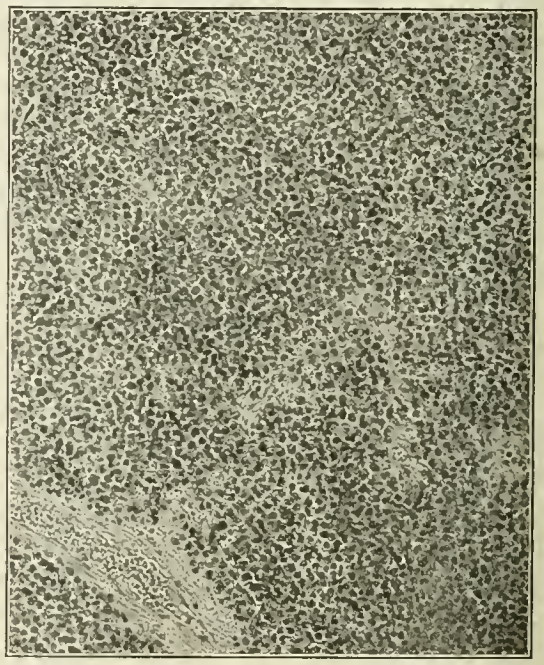


Fig. 4039.—Microphotograph of a Section from a Typical Myeloma. There is a marked uniformity in cell type throughout the section, and the tumor is richly supplied with thin walled blood-vessels. Hæmalum and eosin staining. Zeiss objective "B".

exhibits certain fairly constant characteristics. The total amount is usually two or three liters per day (Boggs and Guthrie) with a practically normal specific gravity. It is said to foam more readily than normally upon shaking and turns darker on standing. Of the greatest importance, however, is the fact that it contains in relatively large amounts the so-called Bence-Jones albumose, sometimes fifty to seventy grams per twenty-four hours. This substance has been shown to be not an albumose but a true protein, and is readily detected by heating urine which has previously been acidified with five per cent. acetic acid

to boiling and then cooling. Precipitation of the Bence-Jones protein occurs at 50° to 60° and with boiling the precipitate is partially or completely dissolved, but reappears upon cooling. A large percentage of all cases of multiple myeloma show this peculiar urinary finding although there are some well-authenticated instances in which it has been entirely absent throughout the entire course of the disease. On the other hand, Bence-Jones proteinuria also occurs in other forms of bone marrow disease, but these cases are few in number and the amount of the protein substance excreted is very much smaller, ranging from a trace to two grams per day (Boggs and Guthrie). Quantitative study of the excretion of the Bence-Jones body therefore takes on a most important diagnostic value and it must be borne in mind that proteinuria may precede any other signs or symptoms pointing to disease of the bones or bone marrow.

The *blood* shows a severe anemia as the process advances, but the white cells are usually unaltered. Herein the condition of multiple myeloma is in marked contrast to the leukemias, a group which it closely resembles in many other respects. The spleen and lymph nodes are likewise usually entirely free from involvement in the disease process.

In the later stages two other groups of symptoms appear. One of these results from the increasing asthenia and emaciation, the other is due to pressure upon, or invasion of, the spinal cord and nerve trunks. In this second group there may be found various paralyses, incontinence of urine and feces from loss of sphincter control, persistent coughing, pains in the extremities, etc.

Differential Diagnosis.—Multiple myeloma differs from *osteomalacia* in being very rare in females among whom more than ninety per cent. of all cases of osteomalacia occur, an incidence which is determined by the association of the latter with pregnancy and the puerperium. As early as 1861 Litzmann found 120 out of 131 cases of osteomalacia in women, and in 1900 Hahn was able to find but thirty-one additional cases in males reported. Osteomalacia usually affects the pelvis, myeloma very rarely. The character of the bone changes is quite different. In myeloma there is replacement of bone by a definite cellular new growth, but the portions of bone remaining retain the usual proportion of calcium salts and although they may be very fragile are still brittle. In osteomalacia, on the other hand, the amount of lime salt is decreased and the bone becomes less brittle and more readily bent.

From true *sarcoma* the differentiation is more difficult and microscopical examination of tissue may be required. However, the so-called myeloid sarcomas are more apt to occur in the long bones, frequently give rise to metastases and, if they show the Bence-Jones proteinuria at all, do so in much smaller amounts than do typical cases of multiple myeloma.

The various *leukemic* conditions are to be differentiated by the blood changes and by the activity of lymph nodes and spleen in the disease process. If leukemic bone marrow is subjected to microscopical examination, it will be noted that the hyperplastic changes are not confined to one cell type as they appear to be in a myeloma.

Course and Prognosis.—The duration of the disease has been noted as varying from four months to eight years with an average of two years. In practically all cases which have been studied from the standpoint of the proteinuria death has occurred within two years after the recognition of the Bence-Jones body. A case reported by Groves is an apparent exception to the rule of an early fatal termination. This case is of twelve years' duration, has sustained several spontaneous fractures and showed a Bence-Jones proteinuria of sixty-three grams per twenty-four hours. At the time that the case was reported the disease was apparently quiescent, the fractures united, and the general condition of the patient improved. However, it must be noted that there had been no microscopical verification in this instance.

Treatment.—In view of the hopeless prognosis very little is to be said in regard to treatment. Because of the close relationship between multiple myeloma and leukemia the measures which cause remissions in the course of the latter have been applied to the former. Röntgen rays and arsenic, however, have little or no effect in multiple myeloma. The use of benzol awaits further investigation.

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Bibliography.

A few of the more important references to multiple myeloma are here listed. Among these several complete bibliographies may be found.

1. Bence-Jones: Phil. Trans. Roy. Soc., 1848, part I, p. 55.
2. Rustizky: Deutsch. Zeitschr. f. chir., 1873, Bd. iii., s. 162.
3. Shennan: Edinb. M. J., 1913, N. S., x., 321, 414.
4. Gould, Bland-Sutton (et al.): Proc. Roy. Soc. Med., Lond., 1912–13, vi., Surg. Sect., 35–94.
5. Boggs and Guthrie: Internat. Clin., Phila., 1913, 23, s. I, 86–91.
6. Groves: Ann. Surg., Phila., 1913, lvii., 163–170.
7. Stumm: Surg., Gynec. and Obst., Chicago, 1912, xv., 653–662.

Myiasis.—Myiosis. Parasitism by dipterous larvæ which may be normal or facultative. The families and genera, the larvæ of which most commonly occur in man, are: *Oestridæ*, botflies; *Sarcophaga*, flesh-flies; *Chrysomyia*, the screw-worm; *Phromia*, *Calliphorinæ*, blowflies; *Anthomyiidæ*, fruit-flies; *Muscidæ*, houseflies. See *Insects, parasitic.* A. S. P.

Myocardium, Diseases of the.—See *Heart, Myocardial Disease.*

Myoma.—A myoma (from μῦς, muscle, and ωμα a suffix denoting a tumor) is an autonomous new growth having the muscle cell as its characteristic and essential histologic element. Such a tumor takes its origin from previously existing muscle cells or the anlagen of such and is therefore of mesoblastic origin and belongs to the general group of mature connective-tissue tumors.

Corresponding to the two varieties of muscle cells, plain and striated, two kinds of myomas are recognized. A neoplasm which has the smooth or non-striated muscle cell as its physiologic prototype is known as a *leiomyoma*, *myoma lævicellulare*, or simply as a *myoma*. If the physiologic prototype is to be found in either mature or immature striated muscle cells, the neoplasm is called a *rhabdomyoma* or *myoma striocellulare*. The leiomyoma is one of the most common tumors and has its chief importance as the so-called uterine "fibroid." The rhabdomyoma, on the other hand, is a relatively rare growth and is usually found in association with other kinds of tissue in mixed tumors of teratomatous origin. Since the leiomyoma and the rhabdomyoma are quite unlike in all respects they must be given separate consideration.

I. Leiomyoma.—As seen in the *gross*, a pure leiomyoma is a rather soft, gray or reddish-gray tumor. Of expansive growth, it is usually found as a rounded nodule, which is often solitary in other locations but in the uterus develops from multiple foci of growth in practically all cases. The pure myoma, however, is not the form most frequently met with, for there is usually an abundant stroma of fibrous connective tissue throughout these tumors and the gross appearance varies with the relative proportions of the two tissue elements. Such leiomyomas are much firmer than those of a purer type, and are often white, grayish white, or yellowish white in color. The cut surface

has a peculiar glistening striated appearance, usually described as resembling watered silk.

Leiomyomas range in size from those which are only microscopically demonstrable to those which are larger than a child's head. In the case of multiple tumor nodules, such as are frequently found in the uterus, all gradations in size may be noted in a single specimen. As a rule, the smaller, and doubtless younger, nodules show the greater proportion of muscle tissue; that is, they approach more nearly the type of the pure myoma.

There is also wide variation in the relationship of the neoplasm to the surrounding tissues. The tumor nodules may be so sharply defined that they can be "shelled out," leaving behind a smooth walled capsule, or the neoplastic tissue may be somewhat diffuse at its periphery. In the latter case it may be quite impossible to tell the extent of the new growth without microscopical examination.

Through growth in the direction of least resistance and through the extrusive effect resulting from the contraction of the normal surrounding musculature, a leiomyoma arising in the wall of an organ may appear as a subserous or submucous mass. As growth proceeds this may become polypoid and pediculated. In producing this result, the force of gravity may be added to the factors above mentioned.

The *microscopical* identification of a leiomyoma depends upon the recognition of the smooth muscle cells. If there is difficulty in differentiating between these and the connective-tissue elements which are always present in greater or less degree, the use of reticulum stains such as Mallory's or Van Gieson's methods will decide the question. A well-differentiated eosin stain in itself will serve to distinguish the two tissues through the greater tenacity with which the involuntary muscle cell retains the dye. However, a close inspection of the cells will usually suffice. The nuclei of muscle cells are longer, more rod like and more bluntly rounded at the ends than the nuclei of connective-tissue cells. Likewise, the non-striated muscle cells when seen in cross-section each show a definite protoplasmic body enveloping the nucleus. The nuclei of connective-tissue cells, on the other hand, are more spindle shaped and when seen in cross-section have very little cell protoplasm surrounding them.

Myoglia fibrils, similar to those found in normal plain muscle, have been demonstrated in myomas and are said to exhibit more than the usual variation in size and arrangement. This is to be expected since the nuclei and cell bodies in certain cases also depart widely from the usual type as described above.

Site.—By far the larger number of leiomyomas are found in the uterus and its adnexa. Next to the uterus the gastrointestinal tract and the skin are the most frequent sites, but leiomyomas are more rarely found in the bladder wall, urethra, kidney, ovary, testis, prostate, and vagina. The special characteristics of the neoplasm in these various locations will be taken up later.

Etiology.—The myoma arises from preexisting muscle cells. The myomatous metaplasia of connective tissue which has been assumed in order to explain the origin of certain tumors of this group seems highly improbable. Most authors, including Borst, agree that the uterine leiomyomas arise in the involuntary muscle of the vessel walls and the arrangement of the neoplastic muscle bundles about the blood-vessels seems to bear this out. In spite of the general agreement upon this mode of origin, it must be borne in mind that on purely *a priori* grounds, as Adami says, one might expect that non-striated muscle tumors arising in an organ, itself composed of non-striated muscle, would take their origin from the mass of the organ and not from its blood-vessels. The presence of glandular elements in some uterine myomas has been much used as an argument for a congenital origin of all of these tumors from Wolffian body and Müllerian duct remains. In some cases, however, it has been shown that these epithelial structures are in direct continuity with the endometrium so that this argument has lost its weight to some extent. In leiomyomas of the skin, the point of origin has in some instances been described as the involuntary muscle of the blood-vessel walls and in others as in the arrectores pilorum.

The factor which actually determines or incites the neoplastic growth remains unknown. The large proportion of uterine fibroids in nullipara has suggested that the tumor growth is here but a manifestation of the otherwise latent developmental energy which has never been called into physiologic activity. Since, however, it is at present impossible to say whether the myoma may not be the cause rather than the result of the sterility in many of these cases where the two conditions are coincident, this view cannot be fully accepted. Most authors consider that various chronic inflammatory conditions have much to do with the origin of leiomyomas, but we have not the same definite examples of this that we have in the case of certain other neoplasms, especially some of those of epithelial origin.

Varieties.—To many varieties of leiomyomas, arising through combination with other tissues and through retrograde changes, special descriptive terms are applied. The variety depending upon the presence of a large proportion of connective tissue is the most common. Such myomas are called *leiomyofibromas, fibromyomas,* or simply *fibroids.* If the tumor is highly vascular it may be described as a *myoma telangiectaticum, angiomyoma,* or *myoma cavernosum* if the vessels are greatly dilated as well as numerous. If the lymphatic channels are greatly dilated it may be spoken of as a *myoma lymphangiectaticum.* Those myomas in which the glandular elements are included are called *adenomyomas* or *von Recklinghausen's* tumors. Through liquefaction necrosis large cystic spaces may be formed in the interior of a leiomyoma and to such a tumor the term *myoma cysticum* may be applied. The soft forms with rather abundant fluid content are contrasted with the denser and more fibroid tumors through the use of the terms *leiomyoma molle* and *leiomyoma durum.*

Growth, Benignancy, Malignant Change.—The leiomyoma is essentially a benign tumor, growing with relative slowness and by expansion. A number of instances of metastasis of a pure leiomyoma have been reported, yet this is an exceedingly rare occurrence and the presence of a metastatic growth should lead one to expect that the leiomyoma in question had undergone sarcomatous change. Only when this possibility has been carefully excluded by microscopical examination can the presence of a true myomatous metastasis be affirmed.

Sarcomatous change in leiomyomas is of frequent occurrence and is made known by the greatly increased cellularity and by the very atypical appearance of both nuclei and cell bodies. There now seems to be abundant proof that the malignant change may take place in either the myomatous or the connective-tissue portion of the myofibroma and in either case the term *myosarcoma* is loosely applied to the resulting neoplasm. It is better, as Kaufmann, Borst, and others have emphasized, to reserve *myosarcoma* for the cases in which the sarcomatous change takes place in the connective tissue of a fibromyoma, since it properly names a mixed neoplasm, partly myoma and partly sarcoma. To members of the other group in which the muscle cells themselves have undergone the malignant change the term *myoma sarcomatodes* should be applied as emphasizing the fact that here the myoma itself has become sarcomatous.

In addition to the possibility of malignancy through sarcomatous change, a leiomyoma may seriously impair health or even cause death in many other ways,

such as pressure upon neighboring structures, hemorrhages from necrosing or ulcerating surfaces, absorption from necrotic tumor masses, secondary infection, or the severe disturbances in cardiac and renal activity of which the relationship to leiomyoma is but imperfectly understood. On the other hand, these tumors may exist for many years without producing symptoms and then be accidently discovered in the course of an operation or at autopsy.

Uterus.—In the uterus the leiomyoma, in the form of the fibromyoma, is the most common tumor. It is usually situated in the fundus, more rarely in the cervix and but occasionally in the wall of the Fallopian tube or in the broad ligament. In a series of 500 cases Bland-Sutton found that in five per cent. the neoplasm was located in the cervix. Uterine myomas may be found at any age after puberty but are most commonly met with in early middle life and in women who have not borne children. The colored race is especially prone to this condition.

As previously stated, myomas in the uterus are practically always multiple and the tumor nodules are usually roughly spherical in shape. The larger tumors naturally cause a great distortion both of the general contour of the uterus and of the course of the uterine canal, which may be pushed to one side as an irregular tortuous passage. In size there is the greatest variation from minute nodules up to a size of twenty kilograms or even larger.

According to location leiomyomas of the uterus may be *submucous, interstitial,* or *subserous.* The submucous tumors commonly become pedunculated

Fig. 4040.—Microphotograph of a Section from a Uterine Leiomyoma. Hemalum and eosin stain. Zeiss obj. "B".

and then are met with as polypoid masses in the uterine cavity, cervical canal, vagina or even protruding externally. In this situation a leiomyoma may produce an inversion of the uterus. The subserous fibroids when large and numerous may transform the uterus into an irregular mass of the most bizarre shape. When appearing between the layers of the broad ligament a subserous tumor is spoken of as *intraligamentous* and as *retroperitoneal* if it arises low down upon the uterus and passes behind the parietal peritoneum. The pedicle of a subserous leiomyoma may become twisted so that its blood supply is impaired, necrosis takes place and the pedicle becomes severed. The tumor mass thus set free in the peritoneal cavity must suffer necrosis unless through adhesions with other structures an adequate supplementary circulation is provided. Such tumors detached from their original site upon the uterus but still living are spoken of as *wandering, aberrant,* or *parasitic* fibroids. They are to be distinguished from leiomyomas which originate along the uterine ligaments or retroperitoneally and which resemble uterine fibroids both grossly and microscopically, but are in no sense migratory, since they preserve their original attachment.

Uterine leiomyomas are subject to all of the retrograde changes which may occur in similar tumors elsewhere. Hyaline change is so frequent as to be the rule in the larger and presumably older growths, but calcification and liquefaction necrosis are also very common. In some cases lime salts are deposited in the necrobiotic cells and stroma while in others calcification seems to be altogether secondary to necrosis and tissue disintegration.

In the uterus and its attachments there occurs a highly interesting variety of leiomyoma in the *von Recklinghausen's tumor* or *adenomyoma.* This differs from the ordinary leiomyoma in the presence of scattered glandular spaces with epithelial lining. In some cases the glandular and in others the myomatous elements predominate. These tumors are usually more diffuse in their habit of growth than are the ordinary fibroids and they were originally described as occurring in the outer layers of the posterior uterine wall. They may be found in practically any portion of the uterus, however, or in the wall of the Fallopian tubes or along the round ligaments even in the inguinal region.

A very extensive literature has been developed in regard to the von Recklinghausen tumor, all centering about the question of the origin of the glandular structures. It has now been shown quite conclusively that no one origin can be assigned to all. According to Kaufmann these cases fall into four groups, depending upon whether they take their origin (1) from Wolffian body remains, especially the tubules of the paroophoron; (2) from Wolffian duct remains such as the ducts of Gärtner; (3) from structures developed from the Müllerian ducts, including here all of the adenomyomas in which it is possible to trace the continuity between the glandular structures and the endometrium; (4) from inclusions of the serous covering of the uterus.

The possibility of carcinomatous change in the epithelial elements of an adenomyoma must be borne in mind, but apparently this is a rare occurrence. Direct extension or metastases from a coincident adenocarcinoma arising in the endometrium must be carefully excluded from these cases for it is by no means rare to find a carcinoma of either cervix or body developing in a uterus already the seat of myomatous growths.

Gastrointestinal Tract.—Leiomyomas are found in the esophagus, stomach, and intestine. In each of these locations it is possible to describe such tumors as submucous, interstitial, and subserous. Through traction a heavy tumor mass may produce a severe distortion of the gastrointestinal canal. The submucous myomas may cause intussusception (Birch-Hirschfeld), and the subserous examples may produce diverticula (Borst). The subserous myomas of the stomach wall sometimes reach a very large size. In a case mentioned by Kaufmann a subserous myoma developing upon the lesser curvature had a weight of 2,325 grams. In general, these tumors are more nearly pure myomas than the uterine growths. The so-called malignant myoma of the stomach may more

properly be considered a myoma which has undergone sarcomatous change.

Skin.—Leiomyomas of the skin are rather rare but sometimes are to be met with as multiple small cutaneous or subcutaneous nodules. As previously mentioned, the point of origin has been variously described as the blood-vessel walls, the arrectores pilorum and the involuntary muscle fibers of the sweat glands. In those regions where the cutaneous musculature is highly developed, such as the nipple, areola, scrotum, and female genitalia, single myomas of considerable size may be found. These have been grouped together as dartoic myomas (Besnier). Skin myomas are oftentimes mixed tumors with a hemangioma, lymphangioma, or neuroma as the other component.

In the *testis* pure myomatous tumors may be found in part or wholly replacing the organ. Probably all of these, like the mixed tumors of the same location, are in reality teratomatous in origin. Leiomyomas of the *bladder* wall are quite rare, Terrier and Hartmann being able to collect but sixteen cases in 1895. The more or less diffuse fibromyomatous hypertrophy of the *prostate*, sometimes listed as being a true myoma, is usually of a chronic inflammatory origin.

2. Rhabdomyoma.—The rhabdomyoma, or myoma striocellulare, has the striated muscle cell as its essential and characteristic element. In contrast to the leiomyoma it is a rare tumor and is most frequently met with in situations where its chief histologic element is not normally to be found. Moreover, malignancy through sarcomatous change or through combination with a sarcoma is here the rule rather than the exception.

Since it is so often a mixed tumor the appearances of rhabdomyoma are highly variable. The purer types are usually single or multiple, soft, grayish red, circumscribed and sometimes encapsulated nodules which grow by expansion. Rhabdomyomas with accompanying sarcomatous change are more diffusely growing, or may form soft polypoid masses which break down readily.

In *microscopical sections* of rhabdomyomas, fully developed striated muscle cells are practically never found. In place of these, but still revealing the true character of the neoplasm, there are to be found slender, spindle-shaped cells as well as plumper and shorter spindles and irregular protoplasmic masses of a great variety of sizes and shapes. Some of these cells exhibit both a longitudinal fibrillation and a transverse striation, but this degree of development is by no means constant and many of the cells may show no striations whatever or may be striated in certain portions only. The larger cells may show club-shaped extremities with many closely packed nuclei such as are normally found in sarcoblasts. In the slender, elongated cells, however, there may be but a single nucleus placed anywhere along the course of the cell with a sharply localized swelling to make room for it. All of these varying cell types are to be interpreted as embryonic, imperfectly differentiated and imperfectly developed striated muscle cells.

Location.—Rhabdomyomatous tumors are found most frequently in the kidney. However, other portions of the urogenital tract are sometimes involved and cases have been described from the bladder, uterus, vagina, ovary, testis, and prostate. Another interesting group of cases is that of the rhabdomyomas of the heart. The remaining cases are from the most varied locations, such as the lung, orbit, retroperitoneal tissues, parotid, temporal region, sacrum, tongue, esophagus, stomach, and from some of the skeletal muscles.

In the *kidney* rhabdomyomas are frequently combined with glandular elements and a sarcomatous stroma such that these tumors are spoken of as *adenomyosarcomas*. In these, bone, cartilage and fat tissue may be found, as in the complex teratoid tumors of the ovary and testis. More rarely, however, nodules of pure muscle tissue are found in the kidney.

Rhabdomyomas of the *heart* make a small group of something over a dozen fully authenticated cases. These have been carefully studied by Seiffert, Wolbach and others, who have found a marked similarity among all of these cases. The tumor usually consists of one or more sharply circumscribed nodules in the heart wall, set off from the myocardium by a thin connective-tissue capsule. Microscopical examination of these nodules shows a loose-meshed tissue composed of muscle cells exhibiting the greatest variety in size and shape. The location and meaning of the spaces within the meshwork has been a matter of uncertainty but it now seems to be determined definitely that these spaces are in fact intracellular, and are comparable to the undifferentiated and frequently vacuolated central portions of embryonic cells both of the heart and of the body muscle.

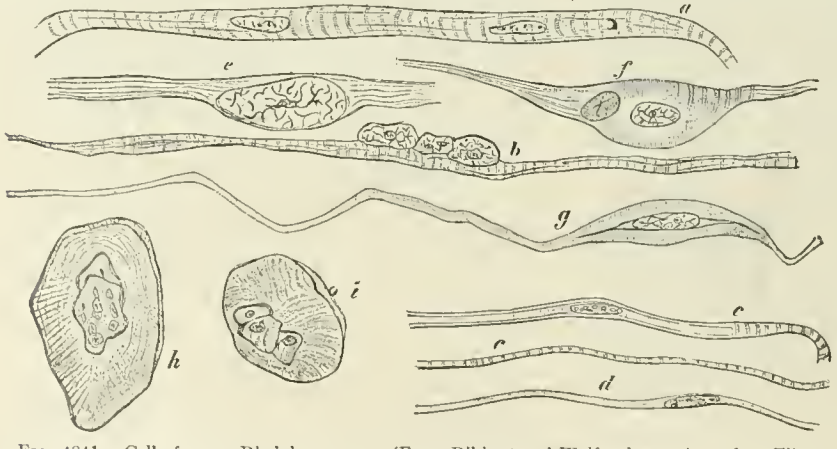

Fig. 4041.—Cells from a Rhabdomyoma. (From Ribbert and Wolfensberger.) *a*, *b*, *c*, Fibers of various sizes with transverse striation; *d*, small nucleated fiber without striæ; *e*, spindle cell with longitudinal striæ; *f*, spindle cell with longitudinal and transverse striæ; *g*, spindle cells, non-striated, with elongated processes; *h*, *i*, round cells with concentric and radial striation.

The coincident occurrence of rhabdomyoma of the heart and areas of cerebral sclerosis is an interesting point which was noted in six of the twelve cases which Wolbach considered as well authenticated.

Etiology.—There can be little doubt that in practically all cases rhabdomyomas arise through disturbances in development. The arguments which lead to thus including the rhabdomyoma among the mixed embryonal neoplasms, the teratoblastomas, are many and forceful. The age distribution bespeaks such an origin, for this tumor type is almost always found in the very young, practically all of the heart cases having been less than four years of age. That there are occasional exceptions to this rule in isolated examples of rhabdomyomas discovered in individuals past middle age, is altogether in accord with the findings in such obvious teratoblastomas as the mixed tumors of ovary and testis.

In the second place, additional evidence is afforded by the embryonic character of the muscle in these tumors. Likewise, the fact that most rhabdomyomas are found in sites normally without striated muscle is of great importance. Finally, the frequent combination of the neoplastic muscle tissue with other of the supporting tissues, such as cartilage and bone, and even with tissues derived from another germinal layer, as in the case of the complex teratomas, makes it seem quite probable that all rhabdomyomas are teratomatous in origin.

Significance, Malignant Change.—The rhabdomyoma, in contrast to the leiomyoma, is of little clinical significance because of its comparative rarity. It is rarely diagnosed during life and requires microscopical study for complete verification as to its character. In most cases the neoplasm in which the striated muscle cells are recognized is essentially a sarcoma and presents the usual characteristics of malignancy. Because of the mixed character of these tumors, however, it is not always easy to determine whether the sarcomatous change is of the muscle element or the connective tissue. If the former is the case the neoplasm may best be called a *rhabdomyoma sarcomatodes,* while if the rhabdomyoma is simply in combination with a sarcoma the term *rhabdomyosarcoma* will emphasize the mixed character of the neoplasm. In either case metastases may be produced. In two or three instances the secondary tumors have been shown to contain striated muscle cells, but this is unusual and the metastases rarely reveal the rhabdomyomatous character of the primary. In many of these cases the discovery of atypical striated muscle cells is chiefly of theoretical interest as directing attention to the probable teratoid character of the neoplasm.

Carl Vernon Weller.

Myopia.—(*μυωπία, μυωπίασις,* also *μυωπός, μυώψ*—from *μύω* and *ὤψ*, signifying winking or contracting the eyelids—German, *Kurzsichtigkeit;* French, *vue courte;* English, short- or near-sightedness)—is mentioned by Aristotle, in the Galenical writings, and by the Byzantine medical authors—Oribasius, Aëtius, Paulus Ægineta, and Actuarius. It is described as a congenital condition, in which small near objects are seen distinctly, but distant objects imperfectly or not at all; also as the opposite condition to that occurring in old persons who distinguish small near objects, such as written characters, imperfectly, but see well at a distance. It is further recognized as incurable.

These brief statements, which comprehend practically the sum of the teaching of the earlier writers on medicine, and which were not seriously questioned until after the middle of the last century, include, nevertheless, two fundamental errors: (*a*) M,* although very common in children, and dependent in many cases on inherited tendencies or conditions, is very rarely congenital; and (*b*) M is not the opposite condition to presbyopia—which is a disability resulting from impairment of the function of accommodation incident to advancing age—but is really the opposite of hypermetropia—H, which is a congenital condition, and which, like M, consists essentially in a faulty proportion between the radii of curvature of the refracting surfaces of the eye and the length of the anteroposterior axis of the eyeball.

As in H the axis of the eyeball is, as a rule, actually shorter than in the normally proportioned (emmetropic) eye, so in M the axis of the eye is, as a rule, longer than in the emmetropic eye. These two opposite anatomical conditions constitute, in fact, the essential variations from the normal in typical H and M respectively, namely, *axial* H and *axial* M.

Fig. 4042 represents, in section, a myopic eye, the dotted outline indicating the section of the emmetropic eye. It has been explained (see *Accommodation and Refraction*) that the sum of the successive refractions at the cornea and the two surfaces of the crystalline lens is just sufficient to focus pencils of parallel rays upon the retina at its normal position *E*, and that, through the exercise of its accommodation, the emmetropic eye is able to focus, upon its retina, pencils of divergent rays, such as are received from near objects. In the myopic eye the principal focus—*i.e.*, the focus for pencils of parallel rays—is in front of the actual position of the retina, so that the retinal image of any distant object is made up of overlapping circles of confusion and is, therefore, imperfectly defined.

The unaccommodated myopic eye is, however, adapted for the correct focussing of pencils of divergent rays emanating from an object at some particular short distance, as shown in Fig. 4043, in which a pencil of rays diverging from *r* is represented as refracted to a focus on the retina of the myopic eye at *M*. The distance of this *far-point* of distinct vision (*punctum remotissimum*—*r*), measured from the eye in meters or fractional parts of a meter, is the reciprocal of the grade of the myopia expressed in dioptries. Representing this distance by R, and the grade of the myopia by M, we have:

$$R = \frac{1}{M} \text{ meter} \quad . \quad . \quad . \quad . \quad [1]$$

By the exercise of its accommodation the myopic eye is able to adjust itself for distinct vision at any distance less than R, up to a limiting point *p* (Fig. 4044), which is called the *near-point* (*punctum proximum*). The distance of the near-point from the eye, represented by P, is the reciprocal of the grade of the myopia plus the range of accommodation, both expressed in dioptries. Representing the range of accommodation by A, we have:

$$P = \frac{1}{M + A} \text{ meter} \quad . \quad . \quad . \quad . \quad [2]$$

From the form of equations [1] and [2], it is evident that, for increasing values of M, both R and P decrease, but that R decreases at a greater rate than P. It follows that for higher grades of myopia, both *r* and *p* fall nearer to the eye than for lower grades of myopia, and that they also fall nearer together.

Subtracting equation [2] from equation [1], we have:

$$R - P = \frac{1}{M} - \frac{1}{M + A} \text{ meter} \quad . \quad . \quad . \quad . \quad [3]$$

The linear measure R − P, which represents the difference in the distance of the far-point (*r*) and the near-point (*p*) from the eye, and which represents, therefore, the linear distance through which the myopic eye is able to adjust itself for distinct vision by the full exercise of its accommodation (A), is its *region of accommodation.* As R is the reciprocal of M, the region of accommodation, R − P, is at its maximum (infinity) when M = zero (emmetropia). Table I shows the measure of R, of P, and of R − P, respectively, for progressively increasing grades of myopia, from 1. D to 10. D, in a young person with an unimpaired range of accommodation of 10. D.

Inspecting Table I, it will be observed that in high grades of myopia both the near-point (*p*) and the far-point (*r*) are very near to the eye, and that the region of accommodation (R − P), although extended,

*List of abbreviations used in this article: M = Myopia; H = hypermetropia; A = range of accommodation; *r* = far-point (*punctum remotissimum*) of distinct vision; p = near-point (*punctum proximum*) of distinct vision; R = distance of *r* from the first principal point of the eye; P = distance of *p* from the first principal point of the eye; R − P = region of accommodation; D = dipotrie or dipotries; *h* = principal point; *h′* = first principal point; *h″* = second principal point; *k* = nodal point; *k′* = first nodal point; *k″* = second nodal point.

by a few centimeters, in the direction toward the eye, is so greatly contracted, as a whole, as practically to annul the part played by the accommodation in seeing at short range; only in the lower grades of myopia, in which r lies farther from the eye than the reading distance, is there a limited field for a partial exercise of the accommodation to meet the restricted requirements of near vision.

TABLE I.

M =.	$R = \frac{1}{M}$ =.	$P = \frac{1}{M + A}$ =.	$R - P = \frac{1}{M} - \frac{1}{M + A}$ =.
1. D.....	1 = 1.000 m.	$\frac{1}{11}$ = 0.091 m.	$\frac{10}{11}$ = 0.909 m.
2. D.....	$\frac{1}{2}$ = 0.500 m.	$\frac{1}{12}$ = 0.083 m.	$\frac{10}{24}$ = 0.417 m.
3. D.....	$\frac{1}{3}$ = 0.333 m.	$\frac{1}{13}$ = 0.077 m.	$\frac{10}{39}$ = 0.256 m.
4. D.....	$\frac{1}{4}$ = 0.250 m.	$\frac{1}{14}$ = 0.071 m.	$\frac{10}{56}$ = 0.179 m.
5. D.....	$\frac{1}{5}$ = 0.200 m.	$\frac{1}{15}$ = 0.067 m.	$\frac{10}{75}$ = 0.133 m.
6. D.....	$\frac{1}{6}$ = 0.167 m.	$\frac{1}{16}$ = 0.063 m.	$\frac{10}{96}$ = 0.104 m.
7. D.....	$\frac{1}{7}$ = 0.143 m.	$\frac{1}{17}$ = 0.059 m.	$\frac{10}{119}$ = 0.084 m.
8. D.....	$\frac{1}{8}$ = 0.125 m.	$\frac{1}{18}$ = 0.056 m.	$\frac{10}{144}$ = 0.069 m.
9. D.....	$\frac{1}{9}$ = 0.111 m.	$\frac{1}{19}$ = 0.053 m.	$\frac{10}{171}$ = 0.058 m.
10. D.....	$\frac{1}{10}$ = 0.100 m.	$\frac{1}{20}$ = 0.050 m.	$\frac{10}{200}$ = 0.050 m.

As a consequence of the displacement and contraction of the region of accommodation in myopia, the interrelation of accommodation and convergence, as it exists in emmetropia (see *Accommodation and Refraction*) is materially altered. Thus, in myopia of M dioptries, the farthest point of distinct vision—r—(under full relaxation of the accommodation) is at a distance of $\frac{1}{M}$ meter from the eye; but, in order to see an object at this distance with the two eyes, the axes of the two eyes must converge to an amount represented by M meter-angles. It follows that for perfect binocular vision, at or within the distance of the far-point, a normal exercise of the convergence, corresponding to the distance of the (near) object, must be associated either with full relaxation or with less than the normal exercise (relative relaxation) of the accommodation; in other words, there is an essential change in the relation between accommodation and convergence from that which obtains in emmetropia, in which (normal) condition an exercise of the convergence measured by any number of meter-angles goes hand-in-hand with the exercise of an equal number of dioptries of accommodation.

As a fact, a notable readjustment of the physiological bond by which the two functions of accommodation and convergence are linked together follows closely upon the progressive change in the refraction in most cases of myopia; and this readjustment is often so nearly perfect as to admit of the easy and sustained use of the two eyes together in near work. Thus in most cases of stationary or slowly progressive myopia, up to a grade of about 3. D, no difficulty is experienced in reading ordinary print, with the two eyes, at approximately the normal reading distance of about $\frac{1}{3}$ meter; also, in notably higher grades of myopia, very fine print may be read, easily and without fatigue, at some shorter distance corresponding to the distance of the point of intersection of the visual axes. Hence the very old and widely disseminated belief that myopes, as a class, enjoy a substantial advantage in respect of strong and fine vision in near work, and that this advantage, together with the further advantage of partial or complete exemption from the ordinary disabilities incident to presbyopia, may be held to outweigh the single recognized disadvantage of imperfect vision at a distance. That this old belief is, in the main, erroneous, and founded in ignorance or imperfect appreciation of the pathology of myopia as the visual expression of distention of the eyeball from disease, is proved by the anatomical demonstration of extensive and characteristic lesions in the fundus and coats of the eye in high grades of myopia; by the study of these lesions in the living eye in their successive stages of development, as revealed by the opthalmoscope; by extended statistical researches on the refractive conditions existing in the eyes of school children in the lower and higher classes and grades; and by clinical experience based on successive examinations of the eyes of individual myopes, extending often over many years.

Two fundamental facts, based on exhaustive studies of myopia during the past half-century, are definitely established:

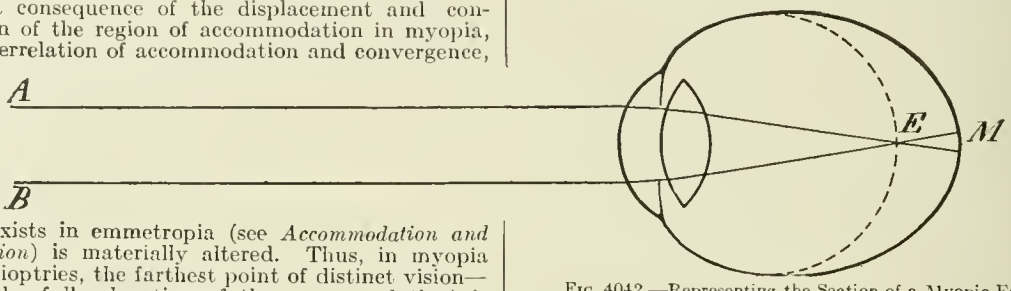

FIG. 4042.—Representing the Section of a Myopic Eye.

(*a*) Myopia is ordinarily the optical expression of

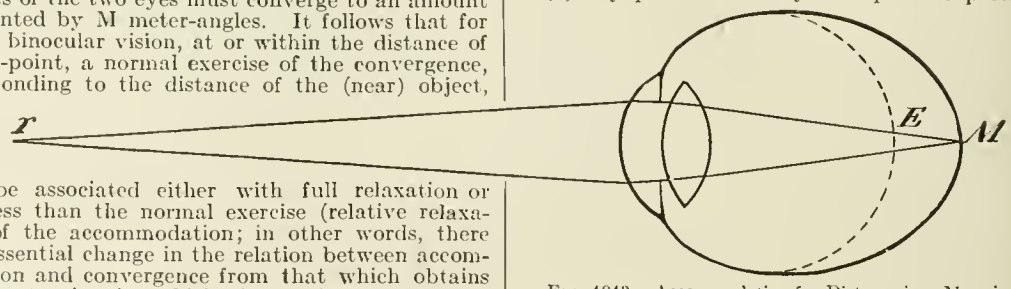

FIG. 4043.—Accommodation for Distance in a Myopic Eye.

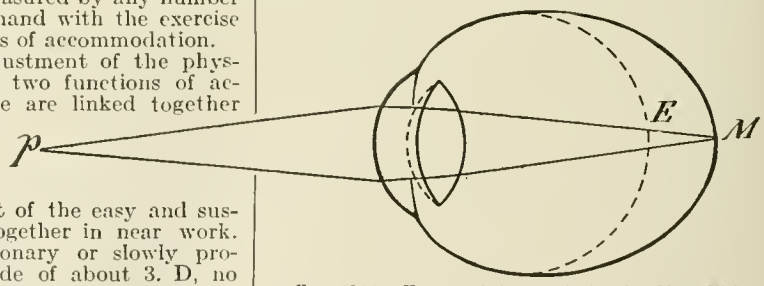

FIG. 4044.—Extent of Accomodation for Near Vision in a Myopic Eye.

an elongation of the anteroposterior axis of the eyeball, dependent on a pathological distention of the globe. Furthermore, this distention is in many cases

rapidly progresive, and not infrequently attains to so high a grade as to become a grave menace to the integrity of the eye as an organ of vision.

(*b*) In many cases of myopia, especially when it is of high grade or of rapid development, the compensatory readjustment of the convergence to the displaced region of accommodation is in so far incomplete as to give rise to a state of persistent conflict between accommodation and convergence. As alternative issues of this conflict there may result either an habitual exercise of the accommodation in excess of that which is required for perfect vision at the distance of the point of intersection of the visual axes, or accurate accommodation for the actual reading distance accompanied by fatigue or insufficiency of the recti interni muscles—muscular asthenopia, or relative or actual strabismus divergens.

A myopic eye looking through a concave lens of any (negative) power up to the measure of its myopia is rendered virtually less myopic. With a concave lens of N dioptries, taking N < M, the uncorrected part of the myopia is M − N dioptries.

If we take N = M (Fig. 4045), we have M − N = zero, in which case the myopia is completely corrected (neutralized) by the concave lens, and the eye is rendered virtually emmetropic, *i.e.* the far-point (*r*) is carried off to an infinite distance. At the same time the near-point (*p*) is removed farther from the eye, to a distance, $\frac{1}{A}$, determined by the magnitude of the range of accommodation.

The effect of a concave lens added to a myopic eye is, then, to remove both the far-point (*r*) and the near-point (*p*) to a greater distance from the eye; but the recession of *r* is greater than that of *p*. The region of accommodation (R − P) is therefore enlarged, attaining its maximum (infinity) when the (negative) power of the lens is numerically equal, in dioptries, to the grade of the myopia.

As a result of this reëstablishment of a normal region of accommodation, with the far-point (*r*) at infinity, the requirements for the conjoined exercise of the accommodation and the convergence in binocular vision become identical with those which obtain in emmetropia—the distance of the near-point, as determined by the exercise of a certain number of dioptries of accommodation, now coinciding with that of the point of intersection of the visual axes, as determined by an exercise of the convergence measured by the same number of meter-angles. As a rule, in uncomplicated myopia of low or medium grade, with unimpaired range of accommodation and normal acuity of visual perception, little or no inconvenience is experienced in utilizing fully the enlarged region of accommodation and, at the same time, readjusting the convergence to the changed optical conditions imposed by the wearing of neutralizing concave glasses. In the higher grades of myopia, especially if concave glasses are to be given for the first time, only a partial optical correction may be accepted in the beginning, and the full correction may have to be reached by a later change, or perhaps through one or more changes, to glasses of greater power.

With advancing years, as the crystalline lens becomes progressively harder and less capable of undergoing changes in form, the range of accommodation (A) diminishes in myopia just as in emmetropia and in hypermetropia. With decreasing A, approaching zero in old age, $P = \frac{1}{M + A}$ . . [2] increases, approaching $R = \frac{1}{M}$ . . [1] as a limit; the region of accommodation (R − P) being then reduced to zero through the recession of *p* to *r*. At the practically unchanged distance of *r*, the vision of the myopic eye is still perfect, and whenever *r* lies within a convenient reading distance from the eyes, as in myopia of not less than 3. D or 4. D, convex glasses are not needed for reading. In myopia of less than 3. D the need of convex reading glasses is first experienced later in life than in emmetropia, and relatively weak glasses then suffice. Similarly, in the higher grades of myopia, concave glasses weaker than those which completely correct the eyes for distant vision must be given for reading at the best distance from the eyes.

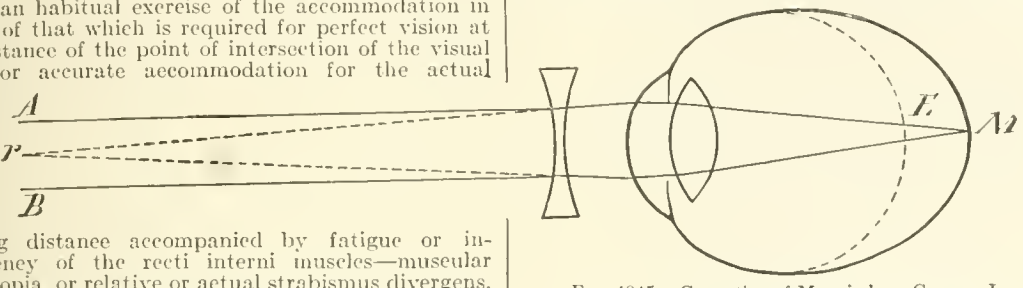

Fig. 4045.—Correction of Myopia by a Concave Lens.

Although the tendency in axial myopia, is, as a rule, in the direction of a progressive increase in grade as a result of progressively increasing distention of the eyeball, in a notably large proportion of all cases of myopia this tendency becomes arrested sooner or later, and the length of the axis of the eye may then continue stationary for many years or during the remainder of life. In such cases a small decrease in the grade of the myopia, amounting to a dioptrie or two, or perhaps a little more, may generally be detected in old age, as a result of a physiological decrease in the refractive power of the crystalline lens. On the other hand, an increase of a few dioptries in the refractive power of the crystalline lens is not infrequently observed as an incident of beginning senile cataract, and from this cause a true lenticular myopia may make its appearance in old age, or a pre-existing myopia may develop a considerable increase. Thus certain elderly persons, who have used convex glasses in reading for perhaps many years, discover that they can read as well or better without glasses (so-called second sight), and in certain cases of myopia it is found that the concave glasses which have been habitually worn are no longer perfectly satisfactory in distant vision. A revision of the glasses worn by myopes, whether for distance or in reading, is therefore generally indicated in advanced life, changing oftenest to somewhat weaker concave glasses, but occasionally to stronger, according as the lenticular refraction is found to have diminished or to have undergone a pathological increase.

The size of the retinal image of any object situated at or within the distance of the far-point of the myopic eye is greater than in the case of the same object focussed by an emmetropic eye through the exercise of its accommodation, in the ratio of the respective distances of the second nodal point of the eye (*k''*) from the retina. The size of the retinal image increases, therefore, for every increase in the length of the eyeball, so that a young person, with uncomplicated myopia of high grade, may enjoy, for a time at least, exquisitely fine sight for small near objects. With the correction of the myopia by concave spectacles, the nodal point is moved nearer to the retina, and, in the case of a neutralizing concave glass worn at the anterior principal focus of the

eye (about 13 millimeters in front of the cornea), the distance of the nodal point from the retina, consequently the size of the retinal image, becomes the same as in emmetropia. Owing to this diminution in the apparent size of small near objects, it not infrequently happens that a myope of high grade, although accepting neutralizing concave glasses for distance, is disinclined, or, in the case of subnormal visual acuity, is unable to use them in reading. This may become a source of grave embarrassment to the ophthalmic practitioner, who recognizes the dangers attendant upon the habitual use of the uncorrected eyes in fine near work, but may find it difficult to persuade a young patient to abandon such work as a means to the conservation of his sight.

Origin and Development of Myopia.—In young children hypermetropia is the typical refractive condition. Of 100 eyes of infants from one to four weeks old, measured, under atropine, with the opthalmoscope, by Horstmann, 88 (aggregating 244. D) were hypermetropic, 10 were emmetropic, and 2 (aggregating 4. D) were myopic. Of 100 eyes of children between one and two years of age, similarly examined under atropine, 84 (aggregating 188. D) were hypermetropic, 10 were emmetropic, and 6 (aggregating 8. D) were myopic. Of 100 eyes of children between four and five years of age, 74 (aggregating 188. D) were hypermetropic, 13 were emmetropic, and 13 (aggregating 22. D) were myopic.

Of 10,060 pupils of public schools in Breslau (including 1,486 children in five village schools) examined subjectively by H. Cohn, the percentage of cases of myopia increased progressively from an average of 6.7 per cent. in twenty elementary schools, to an average of 26.2 per cent. in two gymnasia (colleges). The grade of myopia also increased from an average of 1.8 D, in the elementary schools, to 2. D in the gymnasia.

Erismann measured the refraction in 4,338 pupils of schools in St. Petersburg; he found: of hypermetropes, 43.54 per cent.; of emmetropes, 26.10 per cent.; of myopes, 30.36 per cent. Tabulated in percentages for successive years of school life, Erismann's statistics show, for seven consecutive school grades, a progressive decrease in hypermetropia from 55.6 per cent. in the lowest to 36.2 per cent. in the highest grade, and an increase in myopia from 15.8 per cent. in the lowest grade to 42.8 per cent. in the highest. The percentage of emmetropic is given as 28 per cent. in the lowest grade, 25.1 per cent. in the sixth grade, and 21 per cent. in the seventh (highest) grade; in grades I. to VI. it fluctuates between 28 per cent. and 25.1 per cent. averaging 26.1 per cent. Studied as a whole, the numbers show (*a*) a progressive increase in the percentage of cases of myopia, (*b*) a concomitant progressive decrease in the percentage of cases of hypermetropia, and (*c*) a nearly constant percentage of cases of emmetropia. They thus emphasize the fact, previously suspected, but denied by Donders, that the ranks of myopia are recruited, through emmetropia as a transient condition, from eyes originally hypermetropic. It follows that a condition of emmetropic or even of hypermetropic refraction may be present in an eye which has already undergone notable distention, and that the beginning of the pathological process typical of myopia must be dated back, in many cases, to a period possibly long antecedent to the development of myopic refraction. In this fact is found an explanation of the cases in which pathological conditions characteristic of myopia of high grade are seen in eyes of relatively low myopic refraction, or, more rarely and less highly developed, in eyes which are optically emmetropic or hypermetropic.

An enormous mass of statistical material gathered by many observers in many lands shows conclusively that with moderate and easily explicable variations in the percentages, the conclusions based on the original researches of Cohn and Erismann are essentially true for all highly civilized communities.

Distribution.—Myopia is preëminently a disease of the higher ranks of society, and of highly cultured peoples. In a relatively small proportion of cases, myopia of high grade and of malignantly progressive type is observed in laborers or other persons who have never been subjected to the conditions generally recognized as especially causative of myopia; in these cases an inherited predisposition to myopia may be suspected. Myopia often occurs in certain families, appearing in several children of a myopic parent or parents, and sparing others. Soldiers and sailors are, as a rule, exempt; but this is mainly a result of selection. Savage races are largely exempt from myopia.

Age.—The statistics of myopia show that it is essentially an acquired condition; also that, in school or college, myopia of high grade occurs almost exclusively in the more advanced classes. Every case of myopia must, therefore, be regarded as having passed through a progressive change from a lower to a higher grade, and, especially in the case of a young person, as, possibly or probably, still in a stage of continuous or remittent progression. The study of the refraction of individual young myopes, examined from year to year, enforces the same conclusion. The age at which a more rapid increase is ordinarily first noticed follows very closely upon that at which considerably increased demands are made upon the eyes in study, namely, about fourteen years. From about the fifteenth to about the twenty-fifth year the increase is generally most rapid. This corresponds, in a general way, to the years of advanced preparatory and collegiate study, with some added years in the university or in a professional school. It also includes the ordinary period of apprenticeship to trades which may demand close and continuous application. Furthermore, a somewhat rapid rate of increase may be expected to go on, for a time, after the special determining conditions have been mitigated or have ceased to be actively operative.

In considering the influence of age in its relation to the development of myopia, the greater extensibility of the scleral tissue in children may be assumed to play an important part. Also, in older subjects, the stretched and thinned sclera of the highly myopic eye may oppose inadequate resistance to continuing distending forces to which it has already yielded. As a fact, myopia is seldom developed, in a previously healthy emmetropic eye, after the term of youth has been passed; the apparent exceptions are almost always instances of increase in the grade of pre-existent, but unrecognized or unacknowledged short-sightedness.

Myopia of high grade (10. D or more) is occasionally observed in a child of eight or nine years, and should then be contemplated with great solicitude in view both of the disability incident to the high grade to which it may be expected to attain and the fear that, later in life, the integrity of the eyes may be endangered.

It has been erroneously assumed that myopia tends to diminish with advancing age. On the contrary, it is always either progressive or, at the best, stationary. An apparent exception, based on certain cases in which a myopia of low grade disappears as a result of a decrease in the refractive power of the crystalline lens in old age, also the occasional late occurrence of a lenticular type of myopia dependent on a pathological increase in the refractive power of the crystalline, have been already mentioned.

Classification.—Donders has divided myopia

into three categories, basing them on the course and progress of the disease, namely: (1) stationary M; (2) temporarily progressive M; (3) permanently progressive M.

(1) The type of the stationary class is represented mainly by cases of myopia of low grade, which increase slowly up to a limit not much exceeding 2.5 D to 3. D at the age of twenty-five years; after the twenty-fifth year the increase is insignificant. In this category are included certain cases of myopia of higher grade, which follow a similar course of slow and limited progression. After the age of about fifty years, distant vision often improves, owing in part to the smaller pupils, in elderly people, lessening the diameter of the circles of confusion in the retinal image, and in part to the slight physiological decrease in the refractive power of the crystalline lens.

(2) The temporarily progressive class includes those cases which increase rapidly up to about the twenty-fifth year, and become stationary, generally before the thirtieth year, after having attained a grade averaging about 8. D. At this grade the myopia remains practically stationary during the remainder of life, but with a tendency, in certain cases, to recrudescence, which may bring the case under the category of—

(3) Permanently progressive myopia. In this class a myopia of 6. D or more, at the age of twelve years, develops continuously, but generally at a decreasing rate, up to a limit which may reach or exceed 20. D at the age of sixty years. "The worst is then to be feared. It is rare at sixty years of age to find a tolerably useful eye with myopia of 16. D or even of 13. D" (Donders).

Ophthalmoscopic Appearances.—The region of the fundus about the entrance of the optic nerve (optic disc) is the seat of certain very characteristic changes which, although occasionally seen in eyes of emmetropic or even of hypermetropic refraction, are so constant in myopia that they are justly regarded as typical of this disease. Especially characteristic is an alteration in the choroid which, form its general configuration, is known as the "crescent" or "sickle" (Fig. 4046. This appears, ordinarily, as a whitish or grayish-white area, crescentic in outline, the concavity of the crescent closely hugging the outer margin of the disc, the convexity, either sharply outlined by a more or less conspicuously pigmented border or shading gradually into the normal choroidal tissue in the general direction of the fovea. Traversing this area the finer retinal vessels, which supply the region about the macula, are seen somewhat straightened in their course, as if stretched longitudinally. The crescent may vary in width from a thin sickle-shaped band at the disc margin, from which it is with difficulty to be distinguished, to a large area, approximately parabolic in outline, which, from its resemblance to a conic section, has been named "conus." In other cases, especially in myopia of high grade, the approximately regular curvilinear outline is lost, the altered area taking on irregular and often bizarre shapes.

The myopic crescent is essentially the expression of a localized atrophy of the choroid, accompanied in many cases by a stretching and thinning of the sclera adjacent to and mainly at the temporal side of the optic disc. It then becomes an area of least resistance which may be the seat of a gradually increasing protuberance or, in extreme cases, of a deforming boss, at the posterior pole of the eye (*staphyloma posticum*).

The pathological processes leading to the development of the crescent are still imperfectly understood. In general, the ophthalmoscopic appearances are such as to suggest a sliding of the choroid on the sclera, with attendant stretching of the choroidal tissue at the temporal side of the disc. As a result of this stretching, a localized choroidal inflammation of low grade, passing into atrophy, may be invoked as offering the best explanation of the origin and subsequent enlargement of the crescentic area. The irregular extension of the conus in advanced stages of the disease is clearly the expression of atrophy following choroiditis. Atrophic spots in different

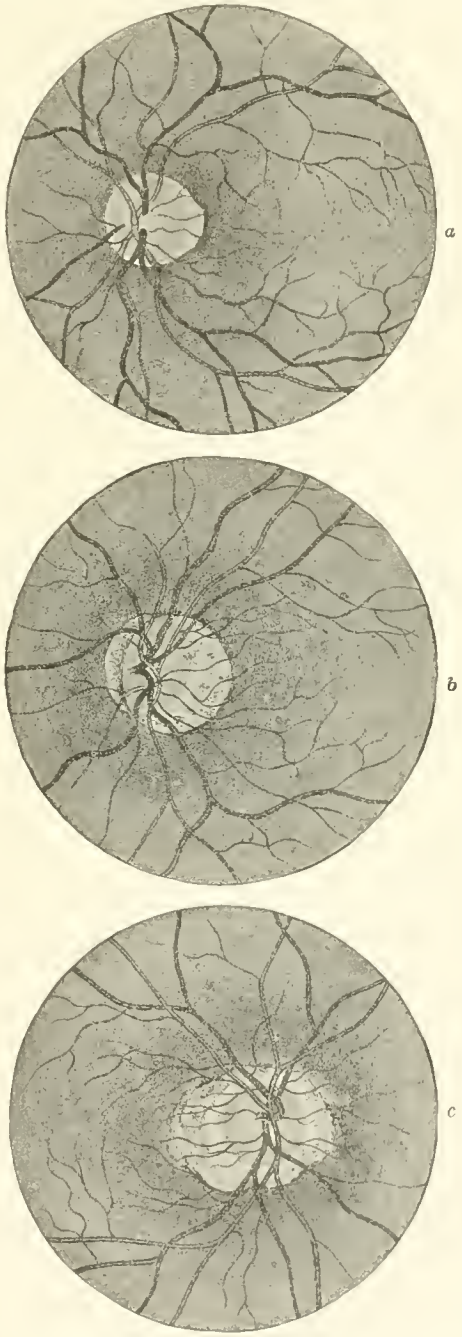

Fig. 4046.—Different Types of Crescents as seen in the Erect Image; *a* and *b*, left eye; *c*, right eye. (From Jaeger.)

parts of the fundus, indicating areas of previous circumscribed inflammation of the choroid, are of not infrequent occurrence in high grades of myopia.

The optic disc in myopic eyes often presents an oval contour, as if shortened in its horizontal diameter. This appearance may be simply the effect of fore-

shortening due to an oblique position of the disc with reference to the direction from which it is viewed. In many cases, however, there is almost certainly an actual variation from the typical circular form.

Capillary hyperemia of the disc is a frequent condition, especially in young myopes whose myopia is in the progressive stage: it may be regarded as the local expression of general ocular hyperemia. At a later period, after the congestion has disappeared, the disc often assumes a pallid tint indicative of anemia, and may even present the appearance of a shallow excavation.

Liquefaction of the vitreous, with the presence of finer or coarser floating specks or shreds, is very common in myopia of high grade and long standing. Myopic eyes are also especially subject to detachment of the retina, a disaster which has been attributed to a dragging of the vitreous upon the retina. A bow-shaped reflex concentric with the disc (best seen through a concave lens, a little weaker than the measure of the myopia, behind the hole in the mirror of the ophthalmoscope) has been described by Weiss as a sign of posterior separation of the vitreous from the retina.

Pathological Anatomy.—A meridional section through the fovea and the distal end of the optic nerve (Fig. 4047) shows, in cases of highly developed conus, a wide separation of the inner and outer nerve sheaths where the nerve joins the globe. Be-

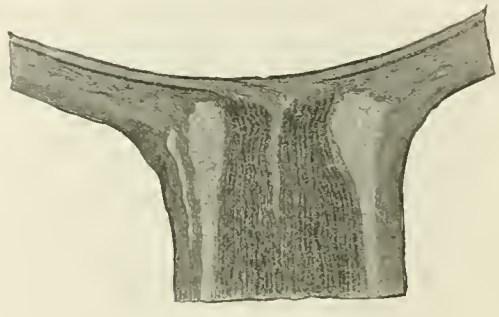

Fig. 4047.—Longitudinal Section Through the Optic Nerve at its Entrance into the Eye.

yond the limits of the conus the outer sheath becomes continuous with and reinforces the sclera, but within the area corresponding to the conus, where the reinforcing fibers of the outer sheath are absent, the outer coat of the eye appears very much thinner than in its normal condition or than at the posterior region of the globe generally.

A general thinning of the sclera, the decrease in thickness becoming gradually more marked posteriorly, is characteristic of the higher grades of myopia.

A typical change in the form of the ciliary body, as shown in a meridional section of the anterior segment of the eyeball, conjoined with an appearance as of an increased development of the radiating fibers and a decrease in the number of the circular fibers of the ciliary muscle, as first described by Iwanoff, may be regarded as an expression of the general stretching of the choroid.

Causes.—The causes leading to the typical pathological changes in myopia are but imperfectly understood. Donders laid much stress on the hypothesis of an inherited predisposition, and this opinion is supported by many clinical facts. Certain families show a very large proportion of myopes, others comparatively few. The inheritance of a special anatomical condition of the sclera or optic nerve, implying less than normal resistance to the operation of distending forces, is not more improbable than the inheritance of a hypermetropic configuration of the eyes. Corneal asymmetry, the ordinary cause of astigmatism, is distinctly transmissible from parent to offspring, and astigmatic refraction is too frequently associated with myopia to admit of reasonable doubt that the former stands in a causal relation to the latter. The general distention of the globe, mainly in its posterior half and especially about the posterior pole, corresponds to the thinner and presumably less resistant scleral region posterior to the insertions of the recti muscles. The immediate causes of the distention, whether they are to be sought in original structural weakness of the tissues or in increased intraocular pressure, or both, are matters of dispute. Continuous close application to fine near work, in which strong accommodation and convergence go hand-in-hand, is a most important etiological factor. After elongation of the globe has begun, convergence for the ordinary reading or working distance tends to evoke accommodation for some shorter distance; but reading or working at this shorter distance implies an increase in convergence, which in turn incites to increased exercise of the accommodation. As a result of this interaction of convergence and accommodation, the tendency is to a progressive shortening of the reading distance, and, *pari passu*, to an increase in the grade of the myopia.

Weiss has suggested that a short optic nerve, dragging on the sclera in inward rotation of the eyes, may be a factor in the development of posterior staphyloma. Stilling has called attention to a particular conformation of the orbit, giving rise to an alteration in the direction of the pull of the reflected tendon of the superior oblique muscle, as a supposed cause of injurious traction upon the globe.

Treatment.—"The cure of myopia belongs to the *pia vota*" (Donders). Erroneous assumptions regarding the causes of short-sightedness have led in the past to the proposal of a variety of futile or harmful plans of treatment. Thus attempts have been made to diminish the convexity of the cornea by the prolonged application of pressure, or by corneal paracentesis repeated at short intervals. Practice in reading at progressively increasing distances from the eye has been strongly advocated, in the belief that a supposed excessive lenticular refraction might thus be gradually lessened. Division of one or more of the recti, or of the oblique, muscles, in order to diminish a supposedly injurious muscular pressure on the globe, has also been advised and practised.

Therapeutic measures directed to the removal of conditions of irritation which not infrequently appear in connection with rapidly progressive myopia, belong to the realm of rational therapeutics. Rest of the eyes from near work, protection from exposure to excessive light, regulation of the general physical condition, and, in some cases, the local abstraction of blood from the temples—preferably by means of the artificial leech of Heurteloup—are all of value. The so-called atropine cure is also employed, with good effect, in certain cases of rapidly increasing myopia; the eyes are kept under the full influence of atropine for about two weeks, in a moderately darkened room, after which the patient is permitted to go about with the eyes well protected by dark glasses; the use of the eyes in near work is forbidden for another fortnight.

Concave Glasses.—The wearing of concave glasses to improve the distant vision of myopes is first mentioned by writers of the latter half of the sixteenth century; but the intelligent prescribing of such glasses, with a view to their effect upon myopia considered as a disease, belongs exclusively to modern ophthalmology; and even now there is notable divergence of opinion on certain points. In general,

it may be accepted as a well-established principle that in uncomplicated myopia of low or medium grade, with normal acuity of visual perception and unimpaired range of accommodation, concave glasses should be chosen of such strength as to correct the vision accurately for distance, and that the same glasses should be worn for near work. Furthermore, it should be the aim to raise the vision, as controlled by tests made at a distance, to the highest point of acuity of which the eyes are capable; and to this end even low grades of astigmatism should be carefully investigated and corrected. The distance at which the glasses are worn, their proper centration before the two eyes, and the direction of the plane of the glasses with reference to the line of sight should all be definitely prescribed and controlled. Inasmuch as the same glasses are worn both for distance and in reading, they should be tilted so that the angle made by the visual axes to the plane of the lenses shall be as nearly equal as practicable in looking forward at distant objects and downward on the book ("panto-scopic" position). The effect of the tilting of the glasses in increasing their effective refractive power in the vertical meridian, and to a less degree in the horizontal meridian, should, in every case in which glasses of high power are required, be considered and allowed for in deciding upon the formula for the lens. The eyes should, further, be reexamined, at first at short intervals and later at intervals of a few months, in order that any change in the grade of the myopia may be promptly discovered and corrected. Explicit instruction should be given as to the kind and amount of work which may be permitted; reading or sewing without glasses, and especially the use of the eyes in near work by failing daylight or by insufficient artificial illumination, should be absolutely forbidden. The glasses (ordinarily spectacles made with elastic sides curved to fit accurately behind the ears) should be worn continuously during the waking hours.

The wearing of neutralizing concave spectacles is ordinarily attended with great comfort to the patient, and the progress of the disease is, as a rule, either greatly retarded or wholly checked. Every renewal or change of glasses should be rigorously controlled, and it should be fully explained to the patient or, in the case of a child, to the parents, that the condition is one that must be kept under continuous observation for years.

Cases of myopia complicated by low acuity of vision, whether dependent on impaired perceptive power of the retina or on irregularity or imperfect transparency of the cornea or crystalline lens, present especial difficulties which militate against the best results from wearing glasses. In general, such patients cannot see small objects unless they are brought very near to the eye, a condition unfavorable to binocular vision. Accordingly, they often form the habit of using only one eye in reading. By this, perhaps unconscious, neglect of the retinal image in one of the eyes, the conditions which ordinarily give rise to a state of conflict between accommodation and convergence are eliminated, so that reading to a limited extent without glasses may be practically innocuous. Concave glasses may, however, be accepted in distant vision, although not in all cases.

Removal of the Crystalline Lens.—The proposal to lower the grade of myopia in extreme cases, or to render a strongly myopic eye either moderately hypermetropic or possibly emmetropic, by the removal of the transparent crystalline lens, has been frequently discussed, although generally rejected by ophthalmic surgeons, to be revived and somewhat extensively practised in recent years. Simple discission of the lens capsule, discission followed by removal of the swollen lens through a small corneal incision, and, in older subjects, extraction combined with iridectomy are the methods which have been recommended and employed. Apart from the immediate risks incident to the operation, and the uncertainty as regards its possible effect in arresting or retarding the progressive distention of the globe, the possibility of later adverse complications, such as not infrequently occur in patients upon whom an apparently ideal operation has been performed for cataract, would seem to forbid resort to an operation on the transparent lens except in extreme cases, and even then only after an exhaustive study of the particular case in all its aspects. In addition to the ordinary chances of disaster following operations for cataract, it is probable that the removal of the lens increases the tendency to retinal detachment, which is always to be feared in the higher grades of myopia. On the other hand, the fact that in the highest grades of myopia the ordinarily beneficial effect of concave glasses, in sharpening the definition of the retinal images, is largely neutralized by the diminution in the size of the images may afford an argument in favor of the operation. The incidental sacrifice of the accommodation should not be accorded undue weight in the exceptional cases in which alone the operation may be regarded as permissible.

Prevention and Control.—Myopia practically always occurs from eye strain, and in the great majority of cases can be prevented, or at least kept down to low degrees. During the growing period of the child, the outer envelope, or supporting tissue of the eyeball, does not attain its full degree of firmness and hardness, and any strain on the focusing muscles has a tendency to make the eyeball stretch. This stretching of the eyeball is really the condition which is commonly known as near-sightedness, and is caused in most instances by strain in reading. If the stretching of the eyeball goes beyond a certain point, the delicate nerve tissues inside the eye are apt to become stretched to an extent which they cannot stand, and tears and breaks occur in them with damage to the sight. These breaks cannot be remedied, nor for that matter can the eye when it is once stretched come back to its normal size. In very high degrees of stretching, even blindness may result. There is a current belief that near-sightedness runs in families, and this, while partly true, is really an unfortunate misconception. Certain families have softer tissues in the eye than others, and their eyes stretch more easily to a certain degree of strain. This should only make such people more cautious to avoid strain and does not by any means imply that it is necessary for such children to be near-sighted. The cause of this strain in the young child is astigmatism. There are other contributing causes, such as a too short eyeball, poor general health, which makes the tissues weaker and less resistant, and also the disposition of the child, some children preferring to sit and read all day rather than to go out and exercise in the open air.

The above has been emphasized by Risley whose report of the examination of the eyes of school children of Pennsylvania published in 1881 was summarized as follows: "Given an emmetropic or normal eye, the probabilities are that no harm will come to it from the educational process. On the other hand, given an eye with an anomaly of refraction, especially astigmatism, the probabilities are, other things being equal, that the educational process will be fraught with pain and danger to the eye."

Risley in 1913 reported a continuation of his studies which were published in 1881 and 1894 in which he shows a steady decrease in myopia from 28.43 per cent. in 1874 to 11.21 per cent. in 1912.

Through the efforts of ophthalmologists, educators have been made to see the necessity of a routine examination of the eyes of school children at the beginning of each school year, and such examinations are now being made in practically every city in the United States. Reports are sent to the parents or

guardian of any pupil whose vision is below standard with the advice, that they consult an ophthalmologist. This has undoubtedly been a large factor in bringing about a decrease in the percentage of myopia. Teachers have been taught to appreciate the dangers of eye strain in pupils with defective sight and special consideration is given such individuals in the way of seating, lessened amounts of work, etc.

The proper illumination of school rooms has been given special consideration by joint committees composed of ophthalmologists, illuminating engineers and architects with a view to overcoming the effects of unhygienic daylight and artificial illumination.

Satisfactory illumination by artificial light of old school buildings does not by any means present the problem that proper lighting by daylight does. In the erection of new buildings the hygienic distribution of artificial illumination and daylight is made a very important part of the plans and specifications.

Investigation as to the effects on the eyes of the glare from the surface of highly calendered paper has resulted in the quite general printing of school books and many periodicals on a matte surface. Black ink devoid of luster is used and special attention is given to the size of type as well as the space of letters, words, lines, and the length of lines, all with a view of reducing eye strain.

John Green.
Nelson Miles Black.

Myosin.—The protein of dead muscle is called myosin and belongs to the group of proteins termed globulins. It is assumed that during the process of rigor mortis the soluble proteins of the muscle plasma are transformed into insoluble myosin. F. P. U.

Myotics.—See *Mydriatics and Myotics.*

Myotonia Congenita.—See *Muscle, Pathology of.*

Myriapoda.—Centipedes. These worm-like arthropods live under stones in moist places. They possess a pair of poison claws under the head. The bites of the larger species are painful and have been known to cause death in children. These animals sometimes occur in the human body in the nose, pharynx, or other cavities. See *Insects, Poisonous.*

A. S. P.

Myristica.—Nutmeg. *Semen Myristicæ*; Ger. *Muskatnuss;* Fr. *Muscade.* The dried ripe seed of *Myristica fragrans* Houttuyn (fam. *Myristicaceæ*), deprived of its testa.

Nutmeg is the product of a handsome, small, evergreen, dioecious tree, native of the Molucca Islands, now widely cultivated in tropical regions, such cultivated trees, mostly in the Malay Archipelago, supplying the commercial article. The fruit is fleshy, one-seeded, and when ripe much resembles the peach. The fleshy pericarp is tardily dehiscent and the seed is enclosed, though only partially covered, by a fleshy network, consisting of the aril. This is removed and dried to form *mace* (which see), leaving the seed as an oval body faintly grooved, where the aril has rested upon it. It is dried by a slow and tedious process, requiring about two months. When dry, the nutmegs are beaten to break the testa, from which the kernel has now shrunken away, and the latter then constitutes the official nutmeg. It is nearly an inch in length and somewhat more than half as broad, oval to ovoid, very slightly flattened in one direction and not quite equilateral, of a rich brown color, slightly shining, more or less furrowed, with a circular scar at the broader end, from which a slight groove runs to a deeper depression near the smaller end. When cut transversely it exhibits a pale, brownish-yellow surface, of a fatty luster, and marked by narrow curved brown lines entering from the surface and containing folds of the tegmen or inner coat. The odor is strong and agreeable, the taste similar and somewhat bitter. The ordinary nutmeg of commerce differs from this in being grayish white from a partial covering of lime, which serves the purpose of protecting it against the attacks of insects, to which it is very liable. Such nutmegs are distinguished as "limed" or "Dutch," the others as "brown" or "Penang."

The important constituent of nutmeg is its volatile oil, stated in most books to amount to from two to eight per cent., but of which there is very much more. The other constituents are the following: about forty per cent. of fixed oil, of which about three-fourths is removable by expression, a small amount of an unstudied bitter principle, starch, protein, gum, and other ordinary constituents. The volatile oil (*Oleum Myristicæ*, U. S., Br., or *Oleum Nucistæ Æthereum*) varies considerably in character, according as a larger or smaller percentage has been distilled from the nutmeg. When freshly distilled it is colorless, but grows yellow or even reddish and thicker with age, at the same time changing its odor to a heavy and somewhat disagreeable character. It has a pleasant flavor, followed by a warming and biting or slightly acrid effect. Its specific gravity ranges from 0.862 to 0.901 at 25° C. (77° F.). It is soluble in an equal volume of alcohol, the solution being neutral, and in the same amount of glacial acetic acid; it is freely soluble in carbon disulphide. It consists chiefly of *myristicol* ($C_{10}H_{16}O$?) and *myristicin* ($C_{12}H_{14}O_3$), together with pinene, myristinic acid, and other unimportant substances. This oil possesses the properties of nutmeg in an intensified degree. The commercial article holds a small amount of the fixed oil in solution. The fixed oil (*Oleum Myristicæ Expressum, Oleum Nucistæ, Adeps* or *Butyrum Myristicæ* or *Nucistæ, Nutmeg Butter*) is expressed by the aid of heat. It usually occurs in the form of cakes, wrapped in palm leaves, is solid and firm at ordinary temperatures, melting at about 45° C. (113° F.), has a mottled, orange-brown and whitish color, a specific gravity of about 0.995, a pleasant buttery taste, but with a slight fragrance and taste of nutmeg, due to the presence of a little of the volatile oil in solution. It dissolves in four parts of boiling alcohol or in two of warm ether. It consists chiefly of *myristin*, $C_3H_5(C_4H_{27}O_2)_3$, with three or four per cent. of free myristic acid. This oil is very much subject to adulteration with, or substitution by, the fixed oils derived from other species of *myristica*, especially that from *M. fatua* Houttuyn. This fat has no special medicinal properties, but merely those of other vegetable fats.

Whole nutmegs are at the present day scarcely ever sophisticated, though the long, wild, or male nutmegs above mentioned as being used to adulterate nutmeg butter, as well as some other species, are occasionally offered for them. Artificial nutmegs, pressed from a prepared paste and very inferior in odor and taste, have been frequently reported.

Properties and Uses.—Almost the entire use of nutmeg is for flavoring purposes, although it possesses useful properties as an ordinary aromatic stimulant and carminative. Many cases of mild, and several of rather severe poisoning by overdoses (from two to five nutmegs) are reported, the symptoms being those of a narcotic or severe depressant, in some respects similar to those of overdoses of camphor. There is no preparation, properly speaking, of nutmeg, though it enters into the aromatic powder and the compound tincture of lavender. Of the volatile oil there is an official five-per-cent. spirit, the dose of which is fl. ʒ ss.–i. (2.0–4.0); the dose of the oil as a carminative is ♏ i.–iij. (0.06–0.2), and a small amount of it enters into the aromatic spirit of ammonia.

Henry H. Rusby.

Myrrh (U. S. P.).—*Myrrha, Gum Myrrh.* A gum resin obtained from *Commifera myrrha* (Nees) Engler (*Balsamodendron M.* Nees.—fam. *Burseraceæ*). The variety of myrrh thus defined is that known in commerce as Somali or Herabol myrrh. It is official in all pharmacopœias, though these are much at variance as to the species named as its source. There appears no good reason to believe that it is derived from any other than the species named in our definition, though the inferior varieties (Arabian and Yemen) and various spurious substances often sold for it are—some of them certainly, others probably—obtained from other species of *Commifera.* This plant is a spiny, large shrub or small tree of northeastern Africa. The myrrh exudes as a thick milky juice from natural and artificial fissures, and slowly hardens to a red-brown mass, which is then collected by the Somali natives, either from the plant or from the ground where it has fallen. "Drossy myrrh," containing a large amount of earthy matter, may result from the accidental entrance of dirt into these fallen masses or from its intentional admixture. The substance is chiefly carried to Aden, whence it is exported to Europe and America, either directly or, as was formerly usual, viâ Bombay. The "Turkish myrrh," which a generation ago was a favorite brand, was simply a carefully selected quality exported viâ Turkey. Either at Aden or in Bombay the myrrh is picked and assorted, yet when it leaves those places it commonly contains a considerable percentage of spurious or inferior fragments.

Description.—In irregular, more or less rounded nodules or tears, from 2.5 to 10 centimeters (one to four inches) in diameter, the surface more or less roughened by nodules and small cavities, as though eroded, red brown, dull, and more or less gray from adhering powder; heavy, hard, and rather tough-splintery in fracture, the freshly fractured surface of a waxy luster and oily feel, red brown, usually variegated by gray crescent-shaped spots and intersecting lines; thin fragments translucent, usually strongly so; strongly and agreeably aromatic, the odor characteristic; the taste bitter and somewhat acrid, and producing a hardening and slight wrinkling of the mucous membrane of the mouth, though different from the astringency of tannin; readily powdered when cold and dry, but with difficulty when warm and damp; the freshly fractured surface, moistened with alcohol, colored purplish, as is the brownish-yellow alcoholic tincture, by nitric acid (distinction from bdellium); yielding a brownish-yellow emulsion with water; the ten-per-cent. ethereal extract acquiring a violet color in the presence of bromine vapor; if six drops of a seven-per-cent. petroleum ether extract be mixed with 3 c.c. of acetic acid, and 3 c.c. of sulphuric acid be then added, forming a heavy lower layer, the latter takes only a light rose color, which does not deepen (*distinction from Bissabul myrrh*); not more than seventy per cent. should be insoluble in alcohol, and the ash should not exceed six per cent.

Constituents.—Good myrrh consists of from two to five per cent., or occasionally more, of the volatile oil *myrrhol*, and from twenty-five to forty per cent., rarely nearly fifty per cent., of resin, the remainder being mostly gum, with a very small amount of a bitter principle, and from two to six per cent. of ash. In "drossy myrrh," the earthy matter increases the ash, frequently to fifteen per cent. or more. In the poorer grades of myrrh the amount of gum is larger, at the expense of the resin. Myrrh resin is a complex substance, the composition of which is not fully understood. Myrrh oil, which is sold for use in perfumery, is yellow or greenish yellow, thick and viscid, and almost as heavy as, rarely appreciably heavier than, water.

Action and Uses.—Myrrh is essentially an aromatic stimulant, with slightly bitter properties, and a mild disinfectant. Its stimulant properties are especially active on mucous or raw cutaneous surfaces with which it comes into contact, so that it is a favorite ingredient of mouth washes, hardening the gums and acting like a mild astringent, and an excellent cleansing and stimulating application to ill-conditioned sores, for which purpose the tincture is diluted to about one-fourth strength. Combined with cathartics, it enhances their activity and is at the same time somewhat carminative. When administered internally it acts as a mild stimulating expectorant and diuretic, through its respiratory and renal excretion. In connection with the latter mode of elimination, it acts as a stimulating emmenagogue. It has from ancient times been credited with specific emmenagogue properties, but these effects have probably been largely imaginary. In all its internal uses it is almost invariably combined with other drugs, as in the pills and the tincture of aloes and myrrh, the pills of iron and myrrh, the compound iron mixture, etc.

The principal preparation of myrrh is the official twenty-per-cent. tincture, the dose of which is fl. 3¼ to i. (1.0–4.0). The Tinctura aloes et myrrhæ contains ten per cent. each of aloes, myrrh, and liquorice root, and the dose is fl. ʒ i. to ij. (4.0–8.0). The Pilulæ aloes et myrrhæ each contain gr. ij. (0.13) of aloes, about half as much myrrh, and one-third as much aromatic powder, the dose being from two to eight pills. The Mistura ferri composita contains 1.8 per cent. of myrrh, 0.6 per cent. of ferrous sulphate, 0.8 per cent. of potassium carbonate, and six per cent. of spirit of lavender, with sugar, etc.

Allied Substances.—*Bdellium* (elsewhere considered) is very similar in composition and properties to myrrh, but is very inferior, being less aromatic and one of its varieties being devoid of bitterness. The myrrh of the Bible is not our myrrh, but the Balm of Gilead or Mecca balsam, from *Commifera* ("*Balsamodendron*") *opobalsamum* (Kunth.) Engler, now rarely seen in commerce.

Henry H. Rusby.

Myxadenitis Labialis.—*Synonym:* Cheilitis glandularis.

Myxadenitis labialis is a chronic inflammation of the lower lip, characterized by pin-point to hempseed-sized elevations, with dilated follicular orifices. The lip appears swollen and tense, the mucous glands are very prominent, and the follicular openings much dilated. The process is usually confined to the vermillion part of the lip, but may spread to the mucous membrane proper or the skin. The disease is almost invariably confined to the lower lip. There is a spontaneous oozing from the lip of a mucopurulent secretion, which dries, thereby causing considerable scaling. At times, the patient awakes in the morning with the lips glued together. The disease was first described by Volkmann, and is a very rare one. The patients seem to be in good health, and no definite cause for the malady has as yet been found. Hyde found a vegetable organism in one of his cases; it resembled oidium.

The disease is very rebellious to treatment. Hyde recommends radiotherapy, cautiously employed. Stelwagon mentions the local application of lotio nigra and glycerin, with the occasional application of a silver nitrate solution. Paul E. Bechet.

Myxedema.—See *Thyroid Gland.*

Myxococcidium.—A yeast that grows in the mosquito, *Stegomyia.* It was at one time supposed to be the yellow-fever parasite.

A. S. P.

Myxoma.—A myxoma (from μύξα, mucus, and ωμα, a suffix denoting a tumor) is a new growth which is composed chiefly of mucous tissue. It therefore has no normally occurring histologic prototype in the adult human body but corresponds in structure to Wharton's jelly of the umbilical cord and to the embryonic connective tissue.

Since it has been a question for debate as to whether mucous connective tissue should be considered a distinct tissue type, inasmuch as it is but the embryonic stage of the entire connective-tissue group, the position of the myxoma as a distinct type of blastoma becomes equally uncertain. This uncertainty has been increased by the fact that through a loose use of the term at least three different groups of tumors have been included under the term myxoma; (1) pure and mixed myxomas, probably congenital in origin; (2) mixed tumors of various sorts which have become in part myxomatous through metaplastic and retrograde changes; (3) edematous fibromas which have only certain gross features in common with myxomas and should not be here included.

Thus it has come about that the term myxoma designates rather a particular type of histologic structure in a neoplasm and as now used does not necessarily imply that the blastoma in question has taken its origin from a nest of embryonal mucous tissue. In *microscopical* section a typical myxoma shows as the ground substance of the tissue a semi-fluid or gelatinous intercellular material containing mucin.

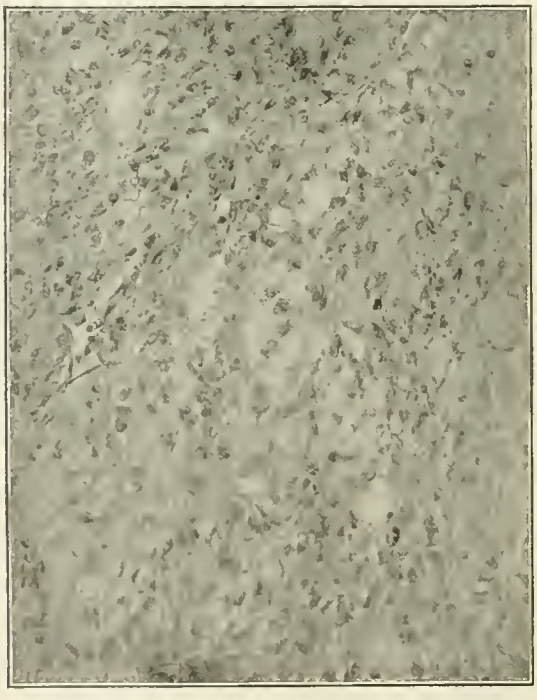

Fig. 4048.—Microphotograph of a Section from a Myxoma. This large tumor, arising from the intermuscular fascia of the thigh, showed in other areas a definite sarcomatous change. Hemalum and eosin stain. Zeiss obj. "DD".

Through this matrix there are distributed numerous polymorphous cells having many long processes which anastomose with those of neighboring cells. The cell bodies are usually well defined and for the most part isolated from each other except as the cell processes meet. Leucocytes and other wandering cells may be found in the tissue matrix and relatively large thin-walled vessels give a rich blood supply.

The amount of mucin in the ground substance varies widely. It frequently is sufficient to cause the fluid coming away from the cut surface to be distinctly stringy or gelatinous and to swell up in water. The ground substance accordingly gives in varying degrees of intensity the staining reactions for connective-tissue mucin, such as the metachromatic reactions with thionin and kresyl-echt-violett, and in it mucin may be precipitated by acetic acid.

Grossly, myxomas are found as rounded, lobulated or polypoid tumors, usually soft, fluctuating, somewhat translucent and grayish or reddish gray in color. In size there is the greatest variation, ranging from microscopic nodules to enormous masses of many pounds' weight. Usually definitely encapsulated, there is never any tendency toward infiltrative growth.

The most common *sites* for the development of myxomas are the faseia, the muscle sheaths, subserous and submucous connective tissue, subcutaneous tissue, periosteum and endosteum, heart and along the nerves. The regions most commonly affected by subcutaneous myxomas are the back, thighs, face, especially the cheek, the axillæ, female genitalia, and scrotum (Borst). In the mixed tumors of the testis, ovary, kidney, etc., areas of typical myxoma are not rare and the myxochondroma is the most common tumor of the parotid.

The problem of *etiology* in the case of myxomas differs from that of most other tumors in that the type of tissue which is characteristic of the tumor does not occur in the adult body (although the vitreous humor somewhat resembles mucous tissue). Consequently there are but three readily conceivable possibilities for the origin of this neoplasm. Either it develops by the proliferation of an embryonal nest of mucous connective tissue; or, as a result of a metaplastic change in some other member of the connective-tissue group, mucous tissue is produced which then continues its atypical growth; or, finally, the myxomatous tissue may represent simply a secondary metamorphosis in another connective-tissue tumor and therefore have no real significance as a tumor type. Each of these views has received some support.

There can be no doubt that some myxomas are congenital in origin. For this bespeak the cases in which myxomas have been found in the heart and mesentery of very young infants. Likewise, the not infrequent occurrenee of areas of myxoma in mixed tumors of ovary and testis of undoubted congenital character suggests that myxoma elsewhere may be similarly explained. The multiple myxomas of the skin and along the nerves are also thought to be congenital in origin.

In the case of a large group of myxomas in which there is a combination with fibrous connective tissue, fat or cartilage, there has been much debate as to the etiology of the mucous tissue. Most authors have followed Borst in considering that it is produced by a sort of metamorphosis of the other and primary tissue; that in a fibroma, for instance, the intercellular fibrils are in part replaced by an abundant mucinous fluid and the connective-tissue cells themselves undergo a transformation into the branched cells characteristic of mucous connective tissue. Similarly, it is claimed that in adipose tissue the fat cells may progressively lose their fat while the supporting connective tissue undergoes the transformation into mueous tissue, and that in a chondroma the matrix undergoes such a mucinous liquefaction while the cartilage cells, freed of their capsules, become typical mucous connective tissue cells. In opposition to this view, however, Ribbert (*Frankfurter Zeitschrift für Pathologie,* iv., 1910, p. 30) emphatically maintains that bone, cartilage, fat, etc., may develop in a myxoma or they may be developed simultaneously as parts of a mixed neoplasm, but that a myxoma never develops from a

fibroma, lipoma, osteoma, or chondroma. Ribbert maintains that there can be no doubt that the myxoma arises from embryonal mucous tissue and is never produced from another type of tissue.

Pure myxomas are rarely met with. In addition to the chance of being mixed with fibrous connective tissue, fat or cartilage, the possibility of sarcomatous change or association with sarcoma must be ruled out. In our experience myxomas which might well pass as of the pure tumor type if but one or two portions were submitted to microscopical examination, almost invariably show sarcomatous areas when many parts of the tumor have been sectioned. This has been especially true of large myxomas of the fascia and muscle sheaths and is a point of great importance in that the prognosis must be guarded in such cases. No myxoma should be declared to be of the pure type until it has been subjected to a thorough microscopical examination.

Myxomas of *mixed type*, on the other hand, are of very frequent occurrence. To these neoplasms special names descriptive of the tissue combination are applied, the terms being arranged in the order in which the various tissues occur, the most abundant being placed last. Thus myxomas combined with fibrous connective tissue, adipose tissue, or cartilage are called *fibromyxomas, lipomyxomas*, and *chondromyxomas*. However, if the view prevails that in such cases the myxoma comes about through a secondary metamorphosis of another tissue, it is better to speak of such a mixed neoplasm as a *fibroma, lipoma*, or *chondroma myxomatodes*. However, if it appears that the fat tissue has developed within or in part replaced the myxoma, the term *myxoma lipomatodes* may more properly be applied. A myxoma rendered dense and firm by much fibrous connective tissue may be called a *myxoma fibrosum*. A *myxoma cavernosum* or *myxoma telangiectaticum* is one in which the blood-vessels are unusually numerous or more widely dilated than normal, while cyst formation leads to the designation of the neoplasm as a *myxoma cysticum*. According to Borst, such cysts may be produced through lymphangiectasia, through hemorrhagic, mucoid or fatty softening, or through the absorption of the blood from cavernous blood spaces.

Malignant change in myxomas is by no means uncommon. As previously mentioned, tumors having for the most part the histologic structure of a pure myxoma, may show here and there definite areas of sarcomatous change. These are known by their great cellularity since through the multiplication of the myxoma cells as they undergo malignant change enormous numbers of nucleated elements are produced. These lie closely crowded together and in most cases are round or spindle shaped rather than polymorphous and branching. These richly nucleated areas appear in sharp contrast to the sparsely nucleated tissue composing a pure myxoma. Such a neoplasm may be called a *myxosarcoma* or, perhaps more properly, a *myxoma sarcomatodes*. It has all the attributes of a malignant tumor, may change from the expansive to the infiltrative habit of growth and may give rise to metastases. When scattered myxomatous areas are found through a sarcoma and there is reason for believing that the myxoma is the product of a secondary change, the neoplasm may be described as a *sarcoma myxomatodes* and here the degree of malignancy is to be judged by the character and location of the primary sarcoma.

The simple myxomas, unassociated with sarcomatous change, are benign tumors. They grow rather rapidly at times, but always by expansion and do not set up metastases. Here and there through the literature are occasional cases of myxomas which have produced secondaries. In a few instances these cases have been reported by very careful investigators, but in judging these cases one must assume that such tumors were in reality myxosarcomas unless they have been proved otherwise by the most complete microscopical examination. For practical purposes, therefore, the myxoma may be considered as never producing metastases. However, a myxoma will recur if not completely removed and there is always the possibility that the recurrence may be more cellular than the original.

The myxomas of certain localities demand brief special mention. In the *heart*, single or multiple nodules of myxoma have frequently been described. They are usually found in the auricular wall as lobulated masses of a semitranslucent, almost glassy appearance. This type is practically always found in young children and is of undoubted congenital origin. The myxomas which have been described as occurring upon the valve flaps have practically all been shown not to be true tumors and Warthin has demonstrated that certain myxomatous areas found in the heart and formerly considered true myxomas by many are in fact areas of cardiac syphilis and after Levaditi staining reveal enormous numbers of spirochetes.

Upon mucous surfaces, especially of the *nasal passages* but also in the pharynx, larynx, intestinal tract and uterus, polypoid growths are frequently found which are grossly described as mucous polyps. Histologically many of these are found to be soft edematous fibromas but some have all the characteristics of true myxomas and must be so considered. In the nose they occur most frequently upon the middle and upper turbinates, are frequently multiple and may reach a large size. Oftentimes it is very difficult to draw a sharp line between the true myxomas and the soft fibromas with myxomatous degeneration, both of which are frequently found arising from the nasal mucosa. The exact relationship between these two types as well as the part played by chronic inflammatory processes in their causation has not as yet been decided.

While myxomas of the brain and spinal cord are rarely met with, the *nerves* are more often the site of multiple myxomatous growths. These develop from the perineural and endoneural connective-tissue sheaths and strongly suggest the multiple fibromas found in the same situation. Here, again, the relationship between these two tumor types cannot be sharply defined. CARL VERNON WELLER.

Myxosporidia.—Neosporida in which spore-formation begins early in the ameboid trophozoite. Each spore has one or more polar capsules. These protozoans usually occur in cold-blooded vertebrates; though one is the cause of pebrine in silk worms. See *Protozoa*. A. S. P.

Myzomyia.—An important genus of mosquitos. Several species carry malaria in West Africa, India, and Ceylon. A. S. P.

Myzorhynchus.—A genus of mosquitos. Some species are known to carry malaria in Asia. A. S. P.

Nails, Diseases of the.—The normal nail is convex both transversely and longitudinally, the surface smooth and glossy and of a pink color, due to the underlying blood-vessels, excepting the lunula which is white. The under surface of the plate is ridged to conform to the papillary ridges of the nail-bed which consists of rete, corium, and subcutaneous tissue. The nail bed is abundantly supplied with blood-vessels, particularly the papillæ of the matrix.

The development of the nail begins during the third month, arising from the ectoderm.

Nail growth varies in different individuals and at different seasons of the year; the average rate being about one-thirty-second of an inch a week, thus requiring from four to five months for the replacement of a lost nail.

The nail-plate or nail body is that portion of the nail which is exposed, the covered portions being termed the *nail-root*.

The nail-bed is that part of the finger upon which the nail-plate is situated.

The matrix is the nail-forming organ and is situated immediately beneath the posterior portion, about one-fifth, of the plate.

The nail walls are those parts which lie along the sides of the nails and over which they form the *nail folds*.

The lunula is the crescent-shaped, white, opaque portion of the plate which lies over the matrix.

The eponychium is the firm horny edge of the nail fold.

The nails and the structures immediately adjacent to them are subject to the same variety of morbid conditions as are other tissues; developmental defects, inflammatory processes and nutritional disturbances being here observed as well as elsewhere.

The general term "onychosis" is applied to all such conditions irrespective of their character or cause but certain specific terms are applied to nail disorders of definite character or due to a definite cause; onychitis, paronychia, perionychia, etc., indicating those onychoses arising from inflammatory processes and onychomycosis indicating an onychosis due to a parasitic invasion. For purposes of convenience these various forms of onychosis may be divided into four groups.

1. Those which are congenital and due to developmental defects.
2. Those which are of local origin, due to trauma, bacterial, or parasitic infection.
3. Those which form part of the symptomatology of an inflammatory disease of the skin.
4. Those due to nutritional disturbances, the so-called trophoneuroses.

As in all disease classifications overlapping and repetition cannot be avoided since the same pathological changes and the same clinical symptoms are frequently the result of wholly different causes.

Developmental Defects.—Strictly speaking, these conditions are not diseases, but malformations having their origin in defective embryonic arrangement or structure of the cells which form the matrix, the effects of which appear in abnormalities in the form, color or texture of the nails, at times alone but very frequently in conjunction with analogous defects of other epidermal structures as the skin and hair, such as ichthyosis, xeroderma, and the various types of alopecia. They are not infrequently hereditary recurring in one or more members of a family through several generations. Although not present at birth, such hereditary malformations may make their appearance in late childhood or during adult life.

On one or more fingers or toes, the nails may be entirely absent (*anonychia*), or the site of the nail may be occupied by a simple accumulation of horny substance, the so-called *epidermal nail*.

The nail plate may be very thin without other changes, but this condition is usually associated with changes in form resulting in a flattening of the nail and raising of its lateral borders so that the outer surface is convex inward instead of outward, a condition known as *koilonychia* or *spoon nail*. Such nails are usually extremely brittle and friable (*onychorrhexis*) and the free edge ragged and fissured. Instead of thinning the nail may show hypertrophic changes (*onychauxis*), rarely, however, without alterations in texture, color, and form. In extreme degrees of this condition in which the growth is chiefly forward, the nail becomes bent like a claw or twisted, sometimes spirally like a ram's horn; it is much thickened, ridged both transversely and longitudinally, hard and shining but usually discolored to a yellowish or brownish hue (*onychogryphosis*). This condition may involve all or only one or two nails, the toes being most frequently affected and in particular, the great toes.

Supernumerary nails are occasionally seen, usually situated on the digits or on rudimentary supernumerary digits; rarely, however, they occur in abnormal positions.

Shedding of the nails without inflammation may occur as an hereditary condition, the nail loss taking place at more or less definite intervals; in such cases however, the nails are rarely normal, being atrophic and deformed.

It is evident that nails in such condition as above described with their broken, fissured edges, afford an exceptionally favorable opportunity for infection and in such cases acute and chronic inflammatory processes are very frequently observed.

Onychoses of Local Origin.—*Traumatism*.—Direct violence to the nail structures as a result of crushing or the forcing of foreign bodies under the nail-plate will be recognized and dealt with as purely surgical conditions.

Onychophagia or biting of the nails is a habit frequently associated with definite nervous disorders or other stigmata of degeneration, although it may be purely imitative as indicated by its practice by a number of children in the same family or school. Less active mechanical or traumatic insults to the nail structures if long continued will, however, by disturbing the normal process of development from the matrix to the smooth hard surface of the perfect nail, result in abnormalities of form, color, or texture of the nail affected; such conditions arising particularly about the toe nails as a result of ill-fitting shoes, or bad posture of the foot; but they are also seen on the fingers of those whose occupation entails constant exposure to irritating substances or physical conditions, as cooks, dyers, confectioners, washerwoman, etc. Varying degrees of hypertrophy of the nail (*onychauxis*) will arise as a result of the above-mentioned influences, at times simple thickening of the nail-plate with more or less opacity or brownish discoloration. In other instances enormous overgrowth occurs presenting the extreme types of onychogryphosis.

A tendency to lateral growth usually results in inward bending of the nail borders, *unguis incarnatus*, or *ingrown nail*, a very painful condition particularly when acute inflammation or infection ensues. (See *Ingrown Toe-nail*.)

Hang-nail.—The nail fold normally presents a firm, smooth edge, the eponychium; but when from lack of care it is permitted to adhere to the nail and being carried forward (pterygium) by the nail becomes much thinned and widened, it is readily broken and frayed and the small fissures thus formed are easily carried back into the nail walls and afford opportunity for infection. Cutting the nail fold with scissors produces the same result, as it removes the natural selvage and allows the cut edge to fray.

Leucopathia Unguium, Leuconychia.—These are terms applied to the familiar condition characterized by the appearance of white areas on the nails, usually in spots or transverse bands, rarely involving the whole nail. Its occurrence is in some manner due to slight injury and is often observed to follow closely the use of manicuring implements. The exact nature of the change is not known but is supposed to arise from interference with the normal process of keratinization.

Bacterial Infection.—Bacterial infections necessarily require for their beginning some lesion of the surface through which the infective agent may enter and these requirements are abundantly met in the deformed nails and the results of traumatism above described. The clinical aspects of the disease processes initiated by such an infection will, of course, vary with the char-

acter and activity of the infectious agent and the resistance of the individual; at times causing a subacute process that interferes with normal nail growth and results in a deformed nail, at other times setting up a violent inflammatory process that results in complete loss of the nail which may be permanent.

Acute Onychitis and Paronychitis.—Clinically, these two conditions are inseparable as neither can develop alone. The symptoms are those of acute inflammation; redness, swelling, and intense pain of throbbing character. In rare instances due to streptococcic infection there may be involvement of the lymphatics and even general sepsis with a fatal termination, such cases are not infrequent as a result of a needle prick during a postmortem examination. Ordinarily, however, the process remains local, more or less pus is formed, the nail is undermined and separated from the matrix, becomes thickened and discolored and finally is cast off, to be replaced at times by a normal nail but very frequently by a deformed one.

An explanation of the loss of a nail through an apparently trivial infection is found in a brief glance at the anatomy of the parts involved. The firm fibrous sheath which forms the lateral and upper nail walls offers an almost inpenetrable barrier to the exit of pus arising in a suppurative process about the nail borders, as pus accumulates, therefore, it will if not released by incision burrow its way entirely around the nail (the old term "run around") or under the nail causing its loss. The practice of poulticing an infected nail in the hope of hastening the evacuation of pus is therefore almost certain to terminate unfortunately.

Onychia maligna is a term that has been applied to extremely acute cases of onychitis, probably of diverse etiology. It is seen usually in debiliated or strumous children; beginning as a slight irritation at the nail border, violent inflammation rapidly develops with intense pain and the entire phalanx is soon involved with the formation at the border of, or under the nail, of an ulcer which is characterized by extreme chronicity and in some cases by involvement of the anatomically related lymphatic glands. That this process may in some instances be tuberculous is indicated by the presence of tubercle bacilli in the ulcer and in the involved glands; the possibility of syphilis should, however, be kept in mind.

Chronic Onychitis and Paronychitis.—Onychitis due to a low-grade infection rarely occurs as a primary process, but usually arises secondarily to some other form of onychosis; particularly affecting those who have their hands constantly in water, in whom several of the finger nails may be involved. The area of the inflammation may be very small and superficial, quite sluggish and consist only of moderate redness and swelling with little pain and no tendency to pus formation. Such a condition will persist indefinitely unless treated and usually brings about some nutritional disturbance in the nail with resulting deformity.

Parasitic Infection.—Onychomycosis is the only disorder of the nails in which the nail structures are primarily attacked, bringing about change in form, color, and texture of the nail-plate, which are due to the direct invasion of the nail-plate or the nail-bed by the fungus of either favus or ringworm. Rarely more than a part of the nail is involved, the disease being usually limited to spots or streaks in the anterior portion, at times at the lateral borders only, again extending from the free edge in a band without lateral spread, or again irregularly scattered in spots over the nail. In some instances the whole nail is involved including the matrix, either directly or as the result of irritation from extension of the disease to nearby tissues and varying degrees of dystrophy of the nail will result. It is exceptional for more than two or three nails to be attacked and usually but one; the process being attended by little or no pain unless secondary infection occurs.

Favus begins either at the free edge of the nail or at the distal lateral edge, being first noticed as an accumulation of débris beneath the nail-plate which in favus is usually spared, since the nail-bed furnishes the more suitable conditions for the growth of this particular fungus. The process extends more or less gradually, rarely, however, beyond the lunula, and the nail plate separated from its bed becomes dry, brittle, and discolored but not thickened as occurs in ringworm in which the plate itself is involved. Favus in other regions is usually coexistent, but it may be limited to the nails.

Ringworm begins in the same manner as does favus but the invasion of the nail-plate also by the fungus produces somewhat different clinical appearances. The same accumulation of débris takes place beneath the nail-plate, which is much elevated, but the plate itself instead of remaining thin and brittle becomes thickened, crumbly and opaque. Rarely the whole nail-plate is involved and replaced by a discolored shapeless crust. The fungus invasion extends more deeply than in favus and the matrix not infrequently is disturbed, resulting in abnormalities of nail growth.

The diagnosis of onychomyosis is readily made when lesions are present elsewhere, but in the absence of these recognition depends upon the demonstration of the fungus by the microscope.

Warts, because of their manifestly infective character, are included among diseases of local origin, although their causative agent is totally unknown. When present upon other parts, transference to the nails is readily accomplished by picking or scratching, but they are frequently observed limited to the nail folds and the space under the free edge in which situations they constitute a very unsightly and often a very painful condition, particularly about the toenails where they are subjected to pressure and where warmth and moisture encourages their growth. As in plantar warts, the growth penetrates deeply and a vigorous curetting is necessary to obtain complete removal, particularly under the free edge which is often undermined for some distance.

New growths having their origin in the tissue about the nail are of rare occurrence, a number of instances have, however, been reported including all the forms of new growth which are observed elsewhere.

Onychoses Coincident with Inflammatory Dermatoses.—Many of the inflammatory processes which affect the skin involve the nails also with the production of more or less characteristic changes in the nail structures. The most frequently observed of these conditions are, however, eczema, psoriasis, and syphilis.

Eczema of the nail may occur as part of a more or less generalized eruption or it may represent only the extension of a localized eczema of the fingers or toes. The condition may be acute with redness, swelling and intense itching about the nail walls; serous oozing soon begins and as the process involves the nail-bed, the nail-plate is lifted up and loosened. Unless the attack be very short, the matrix is also involved and nail growth is disturbed; in any event the attack is usually marked by a band of deformity across the nail. Infection readily occurs and a suppurative process is a not uncommon complication.

Subacute or chronic eczema of the nails is much more common, the process being usually limited to the nail-bed; the normal functioning of the matrix is, however, disturbed, as evidenced by the appearance of numerous opaque spots in the nail substance which gradually coalescing form irregular elevations which soon exfoliate and leave pits and depressions. Changes in the epithelium of the nail-bed bring about varying degrees of thickening with a resulting distortion and bending of the nail-plate. The clinical course of this condition is marked by remissions and relapses and it is not uncommon to see nails with transverse bands of normal and deformed substance which mark these

variations. In cases of long duration, the nail becomes very rough and discolored, deeply pitted or furrowed, and cracks and splits very readily; if the matrix be seriously involved, a permanent loss of the nail may result.

Hyperkeratosis subungualis is regarded by some observers as a localized eczema, the process being limited to the nail-bed. It begins at the outer angles and involves the whole bed except that part covered by the lunula. It consists of an enormous thickening of the horny layer which is more marked at the outer borders than in the midline, thus bringing about a flattening of the nail-plate. There is no evidence of inflammation and the nails are not cast off.

Psoriasis may rarely affect the nails alone but more commonly occurs in conjuction with the eruption elsewhere, several nails are usually symmetrically involved but rarely all. The appearance of the affected nails varies within the widest limits from a slight pitting of the nail surface to complete involvement with great thickening and discoloration. The process begins usually at the free border and extends downward; the nail, being lifted from its bed by an accumulation of dry scales beneath, becomes opaque, discolored, and furrowed, the free edge split and ragged.

Syphilis as it affects the nails presents essentially the same features as do syphilitic lesions of other epithelial tissues except as modified by differences of structure. The nails are attacked chiefly during the period of secondary activity of the disease but they may be the site of primary infection or undergo trophic changes as a result of later syphilitic processes of the nervous or vascular systems.

Chancre may develop about any part of the nail border beginning as a slight fissure or erosion which gradually enlarges and becomes indurated; although usually causing little pain, a chancre which undermines the nail is accompanied by intense pain and great swelling of the perionychial tissues. Any such lesion which is persistently localized and fails to improve under simple treatment is open to suspicion.

Papular lesions may develop either upon the nail-bed or about the nail folds. Beginning as a deep-seated red spot the lesion gradually increases in size, becoming yellowish or brownish with much thickening of the horny layers and when occurring under the nail, destruction of the nail-plate immediately above follows, leaving the dry horny nail-bed exposed; such lesions are very chronic in their course and almost wholly painless. In severe cases of syphilis papular lesions about the nails, beginning in the same manner, often assume an ulcerative aspect as a result of secondary infection, the so-called "paronychia ulcerosa syphilitica" and many or all of the nails may be affected with undermining of the nail-plate and the formation of chronic ulcerations with exuberant granulations; in such cases damage to the matrix usually results with permanently deformed nails or even complete loss. Without doubt many cases of "onychia maligna," previously referred to, have their origin in this manner.

Onychia sicca is a rare condition, seen usually in late syphilis, in which the nails become extremely dry and brittle with ragged edges and surfaces pitted and at times discolored. This condition probably represents rather a trophic disorder of the matrix than a local process.

Disorders of the nails may form part of the symptomatology of any severe and widespread dermatosis; the nail changes are not characteristic, but may assume the type of any of those above mentioned; that is, pitting, grooving, softening, and atrophic or hypertrophic changes. Among the dermatoses thus complicated may be mentioned lichen planus, pemphigus, pityriasis rubra, pityriasis rubra pilaris, psorospermosis, smallpox, erythema toxicans, dermatitis exfoliativa, and atrophoderma.

The Onycho-trophoneuroses.—Disturbance of nutrition of the nails is a frequently observed accompaniment of long-continued or rapidly debilitating illness of any kind. Situated as they are at the utmost periphery of the circulation, it is readily conceivable that the nails should suffer when the general nutrition is below par. Such changes, however, occur when no assignable cause is present and we are then obliged to suppose that the nervous mechanism which controls the nutrition of the matrix is at fault. Or there may be definite nerve lesions, occasioned by direct injury to the trunk or constituting part of an organic disease of the nervous system, as occurs following fractures or severe trauma, or in tabes, multiple neuritis, syringomyelia, etc.

Cardiac and pulmonary diseases, particularly pulmonary tuberculosis, are frequently marked by the development of the so-called "Hippocratic nails" and in acromegaly the nails share in the general enlargement of the distal phalanges. Any of the continued fevers are apt to leave in the nails definite traces of their occurrence in the shape of transverse grooves or zones of pitted nail substance which are often months in disappearing, and of the acute conditions causing similar changes may be mentioned, pneumonia, erysipelas, scarlatina, influenza, and acute rheumatic fever. These changes are chiefly of an atrophic character; the formation of transverse grooves, numerous small depressions, or even complete atrophy with loss of the nail may be observed and extreme brittleness with a tendency to longitudinal splitting is common.

Acute or chronic poisoning by the various metals, arsenic, lead, mercury, or silver may cause atrophic changes in the nails as part of the general symptomatology of these conditions; the same remarks apply to an important group of diseases of obscure etiology in which the general nutrition is greatly disturbed, of which may be mentioned diabetes mellitus, gout, and myxedema.

Treatment.—The treatment of diseases of the nails, aside from those due to wholly local causes, is largely the treatment of the conditions to which most nail disorders are secondary. By local treatment, however, much can be done to relieve discomfort and prevent further complications; and as a prophylactic the proper care of the nails is of much importance.

Care of the Nails.—A tendency to excessive dryness with splitting of the nail and the eponychium should be guarded against by daily inunctions of equal parts of lanoline and cold cream. If the eponychium be kept soft and gently pushed back with a blunt instrument instead of being trimmed with scissors, hang-nails may be largely prevented. Splits in the nail and fissures about the nail-folds are much benefited by being kept covered with flexible collodion until healing occurs. The free edge should be kept properly trimmed and smooth with scissors and file. Nails that are deformed or diseased require particular care in order to prevent local infection. Too vigorous use of the ordinary manicuring instruments is apt to injure the nail and is the most frequent cause of leuconychia.

Onychitis in the early stages may be successfully treated by painting with tincture of iodine or applying wet dressings of 50 per cent. alcohol. Ointments of ichthyol, 20 to 50 per cent., salicylic acid 5 to 10 per cent., or ung. hydrarg. are also useful. If the process is acute, however, and pus forms early incision is required with later surgical dressing. In chronic onychitis the application of silver nitrate in 10 to 20 per cent. solution at intervals of three days is very effective.

If there is much overgrowth of the nail with thickening and hardening, this should be removed by soaking in 2 per cent. soda solution and careful trimming before remedial applications are made.

Onychomycosis due to the fungus of either favus or ringworm is a most persistent and obstinate condition often continuing for many years unless treated. The great thickening of the nail always present in this disease must first be reduced by softening in alkaline solutions or enveloping in green soap followed by careful scraping and the application of parasiticides, such as tincture of iodine, bichloride of mercury, 1 to 500; ointments of sulpur, 10 per cent., and salicylic acid, 3 per cent., calomel, 10 per cent., or white precipitate, 10 per cent. Such treatment is always slow and at times a complete removal of the nail is more satisfactory.

Eczema of the nails, when acute, requires mildly sedative applications, such as wet boric acid or aluminum acetate dressings. The subacute forms are much benefited by applications of silver nitrate 10 to 20 per cent. and the use of lead plaster at night.

The more chronic cases are managed by ointments containing tar, resorcin, salicylic acid, and mercury in such varying combinations as are used in similar conditions on the skin. Internal treatment must not be neglected and is often the more important.

Psoriasis is treated in practically the same manner as chronic eczema, stimulating agents such as chrysarobin, tar, and mercury being most useful.

Syphilis as it affects the nails will yield to treatment directed against the general infection; local treatment, however, will much hasten the cure. In ulcerative or suppurative conditions, wet dressings of bichloride 1–2,000 are effective, and in the papular lesions unguentum hydrargyri kept constantly applied will bring about a rapid resolution. In the atrophic conditions resulting from syphilis constitutional treatment will in time affect a cure but the nails need particular care to prevent local infection.

Trophoneuroses.—A majority of nail disorders are in some degree the result of nutritional disturbance. When the cause can be removed, as may be possible when it arises from mechanical injury or is connected with an occupation, the trouble is soon corrected. Many such cases, however, are of internal origin and here arsenic seems to exert its most beneficial effects and should be tried in any case of nail dystrophy. Any general indication for treatment should be met and the nail disorder will at times disappear in the most satisfying manner. Changes in form and texture of the nails are to be dealt with in a mechanical way by proper use of file, scissors, and knife, as most of them are irremediable. A. J. Markley.

Naja.—A genus of poisonous snakes, including the cobras. These extremely venomous reptiles have grooved fangs immovably fixed near the front of the mouth. A. S. P.

Nanism.—Nanosomia, microsomia, or dwarfism is a condition in which the stature and weight fail to reach the normal minimum for individuals of the same species.

On consideration of such information as we may gather from the recorded history of the many dwarfs that are more or less known to fame, we are led to certain important conclusions. Most of such dwarfs have been well proportioned, without deformity, and of average or more than average intelligence. Some of them have been persons of great vigor and force of character. In fact they may be said to differ but little from ordinary individuals save in the one point of size.

Dwarfs of this type (*Essential dwarfism*) would fall naturally into two classes: those that are diminutive at birth and subsequently develop slowly, so that they always remain more or less stunted; and those that are of normal or even more than normal size at birth and later cease to grow. Authentic information as to the size of dwarfs at birth is hard to obtain. We may, however, correctly infer that they are often below the average size, for dwarfed mothers have frequently borne children in a natural way, and physical considerations would preclude us from coming to any other conclusion. Conversely, normally developed mothers have not infrequently given birth to dwarf children. Instances are on record of newborn infants weighing a pound and three-quarters, or even less, at full term. The subsequent history, however, of these children is unfortunately often unknown.

Inasmuch as in the cases of essential dwarfism the parts are perfect in form and the limbs are in the normal proportion to the trunk, although the body as a whole is defective in size and weight, it has been suggested that here we really have to do with a condition of infantilism which may be defined as a state of imperfect and delayed development, whereby the individual preserves the characteristics of childhood long after these should have disappeared (*ateleiosis*). This view is supported by the fact that in many cases of dwarfism the head is proportionately large, as it is in the infant, the genitalia are undeveloped, and the signs of puberty are absent or delayed (*asexual ateleiosis*). Joachimsthal[1] studying with the Röntgen rays a troupe of exhibiting lilliputians, found that bone formation was imperfect, the various centers of ossification being strictly comparable to those of a child, although the individuals in question were about thirty years of age. Undoubtedly, in some at least of the deficiencies a more complete degree of development and function may eventually be attained. Thus the onset of puberty, though delayed, brings with it some advance in growth, and the appearance of the primary and secondary sex characteristics (*sexual ateleiosis*). Many of these dwarfs have proved themselves capable of propagating their kind. One cannot fail to be struck also with the fact that dwarfs frequently reach an advanced age, the reverse of what is found in the case of that other contrasting anomaly of development, gigantism. This suggests certainly not a defect in the vitality of the body as a whole, but rather an anomaly in the nature and direction of the growth. The normal balance between structure and function is upset and the individual may possess the mind and faculties of the adult in the body of the child. While this is generally true, there is the disturbing exception that once in a while one meets with cases of infantilism in which vitality is impaired as in those curious forms, known as progeria, in which ateleiosis is associated with some of the features of senility. Here, with stunted growth we have emaciation, baldness, muscular and other weakness, and arteriosclerosis. Death from some disease, characteristic of advanced life, such as angina pectoris, may occur at eighteen or even earlier.

With regard to the etiological factors at work in the production of dwarfism we are compelled to admit that our knowledge is far from complete. Our views therefore must partake largely of the nature of hypotheses. Up to the present time but few cases of dwarfism have been studied, and it is chiefly upon the facts gleaned from these and the results of experimentation that our inferences must be drawn.

The condition of dwarfism is clearly but one aspect of the larger question of dystrophy or dysgenesy. Consequently it can be apprehended only by a reference to the elementary principles governing the formation and growth of tissues.

The developmental forces concerned in the elaboration of a new individual may be inadequate to bring the process to completion. If they are totally inadequate, death of the embryo results. Short of this extreme result, however, the nutritional processes may be so modified that we get a deficiency or excess in growth of the organism, either in part or as a whole, or they may be so perverted that we have actual mal-

formation and deformity. There is, therefore, a close relationship between dwarfism, gigantism, malformations, and monstrous births. The peculiarities of development that result in such anomalies may be inherent in the sperm cell or ovum or both, and in this sense are inherited, or they may be due to causes operating on the ovum subsequently to fertilization, either before (intrauterine acquired causes) or after birth (postnatal acquired causes). We have, therefore, to take into account primitive pecularities of cell substance on the one hand, and external causes, nutritional or mechanical, acting on the fruit, on the other.

Again, certain adventitious circumstances, acting apparently on the germinal cells, may play a part. It has long been known to stock-raisers that continued in-breeding will result in the production of diminutive offspring. And it is said that after Napoleon's campaigns there was a diminution of from one to two inches in the stature of the French people. This has been attributed to the fact that the strongest and best developed males were drawn for military service, but, no doubt, poverty, famine, and disease, affecting the people as a whole, were important factors. These observations suggest that defective physical development on the part of one or both progenitors may lead to insufficient vitality, or what might be termed "relative vegetative inertia" on the part of the germinal cells. This leads us to the consideration of the importance of heredity in this connection.

The inheritance of a developmental anomaly is well illustrated in the case of polydactylism. This peculiarity has been known to persist for three, four, or even five generations, although it may in time be eradicated by marriage with normal persons. Reference will be made later to the influence of pressure of the amniotic sac upon the growing embryo in the production of this and other deformities but it would be absurd to suppose that such a cause could be present throughout several generations and in a whole race. We are driven to conclude that there must have been some anomaly in the formation and development of the "Anlage" arising in the earlier stages of embryonic life. This being so, it would not be surprising to find the influence of heredity somewhat marked in the condition of dwarfism. As a matter of fact, dwarfism is not invariably an expression of a hereditary peculiarity, although sporadic cases may occur in several generations derived from the same stock. Certain parents nevertheless seem to have a tendency to produce dwarfs. The fact, however, that while certain members of a family may be dwarfs, others may be normally developed indicates that the cause, whatever it be, is not a constantly acting one, or else that there are a number of factors which must be correlated before the given result will take place. That the issues involved may be very complex is well illustrated by an extraordinary instance related by Ekman ("Dissertatio medica descriptionem et casus aliquot osteomalaciæ sistens," Upsaliæ, 1788) where dwarfism and osteopsathyrosis were associated through three generations. The ancestor could not walk because of deformity. He had four children, of whom one son was a dwarf and one daughter was small and deformed. This son begat by a healthy wife a son who had curved extremities, and was liable to fractures on the slightest provocation. This son in turn married a healthy woman who gave birth to a son who had so many fractures that when he reached adult life he could not move, and a daughter who was dwarfed and also suffered from multiple fractures in childhood. Apparently, then, heredity may manifest itself, not only in the rate and amount of growth, but also in the structure and composition of the tissues. Moreover, these two factors, simple growth and organic formation are not always correlated, and may even be antagonistic. Numerous exceptions to hereditary transmission, however, occur, for when both parents have been dwarfs, the offspring have frequently proved to be normal in size and proportion. What, however, is an occasional anomaly in the case of civilized peoples is a constant racial characteristic in certain of the African tribes, such as the Akkas and Bushmen. This can hardly be explained on any other assumption than that an acquired peculiarity, due to unfavorable environment, has become transmitted and in time impressed upon a great number of individuals, unless we are prepared to accept the other alternative that all races of mankind were originally much smaller than they are at present, and, owing to natural selection and the growth of civilization, gradually developed into a superior organization, a view that, at all events, is not supported by history or tradition. Heredity probably has the same bearing in dwarfism that it has in the case of other anomalies; no more and no less.

The influence of extraneous circumstances on the vegetative power of the germinal cells is well illustrated by some most suggestive experiments.

In experimenting with the fertilized eggs of certain of the humbler forms of life, Roux shows that if, in the two-cell stage, one of the blastomeres be destroyed, the other will regenerate the missing half and eventually give rise to a complete embryo. Endres, Walter, and Morgan have come to similar conclusions in the case of the frog, with the additional observation that the peculiarity is characteristic of the earliest stages only and may be entirely suppressed. In 1891 Driesch separated, by shaking, the blastomeres of the sea urchin's egg when in the two- and the four-cell stage. Blastomeres thus separated produced in time a perfectly formed dwarf of one-half or one-quarter the natural size, as the case might be. Zoja, too, in some remarkable experiments on the medusa was able to produce dwarfs one-sixteenth of the normal size. Morgan has further discovered the important fact that either a half embryo or a complete half-sized dwarf will result according to the position of the blastomere. If, after one blastomere is destroyed, the other be allowed to retain its normal position a half embryo is always produced, as Roux and already shown, If, however, the blastomere be inverted, it gives rise either to a half embryo or a whole dwarf. In this connection we might recall certain early experiments of Saint Hilaire, who produced dwarf chickens by shaking the egg in the direction of its long axis. Thus it would appear that a rearrangement of the cell material may restore that equilibrium of the entire ovum necessary for the production of a whole embryo. This extraordinary power is, however, less marked in the higher forms and is ultimately lost. In view of the fact, however, that parthenogenesis, which is a constant occurrence in some of the lower forms of life, is sometimes to be observed even in such a highly organized creature as the hen, and in fact has been advanced by some authorities to explain the development of certain tumors of the human ovary, it is not impossible that anomalies in the segmentation of the ovum in human beings, may, although rarely, give rise to one type of dwarf at least, namely, that dwarfed from birth. Two factors would appear to be necessary; some cause to blight one-half of the ovum in the very earliest stage of its development, and another producing a disturbance of the cell equilibrium. As to what these factors may be, whether developmental, traumatic, or inflammatory, we have absolutely no information. One or two facts may possibly point us in the right direction. Malposition of the fertilized ovum as a whole may be brought about by intratubal and intrauterine inflammation, instances of this being tubal gestation and placenta prævia. It is not inconceivable, therefore, that endometritis and deciduitis might lead to blighting of a portion of the embryo and disturbance of protoplasmic equilibrium. That a modification of external conditions does have a profound effect on the developing ovum, in some animals at least, we

have ample proof. Dareste, by incubating hen's eggs at a temperature more elevated than that usually employed, got early development and dwarf formation. Gerlach and Koch[2] also obtained a retardation of development and dwarf growth by varnishing eggs so as to exclude all but a small amount of air.

The effect of primitive peculiarities inherent in the germinal cells in producing developmental anomalies of the anlage has already been noted in regard to polydactylism, and it is now pertinent to inquire in how far deficiencies in the formation of those structures more especially concerned in the general maintenance of nutrition, namely, the cardiovascular and nervous systems, the pancreas, thymus and thyroid gland, are of importance in the production of dwarfism and infantilism.

If the circulatory apparatus be deficient either in the size and extent of the vessels or in the formation of the chambers and valves of the heart, it is obvious that the circulation of the blood must be inadequate for the needs of the organism, which consequently may be inhibited in its growth. Long ago Virchow pointed out the association of cardiovascular hypoplasia with other developmental defects, such as scanty production of the pubic hair and small size of the genitalia, conditions that may be regarded as manifestations of partial infantilism (*anangioplastic infantilism*), if we take the view of Hertoghe,[3] that there is such a thing as partial infantilism. Gilbert and Rathery[4] have, it may be mentioned, found a moderate grade of dwarfism in some cases of mitral stenosis.

With regard to the influence of the nervous system in the production of dwarf growth the available evidence is not conclusive. The close relationship of the central nervous system to the nutrition of the tissues is of course admitted by everybody, and we are aware how often injuries to certain ganglion cells or nerve trunks are followed by atrophy or other degenerative disturbance. It would not be surprising, then, to find that a defective development of the central nervous system might lead to aplasia or hypoplasia in the embryo. Of course the more extensive defects of the central nervous system, as anencephaly and amyelinia, are incompatible with life, and consequently cannot be adduced as conclusive evidence on the subject of dwarfism. As a matter of fact, however, whatever information we possess seems to negative the position that dwarfism is in the majority of cases, at least, a neurotrophic disorder. Undoubtedly, some cases of stunted growth and development have been found associated with microcephaly, hydrocephaly, porencephaly and imbecility; yet, as Cruveilheir has shown, the most extensive hydranencephaly may exist without a trace of defective development in the rest of the body, and Vogt, Klebs, and Aeby have pointed out that in microcephaly the individual as a whole may in other respects be well developed. The most we can say is that certain forms of local hypoplasia may with some probability be referred to central nervous disturbances. The probability is increased when in a child with such a defect the process extends subsequently, as in a case recorded by Emminghaus[5] where there was congenital microplasia of one arm followed in the tenth year by a trophoneurosis of the eye and corresponding side of the face. When microcephaly, for example, is found with dwarfism, a general deficiency of the bodily development is also present, apparently because it is the rule for a certain state of development of the body to go with a certain size of the brain; even under abnormal conditions this correlation is maintained.

That the thyroid gland exerts an important and often controlling influence in the processes of nutrition cannot now be denied. In how far athyroidea has to do with dwarfism is still a moot point. The whole question as to the relationship of the thyroid gland to myxedema, cretinism, and deficient development generally will be dealt with more at length shortly. Suffice it to say here that there is considerable evidence to support the view that there are many minor forms of cretinism in which the most striking and characteristic features are absent, and where the analogies to dwarfism are close. Küster extirpated the thyroid gland in a boy of fourteen, whose growth was thereby arrested so that he always retained the characteristics of a boy of that age. Eiselsberg[6] removed the thyroid in two lambs a week old. At the end of six months they weighed 10 and 14 kgm. respectively, while the controls weighed 35 kgm. The disturbance was general and involved the brain as well as the skeleton. Kappeler also found in a boy of twelve and a half years, who had been deprived of the gland, that he did not grow and developed some of the symptoms of myxedema. It may be argued, therefore, that infantilism, as Brissaud holds ("Lecons sur les maladies nerveuses," Paris, 1895), is simply an attenuated form of cretinism. Additional support is given to this view by the fact that some of the cases have been improved by thyroid feeding. Cases of this kind have been recorded by Wunderlich[7] and Dukes.[8] In Wunderlich's case palpation proved the thyroid to be extremely small. In this connection also should be cited an interesting case of Sulzer's[9] in which a goitrous thyroid was removed from a boy twelve and a half years of age. In five years he was a typical cretin. He then began to improve and in four years had regained the normal condition. It was found that a portion of the gland had been left behind at the operation, and that this portion began to grow some eight years afterward. In the same way the compensatory development of an accessory thyroid has an important bearing on the question of cretinism. Even if we are prepared to admit that infantilism is due to athyroidea, the identity of infantilism with dwarfism is not to be maintained. At most can we say that the explanation may hold good for some of the cases. For, as Lorain was the first to point out, instances are met with in which there is no disturbance of the thyroid gland, and the defect in size is not true infantilism, but rather to be attributed to premature epiphyseal ossification.

In pancreatic infantilism these are signs of inadequacy of the pancreas, in that the stools are pale, fatty, and offensive. The form known as thymic infantilism is associated with anemia, obesity, and a tendency to syncope.

So far we have been discussing the relationship of defective organization of the "Anlage" of the various systems to the question of general hypoplasia.

We pass on now to the question of intrauterine malnutrition. In this connection ill health or improper diet affecting the mother or a local anomaly of placentation is the chief factor concerned. The former act by bringing a poor quality of blood to the support of the fetus, and the latter presents a hindrance to the free interchange that should go on between the maternal and fetal bloods. The existence of syphilis, tuberculosis, or chronic alcoholism in the mother might be expected to produce its effect upon the offspring, largely in the form of lowered vitality and increased susceptibility to disease. It is suggestive in this connection that the Japanese are in the habit of producing dwarf pups by feeding the mothers with alcohol. Charrin, furthermore, could produce a similar result by the injection of ptomains. Yet the children of mothers the subjects of long-standing disease or cachexias are by no means always diminutive or poorly nourished. The vitium shows itself, not so much in immediate anomalies of physical development, as in disordered function and defective reserve power. Much discussion has centered round the question as to whether there is such a thing as fetal rickets. Rickets generally makes its appearance during the first or second years of life, after the sixth month, and is commonly atrributed to insufficient and improper alimentation, although unhygienic sur-

roundings may also play a part. It is not impossible that analogous causes, operating during intrauterine life, might produce the same effects. Rickets is not hereditary, although congenital influences may play a part. In former times, and indeed to a large extent even in these days, the term "fetal rickets" has been used in a very loose way to include several affections characterized by imperfect bone formation, such as syphilis, osteogenesis imperfecta, and chondrodystrophia fetalis, which are now, thanks to recent studies, separated fairly well one from the other. It is now the general consensus of opinion that congenital rickets, in the sense of a rickets that has run its course previous to birth, does not exist. To this, however, we shall return.

In one or two cases the study of dwarf fetuses has revealed the fact that there is an abnormal relationship between the fetal placenta and the maternal structures. The chorionic villi were scanty and were composed of thin strands of connective tissue covered by an abnormally thick layer of epithelium, while at the same time the projections of the maternal decidua did not extend through the thickness of the fetal placenta, as is usually the case. The explanation of this that has been offered is that there was a defective development of the decidua, but this is almost certainly incorrect. Chipman[10] has shown that the more intimate connection between the fetal and maternal parts is brought about by a process of absorption, the ectodermal cells of the chorionic villi proliferating and invading the openings of the uterine glands and extending along the sheaths of the blood-vessels. The maternal tissues are thus eroded as it were, and are quite passive in the matter. It may well be, then, that such an anomalous development of the placenta is due not to malnutrition and imperfect cell growth on the part of the mother, but to a primary fault in the growing embryo that evidences itself in an imperfect development of the placenta. Apparently, however, before such an abnormality can result in dwarfing of the fruit it must be quite extensive, for the given result does not always follow. As Langhans has pointed out, a similar peculiarity of placentation occurs in cases of tubal gestation, where the fetus is usually well developed.

Further, the proper interchange of blood and nutriment through the placenta may be gravely interfered with owing to inflammatory disturbances. Here syphilis plays a leading rôle. As is well known, in syphilis hereditaria tarda there is a delayed development of the bony and muscular systems, so that a young man of twenty may look like a boy of ten or twelve. With this there is often an infantile condition of the genitalia and the hair on the pubes and other parts is slow in appearing. The characteristic lesion of syphilis in the placenta is endarteritis, which leads to extensive destruction of the vascular area, with degeneration, atrophy, and fibrosis of the region involved. The placental circulation must in such cases be greatly interfered with. In syphilis, however, other factors enter. We have to admit that the presence of so serious a disease in the parent, usually the father, must have a tendency to lessen the vitality of the germ cell, to say nothing of the presence of the germ of the disease (*Treponema pallidum*) in the fertilized ovum, with all that this implies.

Hitherto we have been discussing what might be called *primary* or *essential* dwarfism (microsomia) in which the predominating element is a deficiency in the vegetative energy of the cells. The affected persons are in fact normal individuals save in the one particular of size and weight. Besides this, however, we have to recognize another class of cases that clearly belong to a different category. I refer to instances of *secondary* or *symptomatic* dwarfism. Here, while the height of the body is below the normal, the weight is not so strikingly diminished as in the true dwarfs. The main feature is, however, that in addition to general hypoplasia, there are evidences of pathological changes in the tissues, particularly in the bones, leading to asymmetry, deformities, fractures, or malformations. The defects are structural as well as nutritional. Just at this point it may be remarked that the exact nature of these cases presents one of the most difficult problems in etiology. In former times many cases of congenital dwarfism of this type were put down to syphilis, rickets, or cretinism. It was soon found, however, that there were some important points of distinction between certain of the cases. The typical features of cretinism were not always present, nor did the disease, if rickets, conform to the picture of the ordinary post-natal affection. These considerations have led investigators to recognize several distinct types, which are by some regarded as separate entities. We have, therefore, to consider in this connection rachitis, cretinism, osteopsathyrosis, chondrodystrophia fetalis, osteogenesis imperfecta, anosteoplasia, and osteomalacia, affections that agree in this, that with more or less stunting of the body there are structural modifications of the bones of an obviously pathological nature.

The amount of confusion that has involved the subject is sufficiently indicated by the number of names that have been proposed for the condition—fetal rachitis, pseudorachitism, cretinoid dysplasia, chondritis fetalis, micromelia chondromalacica, achondroplasia, chondrodystrophia fetalis. A decided step in advance has been made through the researches of Kaufmann,[11] who introduced the name chondrodystrophia fetalis. Here the type of dwarfism is micromelic and the lesions are usually symmetrical. The body is plump, the micromelia rhizomelic, the head large, and the hands often show the so-called "trident" deformity. There are, however, notable differences in the length, curvature, and consistence of the bones of the extremities, and in the configuration of the skull. Kaufmann, consequently, recognizes two groups: one, in which there is a distinct cretinoid appearance of the skull and face, namely, a deeply sunken nose, prominent eyelids and lips, thick cheeks, and large mouth; and another, in which the nose is flattened and retracted as a whole. In the former type the bone is of good consistence although somewhat more vascular than normal, while in the latter the bone is soft. No hard-and-fast line can be drawn between the two forms, and Kaufmann regards them as manifestations of the same process, the differences being due to the chronicity and intensity of the process. The retraction of the root of the nose is usually said to be brought about by premature ossification and synostosis of the os tribasilare. The ethmoid is also somewhat shortened, and in some cases may be the only part affected. Klein has observed well-marked craniotabes in some cases. In some, too, there may be beading at the costochondral articulations, and defective development of the pelvis, glenoid, and cotyloid cavities. Lordosis may also be a marked feature, and Regnault[11] has found the vertebræ involved. The disease begins in fetal life, running its course usually, as it is believed, from the third to the sixth week. As a consequence the bones affected are the base of the skull, the long bones, the ribs, and the pelvis. The bones formed in membrane, those that in late fetal life are mainly cartilaginous, usually escape. Kaufmann has described three subclasses in chondrodystrophia: Chondrodystrophia malacica, in which the bone is soft; C. hypoplastica, in which there are evidences of retarded growth; and the C. hyperplastica in which the epiphyseal ends of the long bones are greatly enlarged. The periosteal ossification is normal, so that the bones become plump and thick, although somewhat irregular, but the growth in length is disturbed owing to faulty ossification at the epiphyseal junctures. Ingrowth of the periosteum at the epiphyseal lines may occur. Microscopically the cartilage cells are deficient in growth, being spindle-

shaped and irregularly arranged, while the hyaline matrix is more or less soft and homogeneous. It is not improbable, however, although the majority of children thus affected are stillborn, that when the affection is of mild type or arises in the later months of fetal life, existence may be prolonged for some time. Parrot has met with an example in a child seven and a half years old, who measured ninety-four centimeters in length. Certain changes in the bones of the hands, notably in the fingers, seem to prove also that the disturbances of ossification may go on at a later period than that above indicated.

The exact relationship of the disease osteopsathyrosis, called by Vrolik and Stilling osteogenesis imperfecta, to chondrodystrophia is still *sub judice*. The studies of Stilling, Hildebrandt, and Harbitz go to show that it is a definite intrauterine process. There is clearly some defect in the process of ossification, for the bones are soft and brittle, with the result that fractures and deformities are common. Microscopical study has shown that the trabeculæ are few in number, irregular, and imperfectly formed. There is no continuous system of trabeculæ with Haversian canals and lamellæ as in normal bone. A point of great interest is the extraordinary manner of ossification of the skull. The calvarium is formed not of continuous bony plates, but of a multitude of small mosaics, sometimes touching one another, but also attached by bridges of periosteum and dura. In a remarkable case described by Stilling, the cranial covering consisted of a membranous sac which contained scattered bony spicules. So far as is known there is no synostosis of the basal synchondrosis in this disease. While the affection has hitherto been found only in the new-born or in very young infants, it is not necessarily fatal, and Harbitz is inclined to think that some cases of dwarfism that have been regarded as examples of fetal rickets or chondrodystrophia may have been osteogenesis imperfecta. As in chondrodystrophia, porosity of the bones occasionally appears to depend on hereditary conditions, and Bircher has found osteoporosis in the case of a chondrodystrophic dwarf (*cf.* also the case of Ekmann, referred to above). We are, therefore, not prepared to believe with Paltauf[13] that the two affections are not related.

To rickets chondrodystrophia bears much resemblance, although there are several differences. In both there is enlargement of the epiphyseal ends of the long bones (chondrodystrophia hyperplastica), the long bones may be curved, the ribs beaded, and there may be spinal and pelvic deformities. In rickets, however, the arms are usually long. Periosteal bone formation is also interfered with. The periosteum is readily stripped off and the underlying bone is softer and more spongy than normal. As the condition heals the bone becomes unusually plump and dense. Basilar synostosis does not occur in rickets. Microscopic study has shown that the epiphyseal zone of proliferation in rickets is thicker than normal, irregular in outline, soft, and very hyperemic, so much so that Kassowitz believed the lesions to be of inflammatory origin.

The microscopical appearances of the growing ends of the bones in chondrodystrophia, are, however, quite different from those in postnatal rickets. No clear evidence of the existence of rickets originating during intrauterine life is forthcoming, yet there is a parallel between chondrodystrophia and rickets, for, as is well known, postnatal rickets, if severe, results in the stunting of the growth of the affected individual, and cases of extreme dwarfism have been met with. The lesions are characteristic. The skull is large, although the face is relatively small. The fontanels remain open for a prolonged period, and bone in certain regions, especially the occipito-parietal, may be so thin as to give way under the pressure of the finger (craniotabes). The forehead is usually large and square, owing to the formation of flat hyperostoses over the frontal eminences. The sternum projects and the sides of the chest are drawn in (pectus carinatum). The spine is often curved and the extremities become greatly deformed owing to the weight of the body and muscular action. The pelvis is contracted; dentition is delayed and the teeth are small and badly formed. The condition is by many believed to be due to infection or possibly autointoxication. This view is supported by the experiments of Morpurgo,[14] who showed that rickety changes in the skeletons of young white rats could be produced by the injection of cultures of a diplococcus. The lesions in rickets, however, are so unlike those of chondrodystrophia in important particulars that it is unlikely that an infective cause is at work in the latter disease. Differentiation between chondrodystrophia and rickets may be made by attention to the following points: The dwarfism in the former is micromelic; in the latter not. Periosteal bone formation is not interfered with in chondrodystrophia, while it is in rickets. In healed rickets the bone is abnormally dense; not so in chondrodystrophia. Basilar synostosis does not occur in rickets. In rickets you do not get "trident deformity" of the hands. Developmental anomalies, like cleft palate and polydactylism, are not found in rickets. Osteogenesis imperfecta is recognized by the fragility of the bones, the peculiar ossification of the cranium, and the lack of basilar synostosis.

It is a suggestive and a striking fact that while we are able to draw these distinctions between the type cases of chondrodystrophia, osteogenesis imperfecta, and rickets, there exist borderland cases in which some of the features of these diseases may be combined. Such a one is that reported by Hektoen,[15] in which in a micromelic dwarf, forty-five years of age, there were 172 Wormian bones in the skull, without premature synostosis of the os tribasilare, with shortness and curvatures of the long bones, enlargement of the articular ends, curvatures of the spine, deformity of the pelvis, osteoporosis and multiple fractures, and a fibroid thyroid. A case presenting features both of chondrodystrophia and osteogenesis imperfecta has been described also by the Countess von Geldern-Egmond.[16]

The etiology of these interesting conditions is still largely unknown. Heredity appears to be a factor in some cases. In one case, recorded by Porak ("Beitrag zur Histologie und Funktion der Schilddrüse," Inaug.-Diss., Königsberg, 1892), a dwarf gave birth to one healthy child and a second with all the signs of the so-called "fetal rickets." Guéniot[17] recounts the operation of Cesarean section on an achondroplastic dwarf, the child being similarly affected. The parents of chondrodystrophic dwarfs as well as their children are nevertheless often healthy. Heredity seems then to play a minor rôle. The influence of heredity in the case of polydactyly has already been dwelt upon, and it is a curious fact that polydactyly may sometimes be associated with dwarfism. An instance of this will be found in *Hutchinson's Archives of Surgery* for April, 1893, where there is given an illustration of a micromelic polydactylous dwarf, copied from Theodore Kerckring's "Spicilegium Anatomicum," published in 1670. The drawing is not entirely to be relied upon, but it is clear that the limbs were too short for the trunk. Both the hands have seven digits; the right foot has eight and the left nine. The condition is not perfectly symmetrical, for in some cases two of the metacarpal or metatarsal bones are welded together. The long bones are plump and, so far as it is safe to judge from the imperfect sketch, the ends appear to have been enlarged. The orbits are deformed, the two halves of the lower jaw are already united, and the ribs are short and badly formed. It is clear that here we have an abnormality of development in few respects comparable to rickets. It may be that here, as in simple polydactylism, we are dealing with a

primary vitium of development inherent in the germinal cell. This view is supported also by the observation of Kirchberg and Marchand, who found cleft palate in a chondrodystrophic infant. One of Bowlby's cases, also, reported as congenital cretinism but really an instance of chondrodystrophia, had a cleft palate and a deformed nose. The right foot had six metatarsal bones but seven toes; the left foot had seven toes.

There is, however, another possible explanation. Recent observations have shown that many forms of hypoplasia, non-closure of sutures, and, in fact, the most extreme deformities may result from intrauterine pressure. The simple weight of a limb resting on a band has been sufficient to erode the soft tissues to the bone. Twisting of the cord about a limb may lead to dwarfing or amputation. The pressure of bands traversing the amniotic sac is also a well-recognized cause of even more extreme deformities, such as anencephaly and craniorachischisis. Dareste believed that a contracted amnion was an important cause of hypoplasia.

In Klebs' text-book of "General Pathology" (vol. ii., 1889, Jena) is an interesting illustration representing a microscopical section through the proliferating end of one of the long bones in a micromelic dwarf. The growing cartilage cells are closely packed together, flattened, with their long axes at right angles to the long axis of the bone. The appearances could not be due to alterations in the ground substance which seemed to be normal, but could be attributed only to the effects of external pressure. This would, of course lead to inhibited and imperfect ossification. The effects of intrauterine compression are well illustrated by the experiments of Fol and Warynski (Thèse de Genève), who brought external pressure to bear upon a growing embryo. They found that the head was the part most amenable to pressure, and could to some extent be restrained in its growth. Warynski, also, by exerting pressure at the site of fusion of the two primitive cardiac rudiments, was able to produce a double-hearted monster. Klebs refers to a most remarkable case in which a contracted sac led to a singular malformation. In an ectopic gestation the fetus was found in a tight sac within the transverse mesocolon. There was syndactylism in the upper extremities and polydactylism in the lower. From the recorded cases it would appear that contraction of the amnion does not lead to dwarfing of the fetus as a whole, but that certain parts are more liable to be affected, as the extremities and head. In this connection also may be remembered the fact that hydramnios is apt to be associated with grave deformities, such as exencephaly and spina bifida, and has been found in a case of osteogenesis imperfecta. The effect of intrauterine pressure has also been emphasized by von Franqué.

It is on the ground of the obvious errors in development which are sometimes associated with chondrodystrophia, and which can only be referred to peculiarities of the Anlage, that Virchow objects to the term chondrodystrophia introduced by Kaufmann. Virchow points out that the condition imperceptibly shades into a pronounced developmental anomaly (*Missbildung*), which is finally represented by the phokomelia of Saint Hilaire.

The small stature, the peculiar facial configuration, and the enfeeblement of mental power, with other minor abnormalities found in some cases of chondrodystrophia, have induced the suspicion that some of these cases of dwarfism are really cases of cretinism. The difficulties in the way of differential diagnosis are great. Thus Dolega, Bernard, and Bircher have pronounced certain cases to be instances of cretinism, and yet a subsequent examination proved them to be Kaufmann's chondrodystrophia, and conversely, Neumann, Scholz, and others have described instances of cretinism as fetal rickets. The difficulties in the way will be readily comprehended if one considers for a moment the lesions in a typical case of cretinism. In the cretin the stature is almost always stunted, Maffei in twenty-two cases out of twenty-five finding the height to be less than 140 centimeters, while several were under ninety-five centimeters. The limbs and trunk are disproportionate. The head is usually relatively large, the top flat, and the occiput prominent, although microcephaly has been found. The fontanels and sutures remain open for a long time. The root of the nose is retracted, and the organ is short and thick with large wide nostrils. The lips and tongue are enlarged. The teeth appear late and are large. The first dentition usually persists throughout life. There is as a rule no hair on the pubes and in the axillæ. The sexual organs are poorly developed, and puberty, if it occur at all, is late. With regard to the finer structure of the bones in cretins, Langhans found that the cartilage cells were small, spindle-shaped, and anomalously arranged, being longitudinal to the axis of the columns. The rows were also often interrupted. The bony trabeculæ were shortened and the marrow spaces in the youngest portions of the bone were large and widely separated. The resemblance to Class I. of Kaufmann's chondrodystrophia is close. Typical cretinism is endemic and associated with goiter. Chondrodystrophic dwarfism is sporadic. Can, then, chondrodystrophia be sporadic cretinism? The recorded cases of chondrodystrophia go to show that the disease is of intrauterine origin, and so far no evidence is forthcoming to prove that the affection ever arises subsequently to birth. Cretinism is said to be congenital in some cases, but the symptoms usually appear some five to eight months after birth, or even later. It is now believed that the changes in the skeleton of cretins are due to delayed ossification of the cartilages. Hofmeister, studying a case of cretinism with the *x*-rays, found that the epiphyseal ends of the bones grew slowly, and that the epiphyseal plates persisted for a long time. The bones were small. Ossification may in time be completed, but the process may take years; in fact, cretins may continue to grow until they are thirty or forty years of age. Periosteal osteogenesis is normal, or may be in excess. The peculiar appearance of the nose is due to premature synostosis of the bones at the base of the skull, although, as Niepce, Stahl, and Klebs have shown, this anomaly of bone formation does not always occur.

The stunted growth is believed by Bircher to be due to defective development of the cartilage cells, as was found occasionally by Virchow and Klebs at the base of the skull. We find, therefore, that cretinism and the so-called chondrodystrophia have much in common. The resemblance can, however, be made out clearly only in the case of chondrodystrophia of Kaufmann's first group. Cretinoid chondrodystrophia might be explained as cretinism that had become marked at a very early period of intrauterine life.

Further information might be obtained by an inquiry into the condition of the thyroid gland in chondrodystrophia. Hofmeister[18] holds that the changes in the bones produced by thyroidectomizing rabbits are identical with those found in chondrodystrophia as described by Kaufmann, H. Müller, Kirchberg, and Marchand. Although we must admit the great similarity of the lesions in the two cases, this, of course, does not prove identity. Leblanc states that chondrodystrophia is often associated with myxedema and that disturbance of the thyroid is the causa morbi. Nasan is of the same opinion. There is no need of entering here into the question of the identity of myxedema and cretinism, further than to say that it is proved practically beyond doubt that the two are one and the same thing, and due to defect in the function of the thyroid. Any differences are to be explained in respect to the time at which the athyroidea first makes itself manifest. Myxedema is

cretinism manifesting itself in the adult; cretinism is myxedema of childhood. In opposition to the views of Leblanc and Nasan may be cited the experience of Cestan, who found a condition of chondrodystrophy in a girl nine and a half years old, unimproved by thyroid feeding for nine months, and of Marie, who in two cases found no benefit from the use of thyroid extract. We should observe, too, that the lesions of chondrodystrophia are said to develop in the earliest period of fetal life before the thyroid is properly formed.

With regard to the anatomical peculiarities of the thyroid in chondrodystrophia it is not always possible to obtain accurate information.

So far, however, as one can learn from twenty-nine cases which I have been able to study in the literature, the thyroid is abnormal in eight, either absent, atrophied, or hypertrophied. And it is further striking that in all the cases in which the thyroid is obviously diseased, with one exception, the clinical type has been cretinoid; with, in two cases, some additional features resembling myxedema. The one exception, Hektoen's case, is probably to be explained on the ground of a compensatory action of the hypophysis, which was considerably enlarged, but otherwise of normal structure. In Bowlby's case, which is recorded as a case of cretinism, being observed before the distinctions between the different forms of abnormal osteogenesis were so closely drawn as they are at present, the skin was edematous and semitranslucent, the nose was broad and flat, and there were no eyelashes or eyebrows. In Salvetti's case the skin was also edematous. In the one case in which vascular struma is stated to have been present (Scholz), there were apparently no signs of cretinism; but this anatomical condition of the thyroid does not of course imply deficiency of the secretion; rather is it akin to what is found in exophthalmic goiter or hyperthyroidism. This association of defective thyroid secretion, which must be admitted where the thyroid structure is so extremely altered, with the cretinoid type of Kaufmann's chondrodystrophia can hardly be fortuitous, especially when we note that in the cases that are distinctly without cretinoid features, the thyroid has been, so far as we can judge from the imperfect information that we are given, practically normal. In settling this latter point we can admit as conclusive evidence only cases that have been controlled by postmortem examination. Still, the position is supported to some extent by clinical cases. It is, it must be remarked, difficult to draw conclusions as to the functional efficacy of the thyroid from an estimate of its size alone derived from palpation. Osler[19] describes two cases of chondrodystrophia in French-Canadian children, who did not present the cretinoid facies, in whom the thyroid was not enlarged on palpation. Joachimsthal also reports a case of chondrodystrophia hyperplastica, without the cretinoid appearance, in which also the thyroid was normal on palpation. As corroborative evidence, also, it may be noted that Virchow in the canton of Glarus, Switzerland, where goitrous cretinism is endemic, found not a few cases of chondrodystrophic dwarfism without the gross signs of cretinism. It would seem, so far as we can judge from so limited a number of observations, that the cretinoid type of chondrodystrophia, as described, is simply a form of cretinism, or at least due to thyroid inadequacy. If this be the case, it then follows that Kaufmann's chondrodystrophia fetalis is probably not a distinct disease entity, but that several differing conditions are included under the one name. Some stress has been laid on the peculiar retraction of the root of the nose, which is so evident a feature in typical cretinism, as an aid in the diagnosis of these conditions. It should be said that this feature is not always present in undoubted cretinism and, moreover, the explanation given of it, namely, that it is due to premature synostosis of the os tribasilare, does not invariably hold good. Some of Kaufmann's cases show that retraction of the root of the nose may be present without premature ossification of the os tribasilare. In these exceptions he attributes the appearance to shortening of the bony parts in front of the os. Conversely, the synostosis may take place without producing any effect on the condition of the nose. Consequently too much weight should not be laid on this point.

It would, perhaps, be also premature to conclude that the other forms of chondrodystrophia may not be dependent on thyroid dystrophy. It is true that Cestan, Marie, and Christopher have failed to get benefit from thyroid feeding in chondrodystrophia. As the disease, however, originates during intrauterine life, by the time the cases come to observation the main damage has been done, and it is not to be expected that any form of medication would have a marked effect on bony structures once they were formed. The only possible chance would be if the cases could be treated from birth; but, so far as I am aware, this has not been done. This fact weakens the therapeutic argument very much. Further, it does not follow that because the thyroid is of normal size and appearance that it is competent to perform its function. While an absolute deficiency in the amount of secretion furnished by the thyroid will undoubtedly produce the symptoms that constitute cretinism or myxedema, it is quite possible that a relative inadequacy will produce the same symptoms. This aspect of the case has been frequently overlooked by writers on the subject. The doctrine of internal secretions supposes the existence of some substance, the product of metabolism, for the secretion to act upon. The thyroid, therefore, may be normal, but if the substance upon which it acts is produced in excess, then the gland will be insufficient for its work, and the various symptoms of athyroidea may make their appearance. In some few instances in which the hypophysis has been invaded by a tumor, symptoms of myxedema have occurred with an intact thyroid, the thyroid and the hypophysis being, as is now well recognized, more or less complementary organs. Relative inadequacy of the thyroid—and, *mutatis mutandis*, the same remark applies to the hypophysis and other glands furnishing an internal secretion—is a factor that can by no means be neglected in these obscure disorders of development. Until, however, we know much more about the nature, chemical and otherwise, of metabolic processes, we must leave such questions to the realm of speculation.

Allied to the above-discussed conditions is anosteoplasia, otherwise called cleidocranial dysostosis. In this affection there is moderate dwarfism with notable defect in the formation of the membrane bones. The face is small, dentition delayed, and the skull is broad and rounded. The clavicles are rudimentary or altogether wanting. The disease is often inherited.

Osteomalacia is due to the decalcification of the bones, and in cases supervening in adults the diminution in height is due to the bending of the lower limbs and spine. When occurring in childhood there is arrest of bony growth as well.

In concluding, we should not forget to say a word or two in regard to the relationship between anomalies in structure and function of the genital tract and the general question of somatic development. It is a matter of common knowledge that the changes in the genital organs which occur at puberty are coincident with an increased nutritional and functional activity of the body as a whole, as is evidenced by the rapid growth, the consolidation of the figure, the production of hair, the deposit of fat, the changes in the voice, and the altered mental characteristics, all of which together constitute the adult type. Certain isolated facts bring this relationship into still greater prominence. Genital hypoplasia, with its associated sexual

torpidity, amenorrhea, and even sterility, has been found in certain dwarfs, in myxedema and cretinism, in acromegaly, and in some forms of gigantism. This would suggest that there is some functional relationship between the thyroid gland, the pituitary body, and the genital organs. The almost constant genital insufficiency found in conditions of athyroidea is so well recognized that I need not do more than mention it. That a similar peculiarity may be associated with lesions of the pituitary body is perhaps not so widely known. Some years ago I performed an autopsy on a female about thirty years of age, who died with symptoms of a basal tumor of the brain. The genitalia were markedly infantile in size and appearance. A tumor of the hypophysis was found, although there were no signs of acromegaly. A similar case is one reported by Babinski[20] who found signs of infantilism, viz., lack of body hair, amenorrhea, an excess of fat, in a girl of seventeen, but without acromegaly, who postmortem exhibited a tumor of the pituitary. Analogous peculiarities have been found in the male in such cases. While it is true that children, the subjects of atrophy of the genitals are often small, instances of the reverse are not unknown. Eunuchs are often of more than normal height. The increase in length is most manifest in the lower limbs, a peculiarity that is to be observed also in the capon, or castrated chicken, and in the ox.

It is in view of these facts that Freund, Klebs, and Verstraeten, have advanced the theory that anomalous evolution of the genital function is at the bottom of developmental dystrophy. If genital evolution be in excess, gigantism or acromegaly will occur; if defective, infantilism or dwarfism results. It seems to me, however, that this is much too strong an assertion, and one that is not supported by the facts, as we know them. Such a theory supposes the existence of an internal secretion in the case of the genital organs, to wit, the testes and ovaries, and while this may be so the association between genital anomalies and developmental peculiarities is not necessarily direct, as cause and effect, but may be indirect through some third factor. We have experimental evidence to show that defect of the thyroid will produce hypoplasia of the genitalia, but not the converse, and in this case as a matter of fact genital hypoplasia is simply part and parcel of a systemic developmental defect. In the case of the pituitary evidence is scanty, inasmuch as experimentation, except in the single particular of pituitary feeding, is extremely difficult. The evidence, so far as I can gather it from autopsies, seems to favor the view that certain lesions of the pituitary, provided they arise early enough, may prevent the proper development of the genital organs. There is absolutely no evidence to prove that hypoplasia or any other pathological condition of the genitalia has produced disease of the pituitary. Could it do so, one would suppose that, considering the very respectable number of cases of aplasia and hypoplasia of the genital organs that have been described, some abnormality of the pituitary body would occasionally have been noted. This is, however, not the case. It would seem more probable that genital hypoplasia, if not indeed always an effect, is an associated condition merely. In regard to the factors at work in this very interesting but obscure condition of anomalous development, the sum and substance of the whole matter is that our views cannot attain finality until we know much more of the chemistry of the internal secretions and of metabolic processes generally. Hitherto the anatomical peculiarities and the pathological chemistry of the thyroid and pituitary glands in cases of dwarfism and giantism have not been sufficiently studied. Nevertheless, I think that after due consideration of the facts brought out in our study of dwarfism, we may be able to draw certain conclusions with a fair degree of probability.

1. That there are two main types of dwarfism, *essential dwarfism* and *symptomatic dwarfism*, which etiologically belong to two distinct categories.

2. The former are to be attributed to peculiarities inherent in the germ cells or acquired shortly after segmentation of the fertilized ovum, the exact nature of which at present remains obscure, or to acquired intrauterine disturbances. The latter are due, not only to the causes just mentioned, but also to acquired disease. In essential dwarfism the defect of development is in time and extent; in symptomatic dwarfism the manner of growth is perverted as well.

3. There is a close association between such conditions as "fetal rickets," cretinism, osteoporosis, osteogenesis imperfecta.

4. Fetal rickets so called has nothing to do with rickets as it is ordinarily understood.

5. The term *chondrodystrophia fetalis* is a misnomer, inasmuch as it implies a local lesion, and, moreover, attributes it to a nutritive cause, whereas not only the cartilage but the bone and soft tissues are involved. Virchow is probably correct in regarding it rather as a developmental anomaly.

6. The three types, chondrodystrophia hyperplastica, chondrodystrophia hypoplastica, and chondrodystrophia malacica, are probably not varieties of the same disease.

7. Chondrodystrophia of Kaufmann's first or cretinoid type is probably a modified cretinism.

ALBERT GEORGE NICHOLLS.

REFERENCES.

1. Joachimsthal: Deutsche med. Woch., 1899, xxv.
2. Gerlach und Koch: Biologisches Centralblatt, 1884, xxii.
3. Hertoghe: Die Rolle der Schildrüse, etc., München, 1900.
4. Gilbert et Rathery: Presse Médicale, May 7, 1900.
5. Emminghaus: Deutsches Arch. f. Klin. Med., ii., 96, and xii., 49.
6. Eiselsberg: Langenbeck's Archiv, 1895, xlix.
7. Wunderlich: Brit. Med. Journal, 1897, ii.
8. Dukes: Brit. Med. Journal, 1898, i.
9. Sulzer: Deutsche Zeitschr. f. Chirurgie, 1893.
10. Chipman: Observations on the Placenta of the Rabbit, Studies from the Royal Victoria Hospital, New York, December, 1902.
11. Kaufmann: Untersuchungen über die sogenannten foetale Rachitis, Berlin, 1892, and Ziegler's Beiträge, 1893, xiii.
12. Regnault: Bull. et Mém. de la Soc. d'Anat., 1901, lxxvi.
13. Paltauf: Ueber den Zwergwuchs, Vienna, 1891.
14. Morpurgo: Centralblatt für Pathologie, 1902, xiii.
15. Hektoen: Am. Journ. Med. Sciences, May, 1903.
16. v. Geldern-Egmond: Inaug. Dissertstion, Zürich, 1897.
17. Guéniot: Bull. et Mém. de la Soc. Obstet. de Paris, January, 1893.
18. Hofmeister: Beiträge zur Klin. Chirurgie, 1894.
19. Osler: Trans. Congress Am. Phys. and Surg., 1897, iv., p. 190.
20. Babinski: Société de Neurologie, June 7, 1900.

Nantucket, Martha's Vineyard, and Cape Cod. —The islands of Nantucket and Martha's Vineyard and the southern district of Cape Cod are climatologically and structurally so similar, and are grouped in such close proximity to each other that it has seemed best in the present description to consider them under one head. Nantucket, as being situated farthest away from the mainland, is to be taken as the climatological type, its climate resembling most nearly the climate of the ocean as experienced on shipboard, of any island on the Atlantic seaboard from Old Point Comfort to the Grand Manan. The climatic attributes may be briefly summed up as follows: (*a*) as being at the ocean level the air contains the maximum amount of oxygen, aqueous vapor, and ozone; (*b*) it contains saline particles, *i.e.* iodine and bromine; (*c*) it presents the most regular variations of barometric pressure; and (*d*) it presents the minimum diurnal variation of temperature. Other stations included in this article resemble it more or less nearly, according to their proximity to the sea and to modifying local conditions subsequently to be considered.

The Island of Nantucket (41° 15′ North Lat., 70° W. Long.) lies in the Atlantic Ocean twenty-five miles due south of the metacarpal joint of the beckoning finger of Cape Cod. It is of a long-horned crescentic shape, and, roughly speaking, is fourteen miles long and four miles wide. It comprises in its entire extent about twenty-nine thousand acres. It is the most easterly of the group of islands known as the Elizabeth Islands, in which are also included Martha's Vineyard, Tuckanuck, Muskeget, and Naushon. It is almost exactly one hundred miles from Boston.

Structurally considered, it is a vast mound of sand lightly covered with vegetable mould, gently undulating in surface, and presenting a series of high bluffs to the sea. At different points its surface is dotted by fresh-water ponds of varying size. The soil is of a light, porous, sandy nature. Rocks are so rare that it would be easily possible to count those worthy of the name upon the fingers of the hand. There are, practically speaking, no trees. The flora is large and varied. Five hundred varieties of species are described as growing without cultivation. The botanic range is wide; heather grows upon the moors; cactus is to be found freely flowering in the month of July, while in August a visit to a vast field of hollyhock-like blossoms of the pink hibiscus is a favorite excursion. A large variety of birds pause at the island upon their semi-annual pilgrimages; black duck and quail live there the entire year, and the neighboring island of Muskeget is a breeding place upon which thousands of families of sea-gulls are annually reared.

Nantucket, the chief town, is situated upon the northern side of the island, on Nantucket Sound. The resident population in 1894 was 3,300, though the summer population is, of course, largely in excess of these figures. In that year 16,306 passengers, not

Nantucket, Mass., Five Years, 1897–1901.

Climatic Data.	June.	July.	August.	Sept.
Average maximum.	67.1° F.	73.9° F.	73.9° F.	69° F.
Average minimum.	55.7°	63.1°	63.2°	58°
Average daily range.	11.3°	10.9°	10.7°	10.4°
Absolute maximum.	78°	86°	87°	85°
Absolute minimum.	44°	54°	56°	46°
Average number of clear days.	7.6	7.8	10.2	11.0
Largest number of clear days.	11.0	10.0	12.0	13.0
Smallest number of clear days.	4.0	1.0	5.0	9.0
Average number cloudy and partly cloudy.	22.0	23.0	20.8	19.0
Largest number cloudy and partly cloudy.	26.0	30.0	26.0	21.0
Smallest number cloudy and partly cloudy.	19.0	21.0	19.0	17.0
Average number rainy.	8.6	10.0	9.6	8.0
Largest number of rainy days.	10.0	13.0	11.0	11.0
Smallest number of rainy days.	8.0	8.0	7.0	4.0
Average total rainfall.	1.45	2.45	2.22	1.75
Average relative humidity for four years.	86.5	89.2	88.3	81.0
Average hourly wind velocity for four years.	10.0	9.5	8.2	10.2

including children, were brought to the island. At the height of its prosperity, when the whaling industry flourished, the population of the island was 10,000. The town is very old (the oldest house bearing the date 1686). Many of the dwellings and warehouses are built of brick, and the number of buildings in general is surprisingly large in proportion to the present population. A general impression of size and antiquity is given to the town. The streets for the most part are paved with stone and asphalt; outside the town clay roads extend in many directions, and the State road, a fine piece of macadamized road, eight miles long, connects the town with Siasconset. At a greater distance from the town the roads consist chiefly of "ruts," and one may ride or drive in almost any direction at will over the moors.

Siasconset, formerly a small fishing village, eight miles from the town and connected with it by a narrow-gauge railroad, is now an exceedingly popular summer resort. It is situated on the ocean and is possessed of several hotels and boarding-houses, a casino, and a fine golf course. The surf bathing is excellent.

The preceding table, compiled from statistics prepared for me by Mr. A. W. Crosby of the weather bureau in Boston, shows climatic data for the five years, 1897–1901.

From the foregoing table it is seen that the average number of rainy days for the four summer months, for five years, was nine per month. This number represents the days during which it rained at some portion of the day. The number of days in which an invalid could not exercise out of doors was of course much smaller. In 1894, for the months of July, August, and September, there were ninety-two consecutive pleasant days.

The prevailing direction of the wind is westerly, blowing, as will be seen by the map, over miles of ocean. One of the most remarkable meteorological phenomena of the island is the rarity of electric storms. Thunderstorms are exceedingly rare, passing north or south of the island. In the twenty-one summers I have passed at Nantucket I have known the lightning to strike but on three occasions. Fogs are a more variable feature, their prevalence differing in different years. As a rule, it is not more foggy than at other seashore resorts.

The average temperature of the water for the summer of 1894 was 72° F. At the bathing beach it is somewhat higher. The cause of this high temperature of the water is a much-discussed question. It is believed by some to be due to the proximity of the gulf stream, but this theory is not borne out by fact. Any one interested in the matter is referred to Dr. Peterman's charts.

The water supply of the town is derived from a large fresh-water pond. It is between two and three miles from the town, and is in an isolated position so far as dwelling-houses are concerned, the house of the engineer being the only human habitation within the watershed. It would be difficult to conceive of its ever sustaining dangerous pollution.

The sewerage of the town has been greatly improved in recent years by the construction of a sewer to the deep waters of the outer harbor.

The average velocity of the wind for the three months of the summer of 1894 was nine miles.

From its isolated position Nantucket is particularly free from contagious diseases. In the ten years, 1890–1900, there have been forty-four deaths from tuberculosis, or eleven per ten thousand; and fourteen deaths from diphtheria, or about four per ten thousand. In 1901 one case of typhoid fever was reported. It was, however, an exceedingly doubtful case, and did not give the Widal reaction. Contagious diseases, when present, are for the most part imported, and are generally so managed as to reduce to a minimum their further dissemination. This is the more readily accomplished because of the intelligent and energetic cooperation of the Board of Health.

The amusements afforded the summer visitors are unusually varied. Boating is excellent. Large catrig boats, under the charge of experienced skippers, are provided in abundance. Those preferring still water may sail in the landlocked waters of the inner harbor, eight miles in extent. More accomplished sailors can pursue their excursions upon the rough waters of the Sound. A daily trip by sailboat and by launch is made to Wauminet, about seven miles up the inner

harbor. Still water for rowing is always found in the inner harbor, and excellent light boats may be hired by the hour. It is particularly safe for women and children because of the shallowness of the water. The fishing is excellent; blue fish abound in the season; scup and plaice fish (the latter a large species of flat fish) are found in great abundance, as is also the English turbot. Lobsters, clams, quohogs, and oysters are also abundant. Pickerel and fresh-water perch are found in the ponds. There is some shooting. Marsh birds are present throughout the summer, plover and snipe are frequently killed during their respective flights, and black duck and rabbits are numerous. Driving is very agreeable; the moors are for the most part unfenced and level, and it is the custom to ride and drive across them in any and every direction. Bicycling is also excellent. The State road is a perfect piece of macadam; the clay roads are fair, and there are several agreeable bicycle paths. Golf is the principal amusement. The course is particularly fine, and in many respects an exact counterpart of the Scotch links. It consists of eighteen holes, is about six thousand yards in extent, and extends over gently undulating ground, in which neither a tree nor a stone interferes with the pastime. The turf is excellent, and fine views of the sea are to be had from many of the tees and greens. Afternoon teas and tournaments are held every week during the season.

From twenty years of summer practice on the island the writer feels able to recommend the climate as especially suited for the extremes of life, the very old and the very young; the smallness of the diurnal range being a most important factor. The absence of contagious diseases also renders it a highly desirable locality for children. It is well suited to those suffering from functional nervous affections, neurasthenia, insomnia, and neuralgia; for valvular diseases of the heart, for convalescence from diseases of the respiratory organs, for chronic dysentery and diarrhea, and especially is it specific for the enterocolitis of children. Cases of tuberculosis and of the scrofulous diseases of children also do exceedingly well at Nantucket.

Nantucket possesses an excellent public library; a museum, containing many objects of interest; the valuable and interesting collection of the Historical Society; an old mill; several light-houses and life-saving stations; churches of nearly every denomination; gas and electric plants. There is an excellent hot salt-water bathing establishment.

There are several hotels and also a large number of excellent boarding-houses and private cottages.

Martha's Vineyard.—Twenty miles west of Nantucket and ten miles south from Wood's Hole lies the island of Martha's Vineyard, an island considerably larger than Nantucket and similar to it in climate, its chief differences consisting in its nearer approximation to the mainland and in the fact that it is comparatively thickly wooded.

At the easterly end of the island Edgartown is situated, a small and very picturesque town with a resident population of about eight hundred persons, and a summer population much in excess of these figures. Bathing, fishing, sailing, and driving are excellent, and there are well-arranged golf links.

Nearer the center of the island and on the northerly shore is the town of Cottage City, probably the most populous summer resort of the cape district. The resident population is about the same as that of Edgartown, but the summer population is estimated as being about twenty thousand.

Vineyard Haven, situated on the north side of the island, lies about a mile to the west of Cottage City, and is an exceedingly popular summer resort. The resident population is about one thousand; the summer population is largely in excess of these figures.

West Chop is a small summer colony northwest of Vineyard Haven. The hotel, casino, and the major portion of the land are owned by a syndicate of Boston men. The bathing and boating are excellent and the views are particularly attractive.

Similar in climate and in the configuration of land are the summer resorts situated upon the southern border of Cape Cod. Among these resorts may be mentioned Wood's Hole, Falmouth, Cotuitport, Osterville, Hyannis, Yarmouth, Harwichport, and Chatham.

Harold Williams.

Napa Soda Springs.—Napa County, California.

Post-office.—Napa Soda Springs. Hotel and cottages.

Access.—Via the Northwestern Pacific, Southern Pacific and San Francisco and Napa Valley Electric Railroads and Monticello Steamship Company. There is automobile service between Napa and the Springs.

The resort is fifty miles from San Francisco, and is charmingly located on the southwestern slope of the Coast Range, at an elevation of about 1,000 feet above the level of the sea. From the Rotunda Hotel many beautiful views are spread before the eye in all directions. Looking southward over the picturesque valley of Napa County one sees a landscape seldom surpassed for loveliness, and which always remains fresh in the memory. The climate is warm, dry, and salubrious, uniting the advantages of mountain air with breezes direct from the sea. The mineral springs here are among the most noted in the State. They number twenty-seven in all, with an average daily flow of about 4,000 gallons. The temperature of the water ranges from 65° to 68° F. The Pagoda spring is an alkaline-chalybeate water, strongly charged with carbonic anhydride. It is delightfully clear and sparkling, and has an agreeably pungent taste. Following is Dr. Winslow Anderson's analysis:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	7.14
Sodium bicarbonate	12.95
Sodium carbonate	1.10
Sodium sulphate	1.62
Potassium bicarbonate	Trace.
Magnesium bicarbonate	3.04
Magnesium carbonate	21.76
Calcium bicarbonate	0.78
Calcium carbonate	9.55
Ferrous carbonate	7.90
Silica	0.74
Alumina	0.57
Organic matter	Trace.
Total solids	67.15

Free carbonic acid gas, 143.62 cubic inches. Temperature of water, 67.7° F.

Over this spring is a beautiful pagoda, supported by solid stone pillars, and, resting upon a tessellated marble floor, a natural stone basin has been artistically arranged, through which sparkling soda bubbles in all its freshness. There are many other important springs at Napa, including the well-known Iron Spring and the Lemon Spring. The former has been analyzed by Professor Lanzweert, with the following result:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	5.20
Sodium bicarbonate	13.12
Sodium sulphate	1.84
Magnesium carbonate	26.12
Calcium carbonate	10.83
Ferrous subcarbonate	7.84
Silicious acid	0.62
Alumina	0.60
Total solids	66.17

Free carbonic acid gas, undetermined. Temperature, 68° F.

The waters of all the springs have the same general characters—alkaline-chalybeate, clear, and sparkling. Napa soda water is highly esteemed as a beverage. It is sold in every city and town of the coast, and is one of the pleasantest summer drinks to be found. The water is an efficient aid to digestion, being antacid and tonic. When taken early in the morning before breakfast its action is gently aperient. The ferruginous salts, held in solution by the carbonic-acid gas, are valuable in anemia and chlorotic conditions, malarial toxemia, and many disorders requiring iron for the constructive metamorphosis of red corpuscles. The water is highly recommended for disorders of stomach, liver, and kidneys. It is bottled and shipped to various markets. The grounds at Napa Soda Springs cover over a thousand acres of hill and valley. The place is thoroughly improved, and the visitor will find every arrangement provided for his comfort and recreation while sojourning there. Numerous trails lead to ideal spots—Dripping Rock, Fern Glade, and many others. Among the attractive features should be mentioned the excellent bathing facilities, both tub and plunge. There is also a swimming tank measuring seventy-five by forty feet with running water varying in depth from four to ten feet.

Emma E. Walker.

Naphthalenum.—Under the title *Naphthalenum*, Naphthalene, the United States Pharmacopœia makes official the hydrocarbon *naphthalene* ($C_{10}H_8$). Naphthalene, like benzene, is the fundamental member of a series of aromatic compounds; it is a common constituent of tars, and is obtained from coal-tar by fractional distillation. Naphthalene, when purified, presents itself in large, colorless, crystalline, rhombic plates of a pearly luster and an unctuous feel. It has a burning taste and a faint peculiar odor. It is insoluble in water, but dissolves in alcohol, ether, benzene, oil of turpentine, glacial acetic acid, and warm oils, both fixed and volatile. It melts at 80° C. (176° F.) and boils at 218° C. (424.4° F.), but yet sublimes at a much lower temperature than that of its boiling-point, and, mixed with boiling water, rises in vapor with the steam. Even at ordinary temperatures a gradual sublimation occurs. It should be kept in well-stoppered bottles.

Naphthalene is, locally, but slightly irritant, and constitutionally is not ordinarily poisonous—probably because of incomplete absorption due to its insolubility in aqueous fluids. Yet naphthalene is decidedly "antiseptic" in the common medical sense of the word. Taken internally, some absorption certainly occurs, since naphthalene swallowed, reappears in the urine. Naphthalene has been used in medicine to prevent decomposition of the urine in cystitis, by administration, by the mouth, of an aggregate of five grains daily; but its main use internally has been for local antiseptic purposes in the intestinal canal, as in diarrhea and dysentery, and as a vermifuge. It has been vaunted also as an expectorant in bronchitis and as a constitutional remedy in typhoid fever. The pharmacopœial dose is two grains (0.125 gm.), but this dose is frequently exceeded and, because of the disagreeable taste, the medicine is best given in capsule, cachet, or pill. A case of poisoning—an exceptional circumstance—has been reported from the taking of a dose of eight grains; and it is certainly risky to give much of the drug if there be any kidney disease or weakness. It is less toxic than benzene, and is said to decrease nitrogen metabolism. As an anthelmintic for the "seat-worm," naphthalene may be given by enema, in sweet oil (1 gm. in two or three tablespoonfuls of the oil). For ordinary internal uses naphthalene has been largely supplanted by naphthol.

Externally, naphthalene has been used for the making of antiseptic dressings in surgery. In this application naphthalene combines the features of a fair degree of efficiency on the one hand, and freedom from irritant or poisonous effects, and from offensive smell, on the other. The only untoward effects charged against naphthalene so far have been that the sharp points of the crystals may wound tender granulations, and that the powder may cake with fluid exudates, and so tend to obstruct the free drainage of discharges. Naphthalene may be applied in bulk, in fine powder, to wound surfaces, or by means of gauze or wool charged with the substance, by the device of steeping the dressing in a strong solution of naphthalene, and then permitting the solvent to evaporate. By this means a porous material becomes thoroughly impregnated with a fine powder of the hydrocarbon. A common solution for the making of such dressings is a twelve-and-a-half-per-cent. solution of naphthalene in a mixture of alcohol and ether in equal proportion. A common, household, use of naphthalene, is in the form of balls or tablets, to keep moths away from clothing.

Edward Curtis.
R. J. E. Scott.

Naphtol.—See *Betanaphthol.*

Naphtol aristol.—See *Diiodo-betanaphthol.*

Naphtol benzoated.—See *Betanaphthol Benzoate.*

Narceine.—See *Opium.*

Narcophine is a recent synthetic product, and is stated to be a double salt, consisting of the meconate of morphine and of narcotine. It is said to be a substitute for opium and to be preferable to morphine in that no nausea is produced by the use of narcophine. The chief mention of this preparation has been in connection with its use as an anesthetic in obstetrical practice, but its introduction is too recent to warrant any definite opinion as to its value. Narcophine is said to contain about thirty per cent. of morphine.

R. J. E. Scott.

Narcotine ($C_{22}H_{23}NO_7$).—Narcotine is, next to morphine, the most abundant alkaloid of opium, varying widely in percentage, both in different varieties and in different lots of the same variety. The amount has been reported as low as one per cent. and as high as ten per cent. It occurs in colorless, shining, acicular or prismatic crystals, melting at 176° C. (349° F.), almost insoluble in water, soluble at 15° C. in 100 parts of alcohol, 35 parts of ether, 2.7 parts of chloroform, 22 parts of benzene, and rather freely in hot acetic acid, by which it is usually extracted. It is only faintly basic and its salts are not crystalline. It is not bitter, but its salts are so, and are at the same time acid. Sulphuric acid turns it, after a time, to a yellow, changing to orange and red; the same, mixed with nitric acid, turns it blood red. It is decomposable into meconin and *cotarnine* ($C_{12}H_{13}NO_3$), the latter far more strongly basic than narcotine itself. Various other substances are obtained from it by different methods of treatment, but they are not of importance except from a chemical standpoint.

Crawford and Dohme (Proc. Amer. Phar. Assn., 1902) report experiments on warm-blooded animals, showing that it produces a fall in blood pressure and slowing of the heart, accelerated but weakened respiration, diminished saliva by small doses, increased by large doses, an anodyne effect upon the intestine, prompt and marked diminution of the urine, and a diminished size of the kidney. Partial elimination through the kidneys and stomach was observed, but none from the bowels, at least not as narcotine. Similar symptoms have been observed in man, together with profuse diaphoresis. The alkaloid, if pure, is in no sense a narcotic, for which reason the name "anar-

cotine" has been proposed for it, though it does not seem wise to introduce this element of confusion.

Therapeutically, narcotine is an antiperiodic, recognized as of considerable value in five-grain doses. Fortunately, since it is used in such large doses, its weakly basic character renders it easily freed from the associated active alkaloids, a character to which careful attention should of course be given. It is a valuable stomachic and digestive tonic in one- or two-grain doses three times daily.

Narcotine has been considerably employed as a secret remedy for the cure of the alcohol and other narcotic habits. Ebert reports many such cases cured or benefited through its use, and his results are confirmed by Schulte. The form of administration in these cases was a grain hourly. No harm resulted from the use of a gram or more per day, beyond the temporary loss of the appetite for food, followed later by an increase of appetite, and by weakening, amounting in some cases to semi-prostration, from the profuse perspiration. HENRY H. RUSBY.

Nasal Cavities: Anatomy and Physiology of the.—I. ANATOMY.—The nose forms the commencement of the air tract, and is composed of two large air channels in the center of the face. The lower portion of this tract is used to convey air; the upper portion has distributed throughout its mucous membrane the terminal filaments of the olfactory nerve; while the whole cavity is employed in voice production.

The nose is divided into the external nose and the nasal cavities. The nasal cavities are separated from one another by a thin partition of bone and cartilage, called the septum. Each nasal cavity is surrounded by a set of accessory cavities, all of which communicate with the nasal cavity. In considering the anatomy of the nose, we find that three divisions may readily be made: (1) The external nose; (2) the nasal cavities; (3) the accessory cavities of the nose.

The External Nose.—The external nose forms the pyramidal projection in the center of the face, extending from the brow to the upper lip. It is directed downward and forward. It is composed of bone, cartilage, and muscles, which are covered externally with the facial epidermis and internally with the nasal mucous membrane.

The apex of the pyramid—the root of the nose, the radix nasi—joins the forehead; the lateral walls form by their junction the dorsum nasi, or back of the nose, which extends from the tip, the apex nasi, to the root of the nose; the lateral borders slope outward to form two wing-like leaflets, which are known as the alæ nasi, or wings of the nose; the free edges of the alæ nasi form the outer borders of the two nasal orifices, known as the anterior nares, which are separated by a median pillar, or columna, the ponticulus nasi. The two anterior nasal orifices open downward and communicate with the vestibule of the nose, which is composed of that portion of the nose which is contained within the cartilaginous framework, and which extends from the anterior nasal orifice to the commencement of the osseous framework.

The walls of the nose proper are composed of the nasal bones, the nasal spine of the frontal bone, the nasal processes of the superior maxilla, the premaxillary portion of the upper maxilla, and the lateral cartilages of the nose. The nasal bone articulates above with the frontal bone; its outer border articulates with the nasal process of the maxilla; while along their inner border, by their union, the nasal bones form a crest for articulation with the nasal spine of the frontal bone, the perpendicular plate of the ethmoid and the triangular cartilage of the nose. The outer surface of this bone is smooth; its inner surface presents a longitudinal groove for the nasal nerve. Lying external to the nasal bone is the nasal process of the maxilla, which articulates along its anterior border with the nasal bone, above with the frontal, and posteriorly with the lacrymal bone. Its external surface is smooth, while its inner surface presents two crests for the attachment of the middle and inferior turbinate bones. The pars premaxillaris of the superior maxilla unites with its fellow below to form the lower rounded portion of the apertura pyriformis, the pear-shaped opening of the osseous nasal cavity. To the apertura pyriformis is attached the lateral cartilage of the nose, thus completing the outer portion of the external nose.

The cartilages of the nose are the septal cartilage; the triangular, or superior lateral cartilages; the alar, or inferior lateral cartilages; the accessory, or sesamoid, cartilages; and the accessory quadrate cartilages. The cartilage of the septum is the most anterior structure of the septum, and is irregularly quadrilateral in form. Its anterior inferior border is unattached, except through loose connection tissue with the columna, which latter is placed anterior to the triangular cartilage and forms the inner border of the

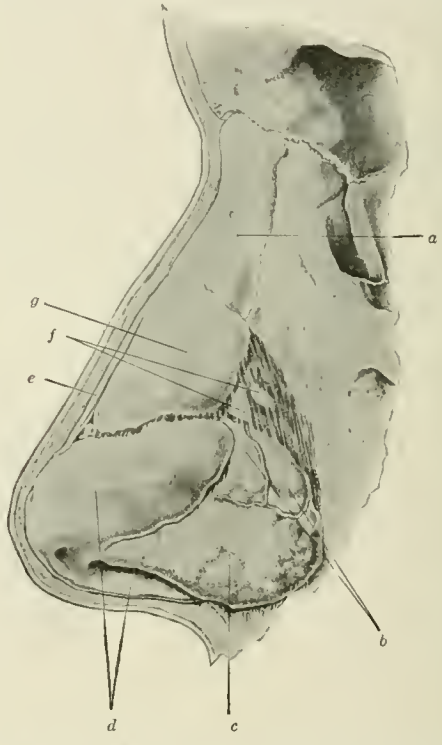

FIG. 4049.—Dissection of the External Nose, Demonstrating the Cartilages and Bones of this Part of the Nose and their Relations to One Another. *a*, Nasal bone; *b*, sesamoid cartilages; *c*, fibrous tissue of ala of nose; *d*, inferior lateral cartilage; *e*, cartilage of nasal septum; *f*, accessory quadrate cartilages; *g*, superior lateral cartilage.

anterior nasal orifice. This border is anchored below to the anterior nasal spine which it embraces. The anterior superior border is attached above to the crest on the undersurface of the nasal bones, next it is continuous with the internal border of the superior lateral cartilages, and below it is received between the internal plates of the lower lateral cartilages. Its posterior superior border is in contact with the perpendicular plate of the ethmoid, and the posterior inferior border is received within a groove formed in the anterior nasal spine of the superior maxilla and the vomer for its reception. The posterior inferior border is frequently found dislocated from the groove which is formed for its reception in the vomer and it

will be found then laterally either to the right or left of the vomeran border. The cartilaginous septum is thinnest in the vestibule of the nose, and increases gradually in thickness as it approaches its attachment to vomer and ethmoid.

The superior lateral cartilage is flat and triangular in shape, partially continuous with the anterior border of the septal cartilage, of which it forms flange-like extensions. It is closely attached along its superior and posterior border to the nasal bone and the nasal process of the superior maxillary bone. Its inferior border is attached to, and partially covered by, the inferior lateral cartilage. The inferior lateral cartilage is bent sharply around in front of the anterior nares so as to form an inner and outer plate. The outer plate lies in the plane of the superior cartilage of the nose, and makes up a part of the outer surface of the nose, while the inner plate lies in contact with the corresponding fellow of the opposite side and forms a portion of the inner border of the anterior nares. The lower lateral cartilages come in contact over the dorsum, but extend only about half-way back to the maxillæ, so that the intervening space in tho alæ nasi not filled with cartilage is made of dense fibrous tissue.

The accessory cartilages are four in number in each lateral wall of the nose. Two of these cartilages are situated in the fibrous tissue which fills in the space between the posterior border of the lower lateral cartilage and the nasal process of the maxilla. Situated immediately above these are two others which are known as the accessory quadrate cartilages. The nose is supplied with certain external muscles which are concerned with the movements of the alæ nasi and with facial expression. These muscles are the pyramidalis nasi, compressor naris, levator labii superioris alæque nasi and depressor alæ nasi. The vessels which supply the external nose are branches of the facial and ophthalmic arteries. The veins empty into the angular vein. The lymphatics empty into the submaxillary lymphatic glands. The muscles of the nose are supplied by branches of the facial, and the general sensation by branches of the first and second divisions of the fifth nerve.

The Nasal Cavities.—The nasal osseous cavities are two large quadrangular-shaped cavities in the center of the face, which extend from the base of the skull above, to the hard palate below, and from the vestibule of the nose anteriorily to the posterior nares posteriorily. They are separated from one another by the osseous septum narium.

Each nasal cavity has a floor which is almost horizontal; a roof which is horizontal in its middle portion, but inclined downward and forward in its anterior portion, and downward and backward in its posterior portion; an inner wall which is vertically directed; and an outward wall which is directed downward and slightly outward. The inner wall, or septum, is partly cartilaginous and partly osseous. The osseous septum is formed by the crest at the juncture of the nasal bones, the nasal spine of the frontal bone, the perpendicular plate of the ethmoid, the vomer, the crest of the sphenoid bone, and the crest situated at the juncture of the two palatal processes of the superior maxillæ and the two horizontal plates of the palate bones.

The vomer is the only independent bone entering into the formation of the nasal septum. It is irregularly quadrilateral in form. It is from one-half to slightly over a millimeter in thickness, contrasting quite strongly with the perpendicular plate of the ethmoid, which is a thin leaflet-like process of bone, of about the thickness of a finger nail. Its lower border articulates with the nasal crest of the superior maxillæ and the palate bones. Its superior border is attached to the rostrum of the sphenoid bone by two wing-like expansions, or alæ. The posterior border is concave and lies free between the posterior nasal orifices. Its anterior border is the longest, the upper portion of which articulates with the vertical plate of the ethmoid, while to the lower portion is attached the cartilage of the septum. Running downward and forward nearly at its middle is a shallow groove for the nasopalatine nerve. The vertical plate of the ethmoid is a thin fragile process of bone which projects vertically downward from the center of the undersur-

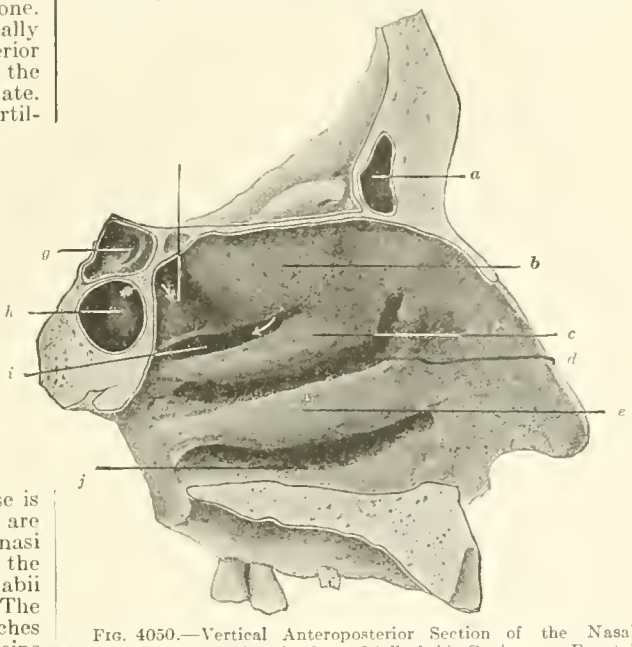

FIG. 4050.—Vertical Anteroposterior Section of the Nasal Cavity, Demonstrating the Outer Wall of this Cavity. *a*, Frontal sinus; *b*, superior turbinate; *c*, middle turbinate; *d*, middle meatus; *e*, inferior turbinate; *f*, sphenoethmoidal recess; *g*, right sphenoid sinus; *h*, left sphenoid sinus; *i*, superior meatus; *j*, inferior meatus.

face of the cribriform plate of the ethmoid bone. The vertical plate of the ethmoid is pentagonal, and its short anterior border articulates with the nasal spine of the frontal bone and the crest of the nasal bones. Its superior border is continuous with the cribriform plate of the ethmoid, and its posterior border with the crest of the sphenoid. The anterior inferior border gives attachment to the cartilage of the septum, and its posterior inferior border articulates with the vomer. The septum is covered with mucous membrane, which is continuous with that which lines the whole of the nasal chambers.

The roof of the nasal cavity is divided into nasofrontal, ethmoidal, and sphenoidal parts. The nasofrontal portion is directed downward and backward, and is composed of that portion of the roof which is formed by the nasal bone. The ethmoidal portion is horizontally directed, and is formed by the cribriform plate of the ethmoid. It is lined with two rows of foramina for the passages of the median and lateral branches of the olfactory nerve. The most anterior foramina give passage to the nasal nerve. The sphenoidal portion looks downward and forward, and is formed by the body of the sphenoid bone. The opening of the sphenoidal sinus is to be seen on the anterior vertical surface of the body of the sphenoid.

The floor of the nose is flattened from before backward, concave from side to side, and wider in the middle than at either extremity. It has a slight inclination downward and backward. It is formed in front by the pars incisiva of the superior maxilla and its palatine process, and behind by the palatine process (horizontal plate) of the palate bone. It presents,

just behind the nasal spine, the upper orifice of the anterior palatine canal. In the region of the anterior palatine canal, the mucous membrane presents a small diverticulum, which is the rudimentary Jacobson's organ. This organ is more highly developed in some of the lower animals, and is an organ of the sense of smell.

The outer wall is the most complicated and interesting portion of the nasal cavity. It is formed, in front, by the nasal process of the superior maxilla and the lacrymal bone; in the middle, by the lateral mass of the ethmoid, the body of the superior maxilla and the inferior turbinated bone; and posteriorly by the perpendicular plate of the palate bone and the pterygoid process of the sphenoid. The lateral mass of the ethmoid bone, which forms a portion of the outer wall of the nasal cavity, and contains the ethmoid cells, reaches from the roof of the nasal chamber, where it articulates with the frontal bone, to the level of the floor of the orbit, where it articulates with the orbital plate of the superior maxilla and the palate bone. Anteriorly, it articulates with the lacrymal bone and the nasal process of the superior maxilla; posteriorly, with the rough surface on the side of the body of the sphenoid bone. These various articulating surfaces serve to complete the ethmoid cells; and the participating bones frequently contain accessory cells. From the anterior end of the medial plate of the lateral mass proceeds a curved process, known as the processus uncinatus, which serves to complete the orifice of the maxillary sinus, and forms the lower boundary of the hiatus semilunaris. This process is a narrow bony plate, which curves downward and backward, almost parallel with the lower border of the middle turbinate bone. It articulates with the superior maxillary, and the inferior turbinate bone, and, through this union, aids in closing the orifice of the maxillary sinus.

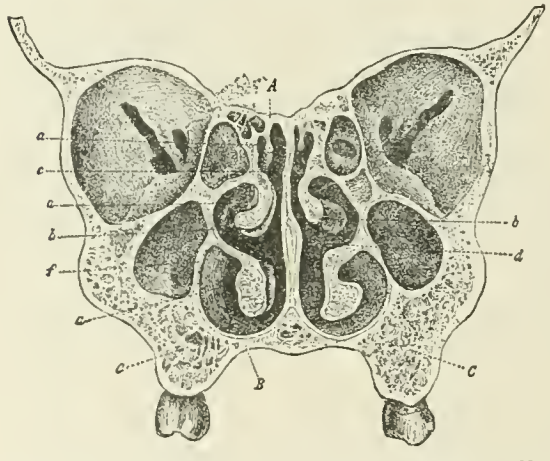

Fig. 4051.—Vertical Transverse Section through the Nasa Fossæ, somewhat Behind their Center. (Zuckerkandl.) *A* Roof of nasal cavity; *B*, floor of nasal cavity; *C*, *C*, alveolar processes; *D*, external wall of nasal cavity; *a*, *a*, *a*, three meatuses; *b*, *b*, middle turbinated bodies; *c*, olfactory slit; *d*, respiratory region.

Encroaching upon the lumen of the nasal cavity are three scroll-like shells of bone, which are known as the turbinate bones. These bones are scroll-like in form, each larger than the other from above downward; their convex surfaces look upward and inward, with a more or less irregular free border. The superior and middle turbinate bones are projections from the lateral mass of the ethmoid; the inferior is an independent bone.

The superior turbinate bone forms a distinct ridge posteriorly but merges into the middle turbinate anteriorly. The middle turbinate is a broad, thin, bony plate, scroll-like in outline, curling down upon itself, and has at its anterior inferior surface a slight projection, which is known as the agger nasi. The inferior turbinate articulates anteriorly with the inferior turbinate crest of the superior maxilla, behind this by the lacrymal process with the lacrymal bone, and posteriorly it articulates with the ethmoid and

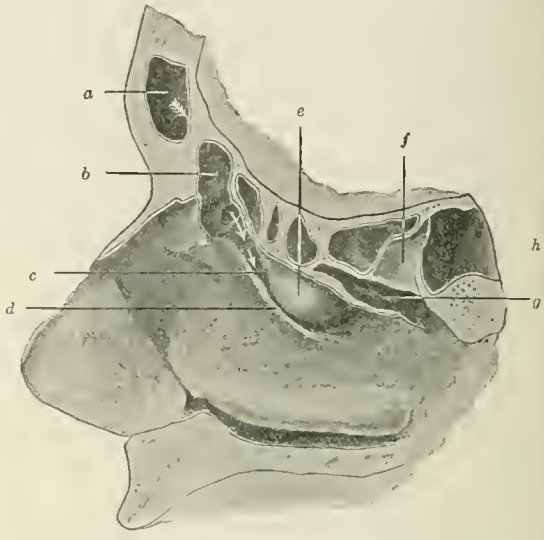

Fig. 4052.—Outer Wall of the Right Nasal Cavity. The superior and middle turbinates have been removed, thus demonstrating the hiatus semilunaris, the bulla ethmoidalis (*e*), the frontal (*a*), the ethmoidal (*b*) and the sphenoidal (*h*) sinuses, the infundibulum (*c*), and the openings of the frontal and anterior ethmoidal cells into the nasal cavity (indicated by white arrow heads). The processus uncinatus is shown at *d*, and the sphenoethmoidal recess at *f*.

the lower crest of the palate bone. Through its maxillary process it aids in closing the lower part of the opening to the antrum. The body of the inferior turbinate curls downward and outward. These three bones, through their situation and outline, necessarily divide the nasal chambers into three anterior posterior incomplete canals, which are designated as the three meatuses of the nasal cavity. The inferior meatus lies between the under surface of the inferior turbinate and the floor of the nose. Slightly in front of the center of that portion of this meatus which is covered by the inferior turbinate bone is the inferior or nasal orifice of the lacrymal canal.

The middle meatus presents many points of great interest to the rhinologist. This meatus lies between the concave undersurface of the middle turbinate bone and the convex upper surface of the inferior turbinate bone; and it extends anteriorly from the vestibule of the nose, into which it opens widely, through the communication which is known as the atrium of the middle meatus, to the anterior fold of the Eustachian tube posteriorly. It is truncated in form, with its widest portion directed anteriorly. The outer wall of the middle meatus presents a deep groove, or semilunar sulcus, known as the hiatus semilunaris. This groove extends from the lower border of the infundibulum, at the anterior extremity of the middle turbinate, to just below its center. The average length of the hiatus is from fifteen to twenty millimeters. The upper boundary of the hiatus semilunaris is created by a bulbous expansion of ethmoid cells, which is designated as the bulla ethmoidalis. This groove is crescentic in shape, and varies from a shallow furrow to almost a complete canal; its direction is from above downward and back-

ward, with its concavity directed upward and backward. At its upper extremity we have the orifice of the frontal sinus, while at its posterior shallow portion is the orifice of the maxillary antrum; slightly irregular in their locations, but usually quite near the orifice of the frontal sinus, we find the openings of the anterior ethmoidal cells. Behind the opening to the antrum we occasionally find a second orifice, communicating with the antral cavity, known as the ostium maxillare accessorium. The superior meatus is closed in front and opens downward and backward. This meatus presents the orifices of the posterior ethmoidal cells and the sphenoidal sinus. In reality, the orifice of the sphenoidal sinus is near the roof of the nasal fossa, on a level with the superior turbinate bone, in the recessus sphenoethmoidalis, which is the recess formed by the junction of the ethmoid with the body of the sphenoid.

The Accessory Cavities of the Nose.—Surrounding the nasal chamber are a set of pneumatic cavities which through their location, as well as by their direct communication with the nasal cavity, have an important anatomical, as well as pathological relationship to this organ. These sinuses are called the frontal, ethmoidal, sphenoidal, and antral. The frontal sinus is a small triangular cavity situated between the plates of the frontal bone above the inner angle of the orbit. There are two cavities which are separated, the one from the other, by a thin septum of bone. The dividing septum is usually placed in the mesial plane, although it occasionally shows deflections to one or the other side. This cavity extends from the mesial plate outward a short distance beyond the supraorbital foramina. The frontal sinuses are very irregular as to their size, shape, and uniformity of relationship one with the other. The average vertical measurement is 31.60 millimeters, the average horizontal measurement 18 millimeters, and the average transverse measurement 25.8 millimeters. The shape is usually triangular, but rarely it may be very irregularly pyramidal, through its projecting upward inordinately between the two plates of the frontal, or outward toward the outer angle of the orbit. The cavities are usually of uniform size and outline, on the two sides, although marked variation in this respect is found to exist. There may be only one cavity filling in the space occupied by two, or one larger cavity projecting over toward a second small cavity; in fact, perfectly symmetrical cavities are rare. This cavity is rarely irregularly placed, and more rarely accessory cavities are found. Inspection of the interior of the cavity shows rarely imperfect partitions, which form recesses, giving the interior an irregular outline. It has an anterior wall formed by the outer plate of the frontal bone, a posterior wall formed by the inner table of this bone, an inner wall formed by the mesially placed septum, and the floor which is formed by the orbital plate of the frontal bone. The frontonasal opening, the ostium frontale, lies in relation to the septum of the sinus, and is situated in the lowest part of the floor. This opening terminates in the middle meatus through the nasofrontal canal at the commencement of the hiatus semilunaris.

The ethmoidal cells are contained within the lateral mass of the ethmoid bone, between its orbital plate and its internal or nasal plate. They vary greatly in shape and size, and are divided into an anterior and a posterior group. These sinuses are composed of a number of small cavities separated from one another by thin partitions of bone. These small cellular cavities vary in number from one to eight in each mass, and usually open by a common duct. Those cells which communicate with the middle meatus of the nose, below the line of origin of the middle turbinate bone, are the anterior ethmoidal cells. Those cells which communicate with the superior meatus, above the origin of the middle turbinate, are the posterior ethmoidal cells. The space occupied by each collection of cells in the lateral mass is not uniformly constant, nor is there any regularity in the number of cells in each collection. The anterior cells may extend far backward, almost to the sphenoid; while the posterior group may extend as far forward in another specimen. The plate of bone separating the two groups of cells is placed diagonally between the outer and inner walls of the lateral mass; and does not normally present any communication of the one group with the other. The ethmoid cells are bounded externally by the os planum, the lamina papyracea, and internally by the two ethmoturbinates. The superior wall of the cells is completed by the depressions or foveæ on the ethmoidal edge of the orbital plate of the frontal bone. Inferiorly they are completed by the ethmoidal edge of the orbital plate of the superior maxilla. Anteriorly they are closed in by the nasal process of the superior maxilla and the lacrymal bone. Posteriorly they articulate with the sphenoidal spongy bone.

The maxillary sinus, or antrum of Highmore, is a pyramidal-shaped cavity, situated wholly within the body of the superior maxilla. Its roof is a thin plate of bone which also forms the floor of the orbital cavity. The infraorbital canal, which serves to convey the superior maxillary nerve and infraorbital vessels, in their passage to the face, lies in the roof of the cavity. The floor of the sinus is formed by the alveolar border of the superior maxilla. This wall bears an important relation to the teeth. The converging of the facial and nasal walls, at their angle of junction, is frequently so acute as to leave a mere groove to form the floor, which is then called the sulcus alveolaris. The floor of the antrum is usually on a level with the floor of the nasal cavity. The layer of spongy bone between the floor of the antrum and the root of the teeth varies greatly. Occasionally this layer is so thin that a mere shell of bone separates the teeth from the antral cavity. Ofttimes slight elevations are seen, in the floor corresponding to the root of the teeth. When of average dimensions, the floor has in relation to it the second bicuspid and the three molar teeth. The posterior wall is the thin plate of bone which forms the anterior boundary of the zygomatic fossa. The inner or nasal wall of the antrum, as it forms the outer wall of the nasal chamber, is the most interesting aspect of this sinus. That portion of the inner wall which is situated below the inferior turbinate bone is continuously osseous, thinnest immediately below the attachment of the turbinate bone, and forms the outer boundary of the inferior meatus of the nose. In the thin portion of this wall, immediately below the attachment of the inferior turbinate, is the point of selection for exploratory puncture. That portion of this wall which is situa ed above the inferior turbinate is partly osseous and partly membranous. The aperture, the ostium maxillare, by which this cavity communicates with the middle meatus, is situated here. As the ostium maxillare lies just beneath the level of the roof of the antral cavity, it permits of only imperfect drainage when affected with pathological changes. Sometimes an additional opening exists in the membranous portion of the nasal wall, designated as the ostium maxillare accessorium. This accessory opening is said to exist in about ten per cent. of cases. The accessory opening communicates with the middle meatus at a plane lower than and posterior to that of the ostium maxillare, and this accounts for the occasional draining away of fluids from the antrum posteriorly into the pharynx. The anterior or facial wall is thin; at its upper margin is the infraorbital foramen. In front this surface is marked by the canine ridge, which corresponds to the socket of the canine tooth. The facial wall is limited externally by the malar ridge. Between these two prominent ridges, the canine and malar, is a

depression, the canine fossa. The canine fossa varies greatly in depth. It is at this point that the external or facial opening is made into the antral cavity. The antral cavity varies also in shape and size, and occasionally septa divide the cavity more or less completely by vertical or horizontally placed lamellæ of bone. The average dimensions are as follows: Vertical height, 3.5 centimeters; the transverse breadth, 2.5 centimeters; and the anteroposterior depth, 3.2 centimeters.

The sphenoidal sinus, on account of its intimate relationship with the cranial, orbital, and nasal cavities forms one of the most interesting of the accessory sinuses. They are two in number and occupy the anterior portion of the body of the sphenoid bone; a vertical mesial plate of bone forms the division wall between the two cavities. Each cavity presents six walls: a roof, floor, an anterior, a posterior, an external, and an internal wall. The roof is formed by the root of the lesser wings of the sphenoid bone, the olivary process, and the sella turcica. This wall is in intimate contiguity with important cranial structures. The plate of bone which forms the roof of the sinus is extremely thin. At the junction of the external wall with the roof of the sinus, the optic nerve and the ophthalmic artery pass forward to the orbital cavity. The floor of the sphenoidal sinus forms the posterior part of the roof of the nasal chamber. The anterior wall is in the vertical plane, although at its lower border it inclines slightly downward and backward to join the floor. This wall is extremely thin, and contains the orifice of communication with the nasal cavity. This wall may be divided into an internal portion, which presents the orifice of the ostium sphenoidale (which opens into the sphenoethmoidal recess), and the outer portion which articulates with the posterior extremity of the lateral mass of the ethmoid, thereby completing the posterior ethmoidal cells. The posterior wall is formed of the posterior portion of the sphenoidal body. The external lateral wall of the sinus varies in thickness, and is in important relationship to neighboring structures. Besides the optic, the following nerves are found in relation with the external wall, abducens, oculomotor, trochlear, ophthalmic, and maxillary. On its cranial aspect, it is in relation to the groove for the internal carotid artery and cavernous sinus. At its anterior aspect it forms the internal boundary of the sphenoidal fissure and the inner wall of the orbit. The internal wall, or septum, is a thin vertical plate of bone which is usually situated in the mesial plane, separates completely one cavity from the other, and rarely is defective. The septum may be irregularly placed, or wanting, thus giving rise to great irregularity in the shape and size of the sphenoidal cavities. These vary in size, shape, and relation to each other. Occasionally accessory cavities are found in the wings of the sphenoid. The average dimensions are as follows: Vertical height, 20 millimeters; anteroposterior depth, 21 millimeters; transverse breadth, 18 millimeters. All of these sinuses are lined with a mucoperiosteal covering, which is continuous with the mucous membrane of the nasal cavity. The surface of the mucosa is lined with columnar ciliated epithelium.

The Mucous Membrane of the Nose.—The mucous membrane lining the nasal cavities is continuous with that of the pharynx, and extends into the pharyngeal orifice of the Eustachian tube and the accessory sinus.

Anteriorly the integument of the face supplied with hair and sebaceous glands enters the nostrils and extends to the inner extremity of the alar cartilage. At the junction of the superior lateral cartilage and the alar cartilage, the limen nasi, there is a narrow zone where the integument presents the characteristics of mucous membrane, and is lined with pavement epithelium and supplied with muciparous glands. From this point the transition is rapid into the characteristic mucosa of the nasal chamber. The anterior portion of the inferior turbinate, as well as the opposite portion of the septal cartilage, may have a mucosa lined with pavement epithelium, or with the columnar ciliated variety. The portion of the nasal tract, known as the olfactory region, is lined with columnar non-ciliated epithelium. This area extends from the roof as low down as the middle turbinate and the upper third of the septum. The remaining portion of the nasal cavities, the respiratory tract, is supplied with a columnar ciliated epithelium. These cells are long and spindle-shaped; and interspersed numerously among these cells are the so-called goblet or chalice cells. The thickness of the epithelial layer is from 30 to 70 μ. The cilia wave toward the postnasal orifices. The cilia are stated to move in a thin layer of fluid. The nasal mucous membrane is inseparable from the perichondrium, or periosteum. The mucous membrane is very thin in the accessory sinuses, very thick over the turbinals, somewhat thinner over the septum, and very thin again over the floor and the undersurface of the turbinated bodies.

The muciparous glands are of the tubular and racemose variety, and are present in great numbers. These glands do not differ in any essential particulars from similar glands located elsewhere in the mucous membrane, being most abundant at the middle and posterior portions of the nasal cavities, and of greatest size at the lower and posterior part of the septum. Beneath the columnar cells of the mucous membrane, we find a homogeneous basement membrane, and below this there is a connective-tissue layer, which is continuous with the periosteum.

The submucous connective tissue and the epithelial elements contain evidences of lymphoid tissue in the presence of leucocytes, lymphoid collections, and occasional lymph follicles.

In the olfactory region, the mucous membrane has quite a different histological structure from that in the respiratory tract. Here the mucous membrane is very thin, and not so vascular. The epithelium is of the columnar type, but is devoid of cilia, having a branching base and a large nucleus. Lying among them are the olfactory cells of Schultze, which are connected directly with the non-medullated filaments of the olfactory nerve. Beneath the epithelial covering, and opening upon its surface, are numerous branched tubular glands, which secrete a serous fluid. These glands are known as Bowman's.

The gross appearance of the colorization of the mucous membrane in the living subject varies in the different portions of the nasal chambers. In the upper, or olfactory, region the membrane is of a yellowish-pink in color; in the respiratory tract it is a bright red color; at the posterior ends of the turbinates, as viewed through the rhinoscopic mirror it has a pinkish-white appearance; while in the accessory cavities it is of a pale pink.

A most interesting feature of the soft structures of the nasal chambers is the arrangement of the submucous tissue over the middle and inferior turbinates and the lower part of the septum. This important feature is the aggregation of venous sinuses and their large size, forming plexuses of blood-vessels over the turbinate bones. These are designated as the turbinate bodies. This term, the turbinate body, is applied to the bone and the investing soft tissue. The mucous membrane over the turbinates is divided into two layers, the adenoid layer with its epithelial covering, and a deep layer forming the periosteum of the turbinate bones. Between these two layers we have a stroma which contains lymph structure. Within this lymph structure we have an abundance of venous channels forming plexuses, which, on account of their rapid dilatation and contraction, under various stimuli, have been designated as erectile tissue, the Schwellkörper of the Germans.

This peculiar action of the venous plexus in the so-called turbinal tissue is not so much due to the arrangement of the veins, and their relation with arterial twigs, as to the characteristic walls, possessed by these vessels, and the arrangement of the muscular fibers and elastic tissue in the surrounding stroma. The muscular layer of these walls is very thick, greater than the walls of the corresponding arteries, and the walls are known to be thrown into irregular folds. The arrangement of the muscular fibers is irregular, although the circular fibers predominate. This arrangement of the vessel walls, as well as the character of surrounding stroma, adapts these walls for the rapid emptying and filling of the venous plexuses. The venous plexuses are more pronounced over the inferior turbinate, especially as to its anterior and posterior extremities; over the middle turbinate, especially along the lower border and posterior extremity; and on the septum, in a line with the middle turbinate, corresponding with the anterior extremity of this turbinate—the tuberculum septi.

The vascular supply to the nasal chambers is obtained from the anterior and posterior ethmoidal arteries, branches of the ophthalmic; from the sphenomaxillary and the alveolar arteries, branches of the internal maxillary artery; and from the artery of the septum, which is derived from the facial artery. The sphenopalatine artery enters the nasal chambers through the sphenopalatine foramen with the nasopalatine nerve. Its internal branch, the nasopalatine, accompanies the nerves of the same name, passing downward and forward upon the septum (which it supplies) toward the anterior palatine foramen.

The external branches supply the outer wall of the nose, the nasal fossæ, the ethmoid cells, the frontal sinus, and the antrum of Highmore. The antral and posterior ethmoid supply the roof, upper portion of the septum, outer wall of the nasal fossa, the ethmoidal cells, and the frontal sinuses. The alveolar branch of the internal maxillary supplies the lining membrane of the antrum. The artery of the septum is a branch of the superior coronary, a branch of the facial. The septal artery supplies the columnar and the lower part of the septum.

The veins of the nasal cavity form plexuses beneath the mucous membrane, and these in turn are drained by various veins. The veins which perform this function are the veins which accompany the sphenopalatine artery and empty into the pterygoid plexus, those which accompany the ethmoidal artery and empty into the ophthalmic vein, and those which empty into the facial vein; and still other veins convey the return blood through the foramen cecum and the cribriform plate to the superior longitudinal sinus and the intracranial veins.

The lymphatic vessels of the nasal cavity empty into the postpharyngeal, the internal maxillary, the parotid, and the upper deep cervical lymphatic glands. Through the cribriform plate of the ethmoid, the nasal lymphatic vessels communicate with the intracranial lymphatics and the subdural space.

The nerve distributions for the nasal cavity consist partly of nerves of olfaction and partly of nerves of general sensation. The olfactory nerve, the nerve of the special sense of smell, arises by three roots: an external root, commencing in the deep substance of the middle lobe of the cerebrum; a middle root, from the caruncula annularis; and an internal root, from the inner and back part of the anterior lobe of the cerebrum. The three roots unite and run forward as a flat band on the undersurface of the brain until it reaches the cribriform plate of the ethmoid, where it expands into what is known as the olfactory bulb. From the undersurface of the olfactory bulb are given off from fifteen to eighteen filaments, which, piercing the foramina of the cribriform plate, are further subdivided and distributed to the nasal mucous membrane. They can be divided into three groups: an inner group which spreads out over the upper third of the septum, an outer group supplying the superior turbinate and the upper surface of the middle turbinate, and a middle group which is distributed to the roof of the nasal cavity.

General sensation is supplied to the nasal mucosa through the nasal branches of the ophthalmic division of the trigeminus. This nerve enters the nasal cavity through a slit beside the crista galli, and then divides into two branches. The internal of these two branches supplies the mucous membrane of the anterior part of the septum; while the other, the external, descends in a groove on the inner surface of the nasal bone where, at the junction of the nasal bone with the lower lateral cartilage, it passes out of the nasal cavity. This branch, in its passage through the nasal cavity, supplies the mucous membrane of the outer wall as low down as the inferior turbinate body. Branches of the anterior dental nerve are distributed to the mucous membrane of the inferior meatus and the inferior turbinate body. Branches from Meckel's ganglion gain access to the nasal cavity through the sphenopalatine foramen, and, after further subdivision, supply the mucous membrane covering the superior and middle turbinate bodies, the ethmoidal cells, and the upper and posterior part of the septum. The nasopalatine, in its passage forward across the roof, distributes filaments in its course, and descends downward and forward along a groove in the septum to the anterior palatine foramen, where it joins the anterior palatine nerve. The Vidian nerve supplies the upper and posterior part of the septum and the superior turbinate. Branches of the sympathetic are also distributed to the nasal mucous membrane, being derived principally from the sphenopalatine ganglion of the sympathetic.

II. Physiology.—The physiological function of the nose is of a threefold character: (1) In relation to respiration; (2) in connection with olfaction; and (3) in phonation. The respiratory function of the nose is by far the most important physiological duty that this organ performs. It is during the passage of inspired air through the nasal chambers that it is warmed, saturated with moisture, and freed from coarse material therein floating. According to the experiments at Aschenbrandt, which have been confirmed by others, a column of air, in its passage through the nasal chambers, on reaching the pharynx, has had its temperature raised to 86° F., and its degree of humidity raised to the point of almost complete saturation.

This function takes place whatever may be the degree of temperature or humidity of the external atmosphere, and is so complete in its action as to functionate perfectly during sudden and very marked changes in both of the enumerated conditions. This function is performed through the exquisite working of the so-called turbinal tissue. When we consider the constant and excessive changes in its functional activities that are persistently taking place, one cannot but marvel at the wonderful nature of this mechanism.

The second important physiological function of the nose is that of olfaction. The sense of smell is dependent upon the impinging of the odorous particles upon the terminal filaments of the nerve ends in the olfactory apparatus. In order for various substances contained in the atmosphere to be appreciated as having an odor, it is necessary that the air should reach the olfactory region and that the peripheral apparatus should be normal. According to Paulsen, the inspired air passes first directly upward under the dorsum of the nose, and then follows the roof, the greater portion of the column passing through the superior and middle meatus and then

descending downward to the postnasal orifice. Odorous particles reach the nose in various forms. Various theories have been offered to explain the mechanism of olfaction, the most important of which are the mechanical, the vibratory, and the chemical. (For further information in regard to the sense of smell, consult the article on *Olfactory Nerve.*)

The third physiological function of the nose is the part which it plays in connection with phonation. The nasal cavities, in connection with the pharynx and the buccal cavity, constitute that portion of the vocal apparatus by which quality and character are given to the voice. The importance of the nasal organ in that office is well demonstrated by the alteration of the character of the voice when from any cause one or both nasal cavities are obstructed.

CHARLES W. RICHARDSON.

Nasal Cavities, Foreign Bodies in.—See *Air Passages.*

Nasal Cavities, Neoplasms of the.—With the exception of polypi, which are very common, true neoplasms are comparatively rarely seen in the nose. Malignant neoplasms are more frequently met with than the benign, if we except the nasal polypus, which is in reality not a true neoplasm but the product of an inflammatory process. Moritz Schmidt, among 32,997 nose and throat patients seen in ten years, found that twenty-four or one in 1,370, presented some form of true neoplasm, while one in every forty-three patients examined had mucous polypi. Notwithstanding that polypi are not, strictly speaking, new growths in a pathological sense, they are included for the sake of convenience under the heading of Benign Neoplasms.

BENIGN NEOPLASMS.—POLYPI.—Edematous or nasal polypi are by far the most common variety of new growth or tumor seen within the nasal passages, and as stated above, are not strictly speaking in the pathological sense true neoplasms. They are said to occur forty times as frequently as all other forms of tumors seen within the nose. They are rarely met with in children under ten years of age, comparatively seldom under fifteen, most frequently between forty and sixty, and occur in men more often than in women.

In hay fever and bronchial asthma one often finds nasal polypi which used to be considered the cause of the former, at any rate they are frequently associated and even then the history of a neurosis usually precedes the existence of the polypus. In hay fever, according to Wright and Smith, the lymph spaces become distended so that serum escapes from the capillaries of the nasal mucosa and distends the stroma spaces. The attacks occur daily and hourly for a month or more, so that after a year or two the mucosa loses its resiliency due to damage to the contractile elements and the status of polypus is set up. It would seem, too, that occasionally a local vasomotor neurosis existed similar to certain bullous skin eruptions, serum is suddenly exuded under the epithelium of the nasal mucosa forming a bleb, which ruptures when touched by knife or snare and the tumor disappears. Again in accessory sinus suppuration, acute and chronic rhinitis, the vasomotor mechanism is possibly responsible for the serous effusion and the formation of polypi. Polypi, too, frequently arise from a malignant base—sarcomatous or carcinomatous.

They are more often multiple than single, and may occur in one or both nasal passages. Almost invariably their site of origin is from or about the middle or superior meatus, and from the middle or superior turbinal or the ethmoid, or from the orifices of the maxillary, frontal or sphenoidal sinuses, or from within these cavities.

It is very rare, indeed, that they originate from the septum or from the inferior turbinal though they may do so. The writer has seen a case in which the polyp had its origin within the orifice of the Eustachian tube.

Woakes taught many years ago that the presence of nasal polypi was evidence of a necrosing ethmoiditis and a result of this latter.

Polypi are pear shaped, oval, smooth, glistening, grayish, bluish gray, or pinkish in color, semi-solid in consistency, and vibrate with respiratory movements, especially in forcible blowing of the nose. In size they vary from that of a small millet seed to an almond, or may be as large as the thumb. Their size is limited at times only by the capacity of the nasal fossa, and if they extend backward into the nasopharynx, the growth may be as large as a walnut or a small peach, in this location being often rounded rather than pear shaped. They often extend forward to the anterior nares, presenting at the nostril and usually with a deeper pinkish color than those within the cavity. They do not often bleed on touching with the probe, nor are they sensitive, though small blood-vessels and a few nerve fibers may be present on their surfaces. In old-standing cases the nose may be broadened externally through their pressure. As stated before they may be unilateral or bilateral, single or multiple, usually the latter. The writer removed on one occasion, eighty-eight distinct polypi from the nose of an elderly woman.

Pathology.—Polypi are composed of edematous mucous membrane, intermingled with inflammatory products, the surface of sac being covered with epithelium, supplied very scantily with blood-vessels and nerve filaments, the pedicle at times very thin and thread-like, at times quite broad, while again the growth may be sessile. At times a polyp may be distinctly cystic, containing as much as a half ounce of yellowish fluid. There is always more or less nasal obstruction, from a mere stuffiness in the nose to a complete obstruction. Obstruction is greater on damp days, less on dry, because of the ability of polypi to absorb moisture from the air. The voice has a peculiar and quite characteristic nasal twang caused by the obstruction plus the oscillation of the pedunculated growth, and when the nose is completely filled, the voice is dead. There is almost always an impairment or a complete loss of the sense of smell with a corresponding impairment of the sense of taste. There is a good deal of watery or purulent discharge from the nose depending on the accompanying sinusitis. Sneezing with a sensation as of a foreign body is a prominent symptom. Cough and a reflex asthma are very commonly the result of nasal polypi, while many of these patients suffer from hay fever. Dull frontal headache from obstruction of the infundibulum, and mental cloudiness or dulness from the accompanying ethmoiditis are very often complained of.

The *diagnosis* is seldom difficult when the growth is seen, but there are times when it is difficult to find a small polyp, or even quite a large one hidden between the middle turbinate and the outer wall, even when the symptoms point to its presence. In such a case it may be seen only after shrinking the parts with cocaine, or brushing it out of its hiding place with a small cotton-tipped probe.

Treatment.—The treatment is surgical. The parts are anesthetized with cotton pledgets soaked in a ten per cent. solution of cocaine and applied with forceps, carrying the pledgets well up toward the roof. If there is no pus and the growths single or multiple and pedunculated, each polyp should be removed with the cold wire snare until all are removed. It frequently happens that all polypi cannot be removed at one sitting, in which case two or three operations at intervals of a few days may be required to complete the removal of all of them. When the growths are quite numerous or the mucous membrane poly-

poidal, the diseased underlying bone, as well as the polypi should be removed, bone-cutting forceps and curette as well as the snare being required. When the disease is quite extensive, polypi filling the nasal fossa, and the ethmoid extensively involved, a more radical operation is indicated, such as exenteration of the ethmoid, after the method of Hajek, Mosher, or Ballenger, special ethmoid instruments being required. Only those specially qualified for intranasal surgery should attempt the radical operation, as it is by no means devoid of danger. Strict cleanliness should be observed. The nose should not be packed following the operation except in very rare cases when hemorrhage calls for it, because of the danger of meningitis. Recurrence is likely to occur after the simple operation, as indeed it may after the most complete radical.

When the polyp is within the nasopharynx, it usually attains a great size, and is much firmer, containing more fibrous tissue than polypi within the nose. The growth here is always pedunculated, usually single, and may fill the whole of the nasopharynx. Removal is often very difficult. A large snare, preferably Jarvis's, is passed through the cocainized nares into the nasopharynx, where the tip of the introduced left index-finger meets the wire and carries the loop under and back of the growth. The snare is now closed gradually, the wire loop being pushed well up with the finger tip, and the growth is cut off at its base, which is usually from the posterior half of the middle or superior turbinate. The growth falls into the throat and is expelled. This operation is often quite difficult. It may be necessary to introduce the snare, via the mouth and back of the soft palate into the nasopharynx, where the tumor is surrounded and cut off. In other cases the pedicle may be severed with scissors introduced through the anterior nares, in which case it is best to remove at the same time the posterior end of the turbinate from which it arises, if that can be determined, as it can be with the aid of the pharyngoscope.

Adenoma.—Pure benign adenoma in which the glandular type of epithelial hyperplasia is the prevailing tissue change is an exceedingly rare phenomenon, being much less common than a malignant adenoma. They occur as papillomatous masses in the nasal fossæ, frequently involving the mucous membrane of the accessory sinuses, especially the ethmoid and sphenoid. They may exist for many years and recur after repeated removals, but if completely eradicated together with the area from which they arise, they may not recur. Often, however, when too late, what seemed at first to the histologist to be a benign growth, proved to be malignant. Note carefully, if a nasal neoplasm is manifestly not an edematous polyp, it is most likely to be a malignant rather than a benign tumor as pointed out by Jonathan Wright.

The *symptoms* of benign adenoma are those of obstructed nasal breathing and epistaxis. On examination one sees a papillary vegetating surface, often associated with edematous mucous membrane or polypi in the region of the anterior or posterior ethmoidal cells. Without a microscopical examination a definite diagnosis as to the nature of the neoplasm cannot be made. The clinical diagnosis often is that of edematous polypi.

Angioma.—This new growth is usually found on the septum and is composed almost entirely of blood-vessels, generally large cavernous veins, surrounded by a slight network of connective tissue, its epithelial covering being the same as that of the part from which it sprang. It may be located in any part of the nasal cavity; however, if seen anywhere but on the septum, it is probably but a localized hypertrophy of the mucous membrane in which the vascular changes are most marked. It occurs at all ages, most frequently in early life, when it may be congenital, and very rarely in old age. It is a soft, rounded, mulberry-like growth, varying in color from a bright red to a purple, movable, pedunculated or sessile, bleeding easily on touching with a probe, and, as before stated, is almost invariably found on the anterior part of the septum. The tumor may be reduced or emptied by pressure, and, if connected with an artery, pulsation may be detected. Frequent attacks of nosebleed, always beginning on the same side, constitute the earliest symptom. The epistaxis may be alarming and difficult to control. Nasal stenosis on the affected side develops with the growth of the tumor, which may be rapid or slow. More or less discharge is likely to be present. There is no pain.

Treatment consists in the removal of the growth by the cold wire snare under cocaine anesthesia and adrenalin to lessen the hemorrhage. If the growth be pedunculated, the application of the snare is simple; if it be sessile, a needle transfixes the growth at its base, the loop of the snare being thrown over this; and in either case one or two hours should be taken in removing the tumor. Recurrence does not take place if the removal has been complete.

Bony Cysts.—Osseous cysts in the nose are not rare. When present, they are found invariably at the anterior end of the middle turbinated bone in persons above twenty, and much oftener in women than in men. There frequently exists in the anterior end of the middle turbinated bone an ethmoid cell, which communicates with the middle meatus or with the other cells of the ethmoid labyrinth. Inflammation causes complete or partial stenosis of the orifice, the secretion is retained, and the cell gradually becomes larger as the walls distend, until finally there is produced a bony cyst. This is covered externally with mucous membrane that may either be normal or have undergone polypoid degeneration with polypi resulting, or, again, may have atrophied. The mucous membrane lining the cavity has columnar ciliated epithelium, and, through pressure of the retained secretion, often becomes attenuated, the glandular elements undergoing absorption, the membrane becoming polypoidal or granulating. The cyst contains air or may be filled with a yellow viscid fluid, mucopus, or clear pus. Mucous polypi are frequently found in the cavity, on removing the cyst, or on opening into it.

The tumor presents itself as a smooth, rounded, anterior end of the middle turbinated body, and varies greatly in size, being often so small as to pass unobserved, while at other times it may be so large as to reach down to the inferior turbinate or even to the floor of the nose, and frequently pushes the septum over sufficiently to cause stenosis of the opposite naris, the tumor occupying the concavity of the septum which it has produced. The symptoms are those due to pressure of retained secretion and to obstruction. Hemicrania with exacerbations of acute pain during colds in the head is the most characteristic and distressing symptom. The pain is referred to the inner side of the eye, radiating to the forehead or across the face, causing often intense trigeminal neuralgia. There is a feeling of pressure and throbbing. Actual exophthalmos may occur from the outward pressure. Attacks of megrim with vertigo and partial unconsciousness and vomiting are often complained of. Nasal obstruction, depending upon the size of the tumor, is present on the affected side and may be quite marked in the opposite naris.

Prognosis is good and recurrence is not to be expected following proper treatment.

Treatment is surgical and consists in the removal of the cyst (under local anesthesia) by the cold wire snare, Grünwald's or other nasal cutting forceps.

Fibroma.—Fibroma is a connective-tissue growth, somewhat resembling histologically the mucous polyp, but differing from it in the large amount of connective-tissue fibers crowded together with but few intervening interstitial spaces. The epithelial covering is the same as that of the polyp. It springs from the submucosa or outer layer of the periosteum, and arises from the posterior third of the middle or superior turbinated bodies or from the roof of the nose, and is said never to spring from the septum. It may arise in the sinuses, and often extends from the nasopharynx into the nasal fossæ. It has a rather thick, firm pedicle or may have a very broad base. If pedunculated, the growth is downward and backward into the nasopharynx, where it appears as a round or pear-shaped grayish-pink tumor, firm and hard to the finger, bleeding easily on probing, having a rather smooth surface, and tending to fill the postnasal space. In the nose it is the same character, but is longer and more slender, conforming to the shape of the nasal cavity. Its growth is steady and persistent, pushing aside adjacent bones, causing ulceration and adhesions, invading the neighboring sinuses and orbital cavities, and producing finally much deformity, such as a broadening of the nose, exophthalmos, and when far advanced the characteristic frog face. The tumor is very vascular and the walls of the blood-vessels are very much thinned. This form of growth occurs in early life, between the ages of fifteen and thirty or forty, and in males more often than in females.

The *etiology* is not known, trauma possibly having to do with the development. Early in the disease the patient has repeated attacks of epistaxis, often severe, the blood coming not only from the tumor, but also from the ulcerated mucous membrane, and nasal obstruction develops first on one side, then on the other, as the nasopharynx becomes filled with the tumor. A copious watery or mucopurulent discharge constantly flows from the nose. The voice becomes thick and nasal, the mouth dry and open, the senses of smell and taste become impaired or lost, and tinnitus and impaired hearing develop. Pain is absent at first, but, as pressure on adjacent parts develops, it becomes steady. Deformity arises if the tumor is not soon removed.

Prognosis is good if the tumor be removed. If it be not removed, death will ensue from copious hemorrhages or from extension of the disease to the brain.

Removal can usually be accomplished by the cold wire snare, but it may be difficult to surround the growth. The large loop is passed through the nose into the nasopharynx, the index-finger of the left hand then pushing the wire about the tumor, when the loop is drawn. The pedicle may be so hard or the base so broad that the wire may be repeatedly broken and the galvanocautery snare be required before the tumor can be severed. The pedicle or base may be cut with scissors, and in unusually large tumors it may be necessary to expose the nose by an external operation before the tumor can be removed. Profuse hemorrhage is to be expected in the removal of fibroma by whatever operation, and death has occurred during operation from this cause. When the surrounding sinuses and structures of the nose are invaded, temporary resection of the superior maxilla by the operation of von Langenbeck may be necessary before the growth can be removed in its entirety. In a recent case of the author and operated by him, a boy of fifteen had a fibroma of the nose completely filling one naris, the nasopharynx and the sphenoidal sinuses as well as the ethmoid. The attachments and adhesions were so numerous and strong that the growth could only be removed in small pieces by snare, scissors, and cutting forceps, the hemorrhage being very profuse and difficult to control. Radium was used without avail. Finally a tracheotomy was done, the carotid of the affected side was tied and Olliers' external operation for exposure of the nasal cavities was performed, giving free access to the growth. The tumor was extensively attached to the base of the skull (cribriform plate) and posterior wall of the sphenoid was removed by snares, scissors, and cutting forceps. Hemorrhage was profuse, though doubtless lessened by the ligature of the carotid. The patient died thirty-six hours later.

Osteoma and Chondroma.—These true bony and cartilaginous tumors are not to be confounded with the exostoses and ecchondroses so frequently met with on the septum. Both are very rare.

Osteoma originates from the accessory sinuses especially the frontal and ethmoid, the vomer and other parts of the bony framework. Both the cancellous and the eburnated varieties are met with. The tumor grows steadily, though slowly, pushing everything before it, invading the orbital cavity, displacing the eyeball, and causing intense pain. The tumor has a bony connection with its point of origin or a pedicle of mucous membrane and connective tissue. It is covered with mucous membrane, and is so hard that it cannot be penetrated by an exploring needle. It is usually single, smooth or irregular, and may be of any size, depending upon the time it has been growing. The symptoms are pain, early and continuous until the pressure destroys the nerve filaments, nasal obstruction with all its results, impaired sense of smell, mucopurulent discharge, and frequent attacks of epistaxis. Exophthalmos, with or without blindness and epiphora, is produced sooner or later, as well as other evidences of external deformity. The diagnosis is made by the history of a slow growth, by the use of the probe or the needle, and in doubtful cases by the microscope.

Prognosis depends upon the extent of the tumor at the time of examination, but it is usually good. The treatment is entirely surgical and nearly always intranasal. The tumor may have to be divided into fragments by the motor trephine, bone forceps, or saw, and removed in pieces when it is too large to be extracted through the nostril. When the tumor is quite large and inaccessible, an external operation will have to be made, but much can be done by intranasal surgery without resorting to the more radical external operation.

Chondroma occurs but seldom in the nose. In twenty-five years experience the writer has never met with a true chondroma in the nose. It is questioned by Jonathan Wright if chondroma as a true benign tumor of heterologous origin ever occurs in the nasal tissues. When it does occur it is said to spring from the anterior part of the septum but may come from the ethmoid or other accessory sinuses. It is a smooth, rounded sessile tumor with a broad base covered with normal-appearing mucous membrane. It is found in early life. The symptoms are those of osteoma, excepting that there is no tendency to bleed. It is differentiated from osteoma by its permeability to the needle and by its sessile base; from malignant tumors by its slower growth, absence of hemorrhage, and harder sensation conveyed through the probe.

Prognosis is good if the tumor is entirely extirpated. Removal is accomplished by the knife, saw, cold or galvanocautery snare.

Papilloma.—Both hard and soft varieties of papilloma are met with in the nose. The hard variety resembles in all respects the cutaneous wart, and is confined to the vestibule and anterior part of the septum, usually of one side, and is commonly single, but may be multiple. Many cases of the soft variety have been reported, but the majority of them are not true papillomata, being nothing more than papillary hypertrophies. These latter, sometimes known as "Hoffman's papilloma," are of common occurrence in hypertrophic rhinitis, occurring along the inferior

border and posterior ends of the inferior turbinated bodies—sites where true papillomata do not occur. True papilloma appears to be restricted to the anterior part of the septum, the floor of the nose, and the anterior part of the external wall. It occurs at any age and in either sex, and is usually single, unilateral, and of small size, but may grow to be as large as a hazelnut, obstructing the nasal orifice. It may be sessile, but almost always be pedunculated, grayish pink in color, with irregular surface and well-marked papillæ, somewhat resembling a raspberry. It is very vascular, bleeds easily, causing frequent attacks of epistaxis, and has some tendency to ulceration. Pain is seldom present. There is more or less profuse nasal discharge. Unless the growth is completely removed, it is likely to recur.

Treatment.—Removal is best accomplished by the cold wire snare, and any part remaining should be destroyed with the galvanocautery. Vaseline or other emollient should be kept applied until healing has occurred, and irritation by picking the nose is to be avoided.

Malignant Neoplasms.—Sarcoma is the commonest form of tumor met with in the nose, if we exclude mucous polypi and other tumors of purely inflammatory origin. All varieties found in other parts of the body occur in the nose, but the round- and spindle-celled sarcomata are most frequently seen, and after these in points of frequency are myxosarcoma, melanosarcoma, and fibrosarcoma, the other forms being much more rare. Both sexes are equally attacked. The period most susceptible to sarcoma in the nose is the fifth decade, between the fortieth and fiftieth years, but no age is exempt, cases being seen in early infancy and in extreme old age. Of eighty-four cases collected and analyzed as to age by Harris (*Phila. Monthly Med. Jour.*, June, 1899), thirty-four, or forty per cent. of the cases, were between thirty and fifty; four were under ten years of age and five between seventy and eighty.

As to *etiology*, little is known. Sarcoma is found so frequently associated with mucous polypi that there would seem to be some basis for the belief that under certain unknown conditions mucous polypi do undergo sarcomatous degeneration. Trauma, accidental or surgical, may be an etiological factor in this transformation from a benign to a malignant growth, and crude methods in operating have been suggested as a possible cause; but facts are wanting to substantiate this, too few cases bearing on this being reported to base any conclusions upon.

Symptomatology.—The earliest symptoms are unilateral nasal obstruction, progressing steadily and rapidly, and repeated attacks of nosebleed. Epistaxis is a prominent symptom throughout the course of the disease, and may become a very serious and alarming one. Discharge from the nose is profuse, at first watery, then mucopurulent and bloody, and later on the odor of necrosis makes it offensive. Pain is conspicuously absent in the early part of the disease, but, as the growth encroaches on the accessory sinuses, it becomes constant and steadily increases in severity. With the spreading of the tumor into the accessory sinuses and neighboring cavities more or less deformity of the face occurs, such as exophthalmos and fulness at the side of the nose and of the cheek with discoloration of the skin over the affected area. The growth may protrude forward through the nostril or backward into the pharynx, as in the case of a two-year-old child seen by the writer. Vision may become impaired from pressure on the optic nerve after involvement of the sphenoidal sinus. Nasal obstruction becomes so complete that the patient has great distress in breathing and in eating, speech becomes thick and muffled, the senses of smell and taste are lost or much impaired, nasal discharge becomes most profuse and offensive, pain is constant, insomnia adds to the distress, and the patient loses weight and strength, and finally dies, unless relieved by surgical intervention, from extension of the tumor through the cribriform plate of the ethmoid or posterior wall of the sphenoidal sinus to the brain, or death may result from sepsis and exhaustion.

The objective appearances of sarcoma are not altogether characteristic. It is usually pedunculated, but may be sessile, and arises most often from the cartilaginous and bony septum and the middle turbinated body, but it has been seen originating from any and all parts of the nose. It may have originated in any of the neighboring accessory sinuses, invading the nose secondarily. The color varies from that of a simple mucous polyp to a yellowish pink or dark red, most often the latter. It is ordinarily quite soft to the touch of the probe and bleeds easily on examination, as in the round-celled variety, or it may be quite firm, as in the fibrosarcoma. The surface is smooth, unless ulceration has occurred. The writer, some years ago, had under his care a physician in whom a gliosarcoma of the dura mater perforated the base of the skull at the region of the sella turcica, invading the sphenoidal sinus, and causing softening and absorption of the cribriform plate of the ethmoid. The glands of the neck are not involved, unless it be by direct extension of the disease to them. Sarcoma is to be differentiated from simple mucous polyp, angioma, adenoma, carcinoma, and syphilis. The iodides should be administered to exclude syphilis in a doubtful case, or the Wassermann test, and a microscopical examination of a piece of the tumor removed by the cold wire snare should always be made.

Prognosis depends upon the site of the origin of the tumor, the extent of its invasion, and the variety of the neoplasm. Sarcoma, having its origin in the septum, especially the cartilaginous part, offers the most favorable outlook, while one arising from the middle or superior meatus is most unfavorable. The round-celled sarcoma, the commonest variety seen in the nose, is also the most virulent. More than fifty per cent. of all cases are fatal. Of 103 cases in Harris' table, the final termination was stated in but fifty-five, and of the latter twenty-five ended in death and thirty in recovery. All but one of the thirty were operated upon. Twenty-two of these latter, however, were reported as cured within a year of operation, and it is probable that recurrence took place in some or many of them later.

Treatment.—Surgical intervention at present offers practically the only chance of recovery. The operation must be thorough and the tumor completely eradicated. If the tumor is pedunculated and arises from the septum, especially at its anterior part, an intranasal operation with the snare may be entirely efficient, but if the growth comes from the middle or superior meatus or invades or involves the accessory sinuses or is inaccessible in any way, an external operation must be done. The nose is released and the parts involved are laid bare, the tumor is removed by cutting or the use of the snare, and the base is thoroughly curetted. Should recurrence take place, this should be removed at once. In inoperable cases—and many are inoperable—Coley's mixed toxins may be given with some hope of diminishing the size and retarding the development of the tumor, even if not curing it; such a course being specially indicated in the spindle-celled variety.

Carcinoma, much more rarely seen in the nose than sarcoma occurs in two forms (*a*) adenocarcinoma and (*b*) columnar-celled epithelioma. Adenocarcinoma arises usually from the mucosa of the ethmoid region and is present in the sinuses primarily or invades them secondarily. By the time a diagnosis is made, the growth has advanced so far that it is impossible to tell its origin. Diagnosis even by microscope is exceedingly difficult, since a growth looking benign

often proves later to be malignant and *vice versa*. The histological findings should be qualified by the clinical course. Metastases occur late. Adenocarcinoma is by far the most common malignant epithelial tumor. Columnar-celled epithelioma begins from the mucosa covering the inferior turbinate, the lower border of the middle turbinate or the septum, oftener than from the ethmoid labyrinth or sinuses. When seen early it is usually a discreet tumor without the preponderating surface proliferation which is seen in papillary adenomata. Its infiltration of the submucosa goes far beyond the surface indications. Metastases may occur early or late. Nasal obstruction and pain of a neuralgic character are early symptoms. The discharge at first is acrid and of a serosanguinolent character, but as ulceration occurs the discharge is more profuse and becomes putrid and fetid, giving to the patient and his surroundings an odor that is persistent and offensive. Repeated attacks of epistaxis occur. Tinnitus and impaired hearing and earache are often complained of. As the growth extends into the accessory sinuses, the orbital and cranial cavities, a new set of symptoms develops. The cheek becomes full, the eyeball is pushed out, vision may become impaired, pain is greatly increased, and finally signs of meningitis or brain abscess develop.

Objectively, epithelioma presents itself early in the disease as an infiltration of the mucous membrane, suggesting a papillomatous hypertrophy, but ulceration soon takes place, leaving the edges of the ulcer hard and the surface angry and covered with a thick, grayish secretion. Bleeding follows the slightest probing. The tumor shows marked tendency to invade the deeper parts, with little inclination to extend outward to the skin. Sooner or later the submaxillary and cervical glands become involved, though this is not always so, and cachexia develops only after the disease has existed for some time. The differential diagnosis is to be made usually from syphilis, lupus, and tuberculosis. Antisyphilitic treatment will often clear up a suspected epithelioma, and when any doubt exists the iodides should be given, if but for diagnostic purposes. Lupus has a very marked tendency to extend to the skin, which is usually involved. In a case of suspected primary tuberculosis, the bacillus will be found if that disease is present. The microscope may be required to determine the diagnosis of epithelioma; in employing it, however, one must not overlook the possibility that the removal of a piece of the tumor may be followed by renewed activity of the growth.

The *prognosis* is absolutely bad, few if any authentic cases of recovery having been reported. The disease appears to be more rapidly fatal in the nose than in most other parts of the body. Treatment heretofore has been unavailing; operation seemingly not only not eradicating the disease, but not affording even temporary relief. The growth recurs rapidly. Much has been hoped of radium but up to the present it has proved ineffective. Pain may be relieved somewhat by orthoform or other local anesthetic, and toward the end narcotics should be given to relieve the sufferer, and antiseptic washes used locally throughout the disease.

THOMAS H. HALSTED.

Nasal Cavities, Parasites in the.—The most important parasites of the nasal cavity are the bacteria, some of which are found constantly in the healthy nose as saprophytic organisms. Of these staphylococci and pseudodiphtheria bacilli are the most common. The nasal cavities also frequently carry various pathogenic bacteria in the absence of any symptoms of disease due to their presence (streptococcus, pneumococcus, Friedländer's bacillus, pyocyaneus, colon bacillus, micrococcus catarrhalis, diphtheria bacillus, meningococcus, organism of poliomyelitis, etc.). Any one of these organisms may be associated with pathological processes due to its presence in the nose; or their presence in a healthy "carrier" may be not only a source of danger to him but also to other individuals coming into contact with him. This is particularly true of the organisms of diphtheria and meningitis. Other pathogenic organisms directly associated with specific pathological conditions in the nose are the lepra bacillus, tubercle bacillus, spirochete of syphilis, glanders, actinomyces, etc. Blastomyces, thrush, and aspergillus of the higher vegetable parasites also more rarely cause diseased conditions of the nose.

The presence of animal parasites within the nasal cavities is of relatively infrequent occurrence. In the majority of cases such an event is purely accidental; true parasitic infection—*i.e.* the presence of animal forms which reproduce, or pass one or more stages of their existence, within the nose—is very rare. As is the case with the external auditory canal, the nasal orifices, under certain conditions, may form favorable avenues of entrance for such creeping forms of animal life as are fond of escaping the light by crawling into dark places. The residence of such animals within the nose is usually but temporary; during this time they do not draw nourishment from the body tissues. The effects produced are chiefly those of local irritation or obstruction. To this condition the term pseudoparasitism may with propriety be applied.

PSEUDOPARASITISM.—Among such pseudoparasites of the nasal cavities may be mentioned earwigs, centipedes, numerous beetles, insects, spiders, mites, bedbugs, leeches, and worms. Entrance into the nose is usually obtained during sleep, very often in the open air during the daytime. The local symptoms of irritation and obstruction may be very slight or severe. Bloody or mucopurulent discharges may be produced. In many cases the chief symptoms are of a nervous character, due to fright or worry. The intruder may penetrate into the frontal sinuses. Such cases may be attended by dangerous symptoms or even result fatally. It is said that centipedes are especially likely to reach the frontal sinuses. Cases are reported of these animals remaining in the frontal sinus for years, drawing their nourishment from the secretions of the cavities, but such reports may be viewed with suspicion.

The occasional entrance of round worms (*Ascaris lumbricoides*) into the upper air passages and into the nasal cavities is of clinical importance. As is well known, these worms may, during the sleep of the affected individual, wander from the intestine, through the stomach and esophagus, into the mouth and upper air passages. Ordinarily no especial symptoms are produced, but the passage of the worm into the larynx may cause serious symptoms of suffocation or even result fatally. Important obstructive symptoms may also arise from the penetration of the worm into the Eustachian tube or tear duct.

The *Oxyuris vermicularis* may be transferred from the anus to the nose through uncleanly habits, but does not remain in the new location.

TRUE PARASITES.—*Protozoa.*—Various forms of protozoa (*Amœba*, *Cercomonas*, and *Trichomonas*) have been reported as occurring in the nose, in such conditions as ozena, purulent catarrh, whooping-cough, noma, etc. It is very doubtful if any of the appearances, described in the majority of such cases, were really protozoa; it is much more likely that they represented degenerating cells, leucocytes, etc. More careful observations are needed to settle this point.

Worms.—The accidental presence in the nose of *Ascaris* and *Oxyuris* has already been mentioned. I have been unable to find in the literature any well-authenticated case of *Cysticercus* of the nasal cavities. Only two or three cases of nasal *Echinococcus* have been reported. In one of these, observed by Rogers, the patient, a woman aged thirty-four years, had had

a severe nasal obstruction for two and a half years. During a violent effort to clear the nose there was an escape of a large quantity of clear, straw-colored fluid. Two months later a cyst-like body was removed by snare from the middle turbinate; this was ruptured during removal. The microscopical examination showed the presence of numerous echinococcus hooklets in the walls of the cyst.

Arachnida.—Pentastoma denticulatum, the larval form of *Pentastoma tænioides*, is found in the nasal, frontal, and maxillary sinuses of various animals, particularly in the dog. Rarely, the parasite may be found in the human nose; the infection usually takes place from dogs, or through the accidental inhalation of the young larvæ, or by the eating of contaminated food. In the latter case the parasite later wanders from the alimentary tract into the nasal cavity. Its presence there causes inflammation, nose-bleed, etc. The diagnosis rests upon the occurrence of severe irritation, and the demonstration of the parasite.

Insects.—The most common and important nasal parasite belonging to this class is the maggot or larva of certain flies, both of the biting and of the stinging varieties. The fly lays its eggs upon either the normal or diseased mucous membrane of the nose; in the latter case probably attracted by the odor of secretions. Certain varieties may force their way into the healthy nose and there deposit their eggs. Such an infection occurs, in the great majority of cases, when the affected individual falls asleep in the open air during the daytime. The *Sarcophaga carnaria, Sarcophaga wohlfahrtii, Musca anthropophaga, Musca cadaverina, Musca domestica, Musca stabulans, Piophila casei, Lucilia macellaria, Œstrus bovis*, etc., have been reported as producing maggots within the human nose. In certain tropical countries, Mexico, Central America, the tropical portions of South America, West Indies, Hindustan, etc., such infections are not uncommon. The condition is known as *Myiasis narium*. In the great majority of cases the affected individuals have a history of ozena or purulent nasal catarrh. The *Lucilia macellaria*, however, frequently attacks the healthy nose.

The symptoms of myiasis are usually very severe; it is said that the sufferings may be so intense as to lead to suicide. The number of eggs laid upon the nasal mucosa may be very great, as many as 500 eggs of *Lucilia macellaria* (Texas screw-worm) having been removed at one time. In other cases several hundred larvæ may be removed or discharged. The eggs hatch rapidly, and nasal obstruction soon results, with intense pain in forehead, cheeks, etc. A watery or bloody discharge, edema of the neck and face, vertigo, sleeplessness, delirium, coma, reflex vomiting, and convulsions mark the affection. Fever may or may not be present. The nasal mucosa may be completely destroyed and the bones denuded through the efforts of the growing larvæ to obtain nourishment. Within a short time, one to two weeks, the larvæ leave the nose to form their cocoons outside. The character of the nasal discharges usually changes after the maggots have left the nose, becoming more purulent. The inflammation may persist for a long time, or in other cases the symptoms may abate immediately upon the removal of the parasites.

The history of the case, the symptoms of rapid obstruction with watery or bloody discharge, and the demonstration of the presence of the maggot make the diagnosis clear. The prognosis is on the whole favorable, but fatal cases may occur.

The treatment of nasal parasites in general consists, first, in the removal of the parasite; secondly, in the treatment of the local condition caused by its presence. In the case of maggots or other parasites which are more or less firmly attached to the mucosa, various antiseptics may be used for the purpose of stupefying or killing the parasite. Inhalation of chloroform, ether, turpentine, bichloride solutions, calomel powder, decoctions of tobacco, balsam of Peru, are among the remedies suggested. The filling of the nasal cavities with warm glymol is advised, especially in the case of maggots; the oil filling up the spiracles of the larvæ kills them, and they are then easily washed out. In very rare cases it may be found necessary to explore the frontal sinus. ALDRED SCOTT WARTHIN.

Nassau.—The town of Nassau, capital of the Bahama Islands, lies on the north shore of the island of New Providence, at a distance of about two hundred miles due east from the southern point of the Florida peninsula, and about thirty miles north of the parallel of latitude which passes through Key West. The exact latitude of Nassau is 25° 5′ 36″ N., only two degrees north of the Tropic of Cancer; its longitude is 77° 21′ 15″ W. It is the largest town in the Bahamas, and has about 10,000 inhabitants. The island of New Providence has an extreme length from east to west of nineteen and three-eighths miles, an extreme width from north to south of about seven miles, and an average width of about five miles. The highest ground in the island is only 120 feet above sea-level, and nowhere throughout the whole group of the Bahama Islands, many of which are very much larger than New Providence, does the surface attain an elevation above sea-level of more than 230 feet. "The formation of all the islands is the same—calcareous rocks of coral and shell hardened into limestone, honeycombed and perforated into innumerable cavities, without a trace of primitive or volcanic rock; the surface is as hard as flint, but underneath it gradually softens and furnishes an admirable stone for building. . . The soil, although very thin, is very fertile. . . . Except in the island of Andros, no streams of running water are to be found in the whole group."

The town of Nassau "extends along the water front for about three miles and back to the crest of a slope, on which stand the Government House and many of the finest private residences, at an elevation of ninety feet above the harbor. The streets are laid out at right angles with each other, and are uniformly macadamized, as are also the numerous excellent drives around the island; and the houses are generally built of stone, with the surrounding grounds ornamented with a tropical profusion of flowers and trees." As for the general character and appearance of the country back of the hill just mentioned, we read, in Mr. Charles Ives' work, entitled "The Isles of Summer," that, "with the exception of a very few square miles occupied by Nassau and its suburbs, there is little upon the island, except water and wilderness; the former is brackish and throbbing, and in some places appearing and disappearing with the long pulsations of the sea's diurnal tides, and the latter, to a large extent, a dense low jungle, with stretches of pine forests rising from a thick undergrowth of scrub palmettoes." Turk's Island, and Dunmore Town, on Harbor Island, are other health stations or winter resorts of the Bahamas.

Nassau is warmer than the Azores, Madeira, Teneriffe, or Bermuda (Solly). There is very little if any rain during the winter, and there is a continuous succession of fine days. The humidity is high and the nights are damp, so that the invalid had best be in doors after 6 P.M., and not venture out too early in the morning.

The water supply is from rain water kept in cisterns, and its purity obviously depends upon the care exercised in keeping the cisterns clean. So far as known to the writer, there is no general sewerage system at Nassau, but the natural drainage is good, as the town lies at an elevation of one hundred feet above the level of the sea. The soft, porous limestone rock absorbs water rapidly, and wells and cisterns in the vicinity of cesspools and vaults may easily become contaminated. The Bahama Islands in gen-

eral are said to enjoy a reputation for healthfulness, the mortality being under eighteen in one thousand (Hinsdale).

There are two great hotels at Nassau, the "Royal Victoria" and "The Colonial," the latter affording accommodations for a thousand guests; there are also many smaller hotels and good boarding-houses, and guests can be accommodated in private families.

Nassau can be reached direct from New York by well-equipped and comfortable steamers; or one can go by rail to Miami, 145 miles distant from Nassau on the east coast of Florida, and from there by steamer in about twelve hours.

There are many attractions at Nassau, although after a while life becomes rather monotonous. The vegetation is tropical and very varied in fruit and flower. The roads are very good for driving or cycling, both inland and along the shore. Sailing, fishing, and bathing are also a feature of the place. A visit to the Sea Gardens is a delightful excursion in the bay, where, through the clear blue water, coral growths of varied hues and forms and sea sponges are seen. There are a good public library, schools, and churches, and reliable

Nassau, Bahama Islands.

	Jan.	Feb.	March.	July.	Sept.	Oct.	Nov.	Dec.	Year.
Temperature:									
Average or normal	70° F.	71	72	82	81	77	74	73	76
Mean of warmest	75	76	78	88	86	82	79	77	82
Mean of coldest	66	66	66	75	75	73	70	69	71
Average daily range	9	10	12	13	11	9	9	8	11
Precipitation in inches	2.4	2.4	4.5	6.5	5.2	7.4	2.8	24	50.5
Wind: Prevailing direction	N.E.–E.	N.E.–E.	E–S.E.	E.–S.E.	E.–N.E.	N.E.–E.	N.E.–E.	N.E.–E.	
Relative humidity	Winter, 83	per cent.;	Spring, 7	6 per cen	t.; Year,	79 per ce	nt.		
Mean number of rainy days	11.0	9.5	6.5	19.0	22.0	15.25	8.0	9.0	

As will be seen from the above table compiled from various observers, the climate of Nassau is a tropical one, characterized by warmth, equality, and humidity. With "perpetual sunshine, continuous good weather," and constant refreshing sea-breezes. Such climatic conditions render this resort a most agreeable winter residence for those desirous of existing comfortably with a minimum of effort in doing so.

medical service. There are both still-water and surf bathing, and an excellent sandy beach, the temperature of sea water being usually about 70°. "Not a beach from Panama to Para, where anything like the comfort and benefit can be found as on this beautiful sweep of sand at Nassau" (Hutchinson). Golf and other outdoor sports are also to be had here.

By chartering a small schooner pleasant excursions for several days can be made to Eleuthera Island, Governor's Harbor, and other neighboring islands.

This climate is essentially the same as that of the lower coast resorts of Florida, and is suitable for a similar class of cases. It is not favorable for tuberculosis, as no moist, warm marine climate is, as has been elsewhere discussed in this Handbook. Neither is it good for rheumatism or neuralgia, on account of the dampness, especially at night. It is, however, favorable for chronic bronchitis and catarrhal affections of the pharynx and larynx. It is said to be very beneficial for Bright's disease, especially the early cases. Cases of neurasthenia and those suffering from the effects of overwork do well here. Convalescents from various diseases with lowered vitality are favorably influenced by the winter climate here, where "no rain falls at that season, and each day is a repetition of the one just passed, balmy breezes and cloud-flecked skies," and where the usual daily range is from 70° to 73° F.

Edward O. Otis.

References.

The Isles of Summer, etc., by Chas. Ives, M. A.

Under the Southern Cross, by Wm. F. Hutchinson, A. M., M. D., 1891.

Notes of Nassau as a Health Resort, by Hamilton Osgood, M. D. Boston Medical and Surgical Journal, 1884, vol. iii., p. 555.

The Nassau Almanac.

In Sunny Lands, by Wm. Drysdale, New York, 1885.

Medical Climatology, Solly, 1897, p. 434.

History and Guide Book to the Bahama Islands, by J. H. Stark, Boston, 1891.

Natrium.—See *Sodium.*

Nauheim. (Bad-Nauheim.)—Of the almost innumerable health resorts and watering places that abound in Germany, none is better known than Bad-Nauheim, incorrectly spoken of as Nauheim. I say incorrectly, because not such a great distance away is another town called Nauheim, which is devoid of all interest to sightseers or invalids. The prefix Bad signifies a bath, and hence designates any place to which it is prefixed as a watering place or spa. This explanation is necessary, since mistakes are sure to occur if letters intended for this famous resort are addressed merely to Nauheim without the distinctive prefix Bad, or if the invalid in quest of health inquire of German railway officials for Nauheim, and not Bad-Nauheim.

Of all the various springs that have been bored from time to time nine are now in use, namely: Kurbrunnen and Karlsbrunnen, which are saline purgative waters; Ludwigquelle, which is alkaline in consequence of its containing sodium bicarbonate; the Great Sprudel or No. 7, in use since 1839, and at that time the largest and strongest of all; and last but not least the Friedrich Wilhelmsquelle or No. 12, now the spring furnishing the greatest flow and extremely rich in CO_2. No. 14 (Ernst-Ludwig) was completed in 1900, having a depth of 209 meters. The tenth one of the old springs, called "Gasbrunnen" combined with the Kurbrunnen and Karlsbrunnen is being experimented with for bathing purposes.

There are nine bath-houses of which No. 5 receives water, after having been freed from gas and impurities, from Springs No. 7 and 12. In this house only simple brine baths are given. Houses Nos. 1, 2, 4, 6, 7, 8, and 9 receive water direct from the springs at a temperature of 87° to 92° F., and very rich in acid and salts so that it can be employed in the "Sprudelstrombad" or flowing effervescing bath. The other houses, except No. 3, connected with spring 14, also obtain waters from the two great springs, but only after they have flowed into their respective basins, so that the temperature of the water is somewhat lower (85° to 90.5° F.) and not quite so rich in CO_2.

It must not be supposed that the baths are always alike in temperature or in their ingredients, or that all invalids are subjected to the same sort of baths. While certain well-known principles are regarded in prescribing the baths, the physician varies the strength and temperature of the baths to suit the requirements of each case. As a rule, the patient is generally given the so-called thermal or warm bath

Analysis of the Bad-Nauheim Mineral Springs.

Solid Constituents in 1,000 Grams of Water.	Bathing Springs.			Drinking Springs.				
	Sprudel No. VII (Grosser Sprudel).	Sprudel No. XII (Frd.-Wilb.-Sprudel).	Sprudel No. XIV (Ernst-Ludwig-Sprudel).	Kurbrunnen.	Neuer Karlsbrunnen.	Ludwigsquelle.	Schwalheimer Brunnen.	Löwenquelle in Schwalheim.
Sodium chloride ($NaCl$)	19.5402	27.1525	22.7090	14.1794	6.2322	0.3629	1.5006	2 1248
Sodium bromide ($NaBr$)	0.0090	0.0122	0.0170	0.0100	0.0044	0.0017	0.0008	0 0032
Potassium chloride (KCl)	0.5953	0.8381	0.6436	0.4042	0.1901	.....	0.0088	.....
Lithium chloride ($LiCl$)	0.0560	0.0626	0.0405	0.0274	0.0158	0.0065	0.0088	0.0066
Ammonium chloride (NH_4Cl)	0.0508	0.0575	0.0753	0.0350	0.0214	0.0070	trace	.....
Calcium chloride ($CaCl_2$)	1.3643	2.7619	2.4493	1.1807	0.4613	.....	.....	.....
Magnesium chloride ($Mg\ Cl_2$)	0.3948	0.5281	0.4663	0.3130	0.1394	0.1395	0.0189	0.0790
Sodium sulphate (Na_2SO_4)	.....	.....	.....	.....	.....	0.0053	.....	0.0013
Potassium sulphate (K_2SO_4)	0.0652	0.0818	0.0787	0.0566	0.0883	0.0335	0.0970	0.1481
Sodium bicarbonate ($Na_2CO_3CO_2$)	.....	.....	.....	.....	.....	0.1170		
Calcium bicarbonate ($CaCO_3CO_2$)	2.4894	1.7953	1.6019	1.5313	0.5618	0.4782	0.8106	1 0356
Strontium bicarbonate ($SrCO_3CO_2$)	0.0302	0.0500	0.0456	0.0247	0.0057	0.0037	0.0014	0.0004
Magnesium bicarbonate ($MgCO_3CO_2$)	.....	.....	.....	.....	.....	0.0405	0.3771	0.4143
Bicarbonate of iron ($FeCO_3CO_2$)	0.0218	0.0289	0.0309	0.0301	0.0055	0.0148	0.0130	0.0261
Manganese bicarbonate ($MnCO_3CO_2$)	0.0063	0.0052	0.0041	0.0048	0.0023	0.0020	0.0118	0.0029
Disodium phosphate (Na_2HPO_4)	0.0004	0.0004	0.0605	0.0009	0.0003	0.0003	trace	0.0005
Disodium arsenate (Na_2HAsO_4)	0.0009	0.0007	0.0008	0.0006	0.0003	0.0002	trace	0.0004
Silicic acid (SiO_2)	0.0164	0.0194	0.0173	0.0181	0.0101	0.0096	0.1088	0.0142
Amount of ingredients held in combination	24.6410	33.3946	28.1808	17.8168	7.7389	1.2227	2.8676	3.8574
Free carbonic acid (CO_2)	3.9634	3.3118	2.9630	2.7880	1.8487	2.1126	2.2363	2.6020
Total ingredients	28.6044	36.7064	31.1438	20.6048	9.5876	3.3353	5.1039	6.4594
Free carbonic acid at 0° C. and 760 mm. Barometer per c.c.	2021.3	1689.0	1511.1	1421.9	942.8	1077.4	1140.5	1320.1
Free carbonic acid at the temperature of the springs and average Barometer of Bad-Nauheim (749.1 mm.) per c.c.	2277.2	1931.0	1715.3	1550.0	1023.9	1168.5	1201.7	1391.6
Temperature of springs	29.9° C.	34.4°C.	32.2° C.	20.1°C.	17.2° C.	18.6° C.	10.3°C.	10.4° C.
Specific gravity at 15° C.	1.0184	1.0255	1.0222	1.0139	1.0067	1.0014	1.0018	1.0033

The above analyses were made in the Grand-Ducal Chemical Commercial Testing Station in Darmstadt (President, Prof. Dr. W. Sonne) in the years 1903, 1904, and 1906.

to begin with, since this is soothing or quieting to the heart. This bath contains very little if any of the saline constituents and is but one-half saturated with carbonic acid. The temperature of such a bath is somewhere about 92° or 93° F. As the condition of the heart improves the water of the bath is reduced gradually in temperature, the amount of salts is increased and the percentage of carbonic acid is raised until the water is saturated with it. The duration also of the baths has been lengthened from time to time, until from only a few minutes at first (three to nine) the patient is able to remain in the tub twenty minutes. By this time probably the baths have become very cool (86° F.) strongly saline, saturated with CO_2 and hence are stimulating and most refreshing. The "Sprudelstrom" or flowing carbonic acid bath is rarely ordered and then only at the close of a course of treatments. Finally sitz- or hip-baths are also resorted to for appropriate cases.

At first the waters of Bad-Nauheim were recommended for the treatment of gout, rheumatism, anemia, and disorders of the female pelvic organs, but their scope has been widened and now embraces diseases of the heart and nervous system. It is especially their success in the treatment of cardiac and arterial disease that now makes these waters so famous.

For the first-mentioned affection patients are advised to drink freely of the water of the Kurbrunnen, which is rich in chlorides of lithium, potassium, and the bicarbonate of lime. When a more strongly alkaline water is indicated, that found in the Ludwigbrunnen is recommended. The springs are thought to be of special virtue in the removal of deposits about the joints. For the stiffness and swelling of the articulations occasioned by gout, baths are ordered which, beginning with thermal brine baths at a temperature of 93° to 95° F., are gradually changed to more stimulating ones, the effervescing water of Spring 12 being considered especially suitable. Finally, resort is had to the flowing effervescing bath, which is powerfully stimulating to the circulation, and is a specialty of Bad-Nauheim owing to the unequalled richness of Spring No. 12, in carbonic acid with its temperature of 92° F.

Patients suffering from anemia and chlorosis are much benefited by bathing in the waters of these springs on account of their containing iron as well as stimulating salts and CO_2. At the same time they drink the purgative waters of the Kurbrunnen and Karlsbrunnen.

Disorders of the female pelvic viscera, particularly pelvic exudates, are said to be favorably influenced by the warm brine baths, either with or without the addition of carbonic acid.

Diseases of the spinal cord, as well as neurasthenia and other disorders of the nervous system, also receive treatment at Bad-Nauheim, and Medicinalrath J. Groedel in his little work, "Bad-Nauheim: Its Springs and Their Uses," cites cases of the kind which have been remarkably helped. Professor Erb, of Heidelberg, sends numerous patients thither and highly praises the virtues of its waters in this class of cases.

As already stated, the waters of Bad-Nauheim are reputed to be of special efficacy in the treatment of both acute and chronic articular rheumatism, being employed in the form of baths, as has been done at other health resorts for centuries. Cases of comparatively recent development are subjected to the influence of the simple warm saline bath, but in protracted or chronic forms of the affection the stronger and carbonated waters are employed. The design

of the bath is to promote healthy circulation in the affected joint, and it is believed that the comparatively cool (92° to 95° F.), strongly saline, effervescing, and hence powerfully stimulating baths of this spa accomplish this result more certainly than do the hot weaker baths given at other resorts.

The treatment of cardiac diseases, for which Bad-Nauheim has justly attained so great a renown, is an outgrowth of the treatment of articular rheumatism. It was Dr. Beneke, one of the earlier physicians at this resort, to whom credit is mainly due for the development of this use of Bad-Nauheim waters. He was a Professor at Marburg, but practised medicine at Bad-Nauheim for twenty-five years, and, in recognition of the indebtedness of this spa to his work, a fountain was erected in his honor in Park Strasse in 1910. Beneke contributed reports wherein he showed that this means of therapy is beneficial in four ways: (1) by preventing relapses of acute rheumatism, which would increase an existing valvular defect; (2) by promoting absorption of endocarditic products in the same way that these waters favor the absorption of inflammatory deposits in the joints; (3) by exerting a soothing effect on the heart's action; (4) by improving compensation in old-standing valvular disease. It was this last-mentioned effect which led Groedel to affirm in a paper contributed to the *Berliner klinische Wochenschrift* in 1878 that these baths improve cardiac energy and are a powerful heart tonic in other diseases besides valvular.

In the light of our modern conception of the etiology of acute articular rheumatism it is interesting, if not actually amusing, to note Beneke's views in regard to the preventive action of these waters. They may improve the general health and hence the resistance to infection, but they certainly can exert no effect on the original focus of infection, as *e.g.* diseased faucial tonsils. Moreover, it is quite unlikely that these waters can promote absorption of endocarditic vegetations, and hence, when as shown by Professor Beneke a cardiac murmur disappears after a course of baths, the result is due to the reduction of dilatation which had permitted a leak. Such at all events is a reasonable assumption, since we know that rheumatism often and usually does lead to dilatation in association with endocarditis even when myocarditis or pericarditis is not present. Consequently, although these baths may prove highly beneficial to persons recovering from a recent attack of rheumatic endocarditis, the value of balneological treatment is shown chiefly by its ability, as claimed by Groedel, to restore compensatory hypertrophy in all forms of heart disease whether valvular or myocardial.

Carbonated thermal brine baths tend to quiet and regulate the action of the heart, improve its innervation, and increase its muscular tone. It is this effect which, in the experience of all physicians who have employed the treatment, makes it applicable to all forms of circulatory disorder, whether depending upon endocardial or myocardial disease, or merely upon nervous derangements. It is generally taught that aortic aneurysm and severe degrees of arteriosclerosis are injuriously affected by such baths, but Groedel has shown that if they are given in such a way as not to augment blood pressure, even these two diseases may be materially benefited. Nevertheless one should hesitate to send to Bad-Nauheim a sufferer from aortic aneurysm, and the writer knows of the sudden death of a man with this disease three days after finishing a course of baths at this resort, although his physician declared he had been greatly benefited.

The methods of employing balneology in the management of cardiac diseases is simple and yet requires an intelligent conception of the principles concerned, and of the effects produced by baths of different strengths and temperatures. The warmer and less strongly saline ones, that is, those of temperatures above 90° F., known as the "neutral zone" are suitable to weak, irritable hearts, since according to observations made by Honan they do not raise blood pressure. On the other hand, baths strong in mineral ingredients and of low temperatures, that is, from 89° to 86° F. and at the same time charged with CO_2 increase arterial tension for a time and hence should be given only in cases with relatively good compensation or, in other words, with predominating hypertrophy. Such baths, therefore, may be considered stimulating to the heart, whereas those of comparatively warm temperatures are soothing and strengthening as well.

A further effect of strongly saline and carbonated waters is the production of cutaneous hyperemia. This, of course, is a capillary dilatation and with the production of this vascular relaxation the endocardial blood pressure is lessened and the overburdened heart is relieved. Hence, the myocardium if not seriously degenerated or weakened is able to contract down on its contents, so to speak, and expel the blood more strongly into the arterial system. At all events it can be demonstrated by careful percussion that there is a reduction in cardiac measurements after a properly given bath as compared with that prior to the treatment.

Finally it is well known that similar if not equally powerful effects can be obtained by the use of artificially prepared waters, but it is not possible to imitate the flowing bath as it is given at Bad-Nauheim. In this respect this spa possesses a distinct advantage over others. Yet in all justice and candor it should be stated that this powerfully stimulating Current bath is rarely resorted to and hence is not indispensable in the balneological treatment of cardiac disease. To the writer's mind the real benefit patients derive from a course of treatments at Bad-Nauheim is found not so much in the greater superiority of natural over artificial waters as in the fact that the individuals frequenting this resort abandon themselves to the one object sought and do not try to keep up their business or social duties while receiving treatment as they are apt to do at home.

Briefly stated the following is the method of ordering the baths. At first, those prescribed are weak in salts (about one per cent. of sodium chloride and one-tenth of one per cent. of calcium chloride) at a temperature of 95° to 92° F., and for a duration of from five to eight minutes. Carbonic acid is not added in the beginning of treatment, or at most is in only a very weak percentage. As time proceeds and cardiac energy grows, the strength of the waters is increased until the salts mentioned approximate three per cent. of the sodium and one per cent. of the calcium chloride. Carbonic acid is added in the course of time, as determined by the judgment of the physician, and *pari passu* the temperature of the water is reduced and the duration of each bath is increased until at last the patient remains in the tub about twenty minutes.

In the fore part of the treatment the baths are interrupted by a day of rest, the frequency of which is determined by the judgment of the practitioner, being ordered after each bath or after a group of two baths, but as the heart gains in strength the rest day comes less often and may not come oftener than after three or four successive baths. Patients are also required to lie down and rest after each treatment for an hour or so, in order that the effect of the bath may be retained and opportunity be given for a nap if inclination thereto be felt.

In addition to balneotherapy patients are usually instructed to take exercise either in the form of massage, the so-called resistance exercises, or, as the heart becomes equal to it, by walking on the level or up the gentle incline prepared for the carrying

out of Oertel's terrainkur. The diet and intake of fluids are also supposed to be carefully regulated.

In bath-house No. 9 is a so-called emanatorium which is an apparatus for charging with radium emanations the atmosphere of a room where patients as ordered by their physicians may spend two or three hours daily, comfortably reading or otherwise amusing themselves in order that the blood may become as highly charged with the emanations as is the atmosphere of the room. The apparatus not only produces the emanations but it at the same time purifies the air of the room. Arrangements are also being made, it is said, for baths in waters charged with radium emanations that physicians may prescribe such radioactive baths when in their opinion such are indicated.

Properly speaking there is no winter season in Bad-Nauheim. The state bath-houses are closed with exception of what is known as the Konitzkystift, which is an endowed hospital. Most of the new bath-houses are heated and hence patients may be accommodated after the regular season ends, but for the most part the physicians of the resort have left soon after the middle of October, not to return until after the middle of April. The real season therefore may be said to extend from about May first to the end of October.

In concluding this brief sketch, which owing to limitation of space is cursory and incomplete, the writer desires to express his sincere thanks to Dr. James Henry Honan and to Prof. J. Groedel, M. D., for valuable assistance rendered by them. The facts herein given have been derived also from numerous writings of Dr. Theodor Schott and others.

Robert H. Babcock.

Naupathia.—*Synonyms:* Seasickness; French, *Mal de mer;* German, *Seekrankheit;* Dutch, *Zeeziekte;* Spanish, *Mareo;* Italian, *Male di mare.* Seasickness or naupathia (ναῦς, a ship; πάθος, sickness) is the name applied to a definite syndrome group that occurs in persons on board a vessel at sea—and of which nausea and vomiting are the most marked phenomena. —certain persons experience somewhat similar symptoms in a rapidly moving railway or trolley car, on the back of a camel, in a balloon, an elevator, a swing, a merry-go-round, etc. It is said that not more than five per cent. of human beings are entirely exempt from seasickness; but while I have no statistics to offer, this proportion seems to me much understated. The same individual may differ in his susceptibility at different times. As a rule, those who make frequent voyages become acclimated; but some persons are always sick on board ship, even in smooth weather. As a rule, weather and the motion of the ship make considerable difference in the number of sick persons on a vessel, and in the severity of the attack in the individual. Age has some influence upon resistance. Very young children are rarely affected, and children below the age of puberty are not nearly so susceptible as adults. Lower animals differ in their susceptibility to seasickness; dogs, horses, cows, sheep, and chickens have been affected; but hogs, ducks, and geese are said to escape, as a rule. The attack varies in both degree and duration, according to the idiosyncrasy and the physical condition of the individual. Merely uncomfortable sensations may be experienced, or the condition may be one of mental and physical collapse.

Seasickness is not in itself dangerous to life—very few deaths having been recorded—nor, on the other hand, is it beneficial, as is sometimes stated.

Symptomatology.—Definite symptoms are presented by this affection. Abnormal increase of appetite may be the first sign, but anorexia—even active disgust for food—is more common. Headache is the rule, and is in many cases attended with a sense of fulness or congestion. It is often most intense, and usually constrictive, over the forehead or temples; sometimes the severity is greatest on the top or in the back of the head. Usually there are pain and a feeling as of pressure in the eyeballs. Often there is pain in the back of the neck. Soreness in the back and neuralgic pain in the extremities may also be present. Nausea and vomiting are, as a rule, most obstinate. Their onset may be preceded by general chilliness with pallor of the face and lips. Ptyalism occurs at times, and there may be a foul taste in the mouth. Constipation ordinarily accompanies the general disturbances; diarrhea is less frequent, but when present, may be distressing. Chilliness and flashes of heat are sometimes complained of. Mental depression, despondency, and even despair are frequently observed. In addition there may be complete loss of will power and of the faculty of concentration. The pulse is usually rapid, but in exceptional cases may be slow. It is always small, feeble, and easily compressed. Blood pressure is lowered. The skin is pale, cold, clammy, and often moist. The urine is diminished in quantity.

Causation.—Numerous theories have been advanced as to the cause of seasickness. All writers agree, however, that the complaint is aggravated by the physical and mental fatigue caused by the preparations for the voyage, by the emotional excitement of parting, by previous imprudences in diet, by constipation, and by want of proper food. The cause of naupathia is believed by some to lie in disorders of certain senses. It is given as visual disturbance caused by the constant mobility of surrounding objects; irritation of the semicircular canals caused by the frequent and varied movements of the ship, and confusion of the muscular sense, or a disturbance of the feeling of the relation of the body to surrounding objects, caused by the unstable conditions prevailing on board a vessel.

Irwin regards seasickness—or motion sickness, as he calls it—as a disturbance of a supplementary special sense whose function is to determine the position of the head in space and to govern and direct the estheticokinetic mechanism by which is maintained the equilibrium of the body. He holds that motion produces sickness by disturbing (*a*) the endolymph in the semicircular canals, (*b*) the viscera in the abdomen, and possibly (*c*) the brain and the subarachnoid at its base. The true primary cause of seasickness he believes to be irritative hyperemia of the semicircular canals. By some the stomach has been regarded as the seat of the trouble. The view taken is that by the shaking of the contents of the stomach, digestion is stopped and fermentation sets in, the undigested fermented food being thrown off by an effort of nature. According to this theory the headache, depression, and vertigo are due partly to the absorption of bile—or of some or many toxic products of metabolism or of fermentation—into the circulation, and partly to irritation of the pneumogastric nerve terminals. Some suppose that the play of the diaphragm and abdominal organs, caused by the movements of the ship, induce spasms and convulsions of the stomach. Another theory attributes the symptoms to a severe intramolecular shaking and irritation produced in the cells of particular organs by rapid movements arising from sudden change of direction of motion. The direct mechanical effects produced on the nervous tissues by the movements of the ship are given by many as the cause of seasickness. These include repeated slight concussions of the brain produced by its being shaken up and down in its bony case; a centrifugal jarring of the brain as a result of motion along the two arcs of a circle described by the axis lines of a ship; shocks inflicted upon the brain and spinal cord by the violent flux

and reflux of the cerebrospinal fluid, induced by the movement of the vessel.

Beard believed naupathia to be a functional disturbance of the central nervous system, the cause being purely physical or mechanical—a series of mild concussions—the agitation of the nervous system by the movements of the ship. Other theories ascribe the syndrome to effects produced on the nervous system by disturbances of the circulatory apparatus. It has been supposed that the irregular variations of barometric pressure produced by the rising and falling of the waves cause oscillations of the column of blood within the larger vessels. Seasickness has been attributed also to sudden and recurring changes of the relations of the fluids to the solids of the body, both of which obey the law of gravity when the body is subjected to alternate movements of ascent and descent; the blood, however, descending more rapidly and ascending more slowly than the solids. Pollarin believed the condition due to the lessening of the ascending force of the blood in the aorta and in the arteries springing from it, caused by the movements of the body and resulting in anemia of the brain. Wallaston, on the other hand, ascribed it to cerebral congestion. Chapman held that the proximate cause of seasickness consists in an undue amount of blood in the nervous centers along the back, and especially in those segments of the spinal cord related to the stomach and the muscles concerned in vomiting. Skinner believes that the motions of the ship cause movements, slight or considerable, and repeated displacements, collisions, and stretching of various organs of the body, especially of the abdominal organs, and unequal and alternate increase and lessening of pressure exerted by the column of blood on the walls of the arteries and veins. This starts a reflex nervous act, an inhibitory influence, causing a paresis of the cardioaccelerator and vasoconstrictor centers. Thus are brought about enfeeblement of the heart's action and frequently a diminution in the number of cardiac pulsations, and a consecutive loss of vascular tone with relaxation of the walls of vessels of medium caliber. This results in a general lowering of the arterial blood pressure, which is the cause of naupathia, giving rise to anemia of the medulla, anemia of the brain, anemia of the skin, diminution of the blood pressure in the kidneys, and the diminution or the absence of action of the sympathetic nervous system upon the unstriated fibers of the intestine and of the arteries, and also upon the intracardiac nerve ganglia. A vicious cycle is thus established.

Gihon considers seasickness a neurosis, and says that while the onset of mild attacks may determine a temporary increase of blood in the cerebrum, it is certain that the lessened arterial tension due to the vasomotor disturbance later deprives the nerve cells of their proper stimulus, and the consequent anemia of these centers results in weakness of the heart and dilatation of the vessels. Even miasmatic intoxication has been made responsible for seasickness (Lemonas).

The theory that seems to me the most plausible is that which attributes to *rupture of labyrinthine compensation* the principal phenomena; thus partially allying the condition to mountain-sickness and aëronauts' sickness, in which this factor plays a subsidiary part. *Concussion of nerve elements* probably adds to the sum total of disturbances; while *autointoxication* is added as a result of the failure of digestion and derangement of metabolism. *Lowered vascular tone* is both a symptom and a cause of other symptoms. Psychopathy (morbid suggestion) is not to be excluded entirely, but is not in itself a sufficient explanation.

Even this theory complex, however, is not entirely satisfactory. There is a suggestive resemblance between car-sickness and seasickness. Now, in my own experience at least, *car-sickness* occurs only in those persons who exhibit the signs of that peculiar constitutional anomaly (so-called *idiosyncrasy*) which I long ago described as *vasomotor ataxia*, and have since given the better—because more comprehensive—name of *autonomic ataxia*. (Recently, certain German observers and their American followers have partially and erroneously redescribed this condition under the two heads of *sympathicotonia* and *vagotonia*.) Moreover, it is a comparatively small number, even of the subjects of autonomic ataxia who readily become car-sick, and of these, the overwhelming majority exhibit defects of refraction or other ocular impairments, and are relieved by the proper lenses, correctly adjusted. The significance of autonomic ataxia is just that its subjects exhibit caricatures or exaggerations of the normal reactions to a given stimulus, that is to say, their reactions do not differ in kind, but only in degree, from those of normal persons exposed to similar influences. In other words, they will exhibit a certain symptom complex under an influence of degree n, which in normal persons will develop only under an influence of degree n^n. Such exactly is the relation of car-sickness to seasickness; and this fact must be taken into the etiologic account.

Prophylaxis and Treatment.—Different forms of treatment—physical, physiologic, and medicinal—have been recommended, in accordance with the various theories as to the cause of naupathia. The exciting cause in every case being the motion of the vessel, a stateroom should be selected near the center of the vessel, away from the engines. An inside room is said by many to be preferable, but in my opinion the lack of ventilation more than counterbalances its supposed advantages. As prophylactic measures, it is advised that all preparations be concluded at least twenty-four hours before embarking, so that the system may not be exhausted by overwork and want of sleep, and that as hearty a meal as possible be eaten before going on board. Those especially liable to seasickness are advised to go to bed before the vessel gets under way, having previously arranged within easy access such things as may be needed for the first day or two; to eat regularly and heartily, but without raising the head, for at least one or two days; to take a mild laxative on the first night out and to keep the bowels open; and, after being able to go on deck and to the table, not to rise in the morning without first eating something. If the sea should become unusually rough, they are to go to bed *before* getting sick. Some have advocated a spare and dry diet, one full meal being indulged in, and soup, pastry, milk puddings, and sweets being avoided.

I have seen good results from the following prophylactic régime: (1) A calomel purge followed by a saline, one week before sailing, and again two days before sailing. (2) Administration of a Seidlitz powder or a saline irrigation followed by complete rest, the morning before sailing. (3) Saline laxatives or enemas daily for the first few days on board. (4) Spending all the time possible on deck. Those very susceptible should maintain a reclining posture in a steamer chair, but out of the direct sunlight. Those but slightly affected should try to move around from time to time, walking a little more each day. (5) Taking for the first day or two light, easily digested food at short intervals. (6) Sponging or bathing daily with cold water, or with hot water preceded by cooling of the head and neck and followed by a cold friction rub or shower. (7) Taking minute doses of picrotoxin (gr. $\frac{1}{100}$ hourly) for ten hours daily for three to seven days preceding the voyage, and for several days at sea. Sometimes epinephrin (commercially known as suprarenalin, adrenalin, etc.) in doses of from gr. $\frac{1}{24}$ to gr. $\frac{1}{12}$, absorbed from the tongue answers better. A fraction of a grain of sugar of milk may be added, and either powders or tablet triturates be dispensed.

This régime, of course, is subject to modification

to meet circumstances—including personal peculiarities, season of year, time of departure, etc., etc.

It is usually advised that the horizontal position be assumed. Various physical expedients have been tried to lessen the motion of the vessel but without success. The twin ferry-steamer, the *Calais-Douvre*, the Bessemer suspended saloon, swinging staterooms, swinging berths and bunks, and the always upright easy-chair, *fauteuil-de-mer* of Dr. Neveu-Derotrie, have all proved failures. Various preparatory exercises to be practised by those intending to go to sea have been suggested. Swinging, turning around upon one foot, the use of rocking-horses, oscillating planks, gyratory chairs, and the like, have been advised. Dr. Hewitt devised a mirror, so hung as to swing on its oblique axis over a swinging platform provided with a seat and movable at will up and down, from side to side, backward or forward, or in a combination of these movements. The person contemplating a voyage was advised to use this contrivance daily for some time before tempting the winds and waves. Various expedients based on the visual theory are recommended. Thus, patients are instructed to keep their eyes closed or covered; to wear smoked glasses or blue or red glasses; or to fix their eyes on some object away from the vessel. The wearing of red spectacles has been advocated on the theory that the effect of the color on the blood-vessels of the brain would be to send the blood to the brain, relieving a cerebral anemia! To lessen the irritation of the semicircular canals, Dr. Minor suggests dropping cocaine in the ear. To keep the intestines quiet, to support the abdomen exhausted by incessant retching and vomiting, to determine the flow of blood to the head, or to provide a substitute for the stimulus and distention of food, abdominal compression by means of a bandage, handkerchief, towel, or napkin has been advised and is really useful. If the abdomen be hollow, a soft folded blanket may be fitted into the depression. Inflating the lungs and holding the breath as long as possible have been suggested as a means of fixing the diaphragm. Hovent, indeed, advocates systematic inhalation and exhalation against pressure by means of my *pneumatic resistance valves*. In my own person the experiment was unsuccessful.

The *dietetic management* usually recommended after the onset of seasickness is that a moderate amount of easily digested food be taken at short intervals. Beard says that one should keep something in the stomach all the time, if possible. Thin soups, broths, and gruels usually may be given. Junket, matzoon, kumyss, clam juice, beef juice, curry, preparations of blood, and predigested preparations of milk, beef, peptones, and the like can often be taken in small quantities, even after nausea and vomiting have occurred. Many experienced ship surgeons advise against the exclusive or excessive use of liquid food and prescribe solids or semi-solids; they believe that liquids encourage vomiting. Some writers recommend mulled wine, grog, Curaçoa, eau de menthe, iced dry champagne, cider, and brandy. Acid or effervescing drinks, such as seltzer, ginger ale, and sweetened water, with the addition of lemon juice or a little citric or tartaric acid, are often refreshing when taken in moderation. Draughts of ice-cold water, or pieces of ice held in the mouth, may give comfort. Coffee and tea as hot as possible, and in small doses, are sometimes soothing and invigorating.

As *curative agents* various forms of counterirritation have been employed, the commonest being a mustard leaf over the epigastrium. Electricity has been applied, chiefly as faradization of the epigastric and hypochondriac regions, in some instances combined with the painting of the parts with a solution of atropine sulphate for cataphoretic effect. Chapman advocated the application of an ice-bag to the spine, believing that thus he could lower the temperature of the spinal region. Baruch, however, asserts that cold applied to the surface of the body, instead of penetrating deeply, calls into action the heat-regulating machinery of the body for the purpose of resisting the invasion of cold into the interior. The success Chapman met with may have been due to stimulation of the spinal centers with increase of vascular tone. The spinal coil would probably be more comfortable than an ice-bag and more easily arranged. If the benefit lie in the elevation of depreciated nerve tone, the best hydriatic application would appear to be the douche. The Winternitz combination compress, so efficacious in cases of obstinate vomiting, should be of service in seasickness, though it will rarely be available. It consists of a stimulating cool trunk compress enclosing an epigastric coil through which circulates water at a temperature of from 122° to 132° F. The cold wet compress at first produces an anemic condition of the skin beneath, with contraction of the cutaneous vessels and irritation of the peripheral nerves. Reaction quickly follows with tonic dilatation of the vessels, the part covered by the coil becoming hyperemic. Dr. Edward Miller, in 1814, recommended the warm bath alone, or alternating with the cold bath, friction of the skin with oil and camphor, or dry friction with powder of mustard.

Various *drugs* and classes of drugs have been employed to meet certain supposed indications. Laxative treatment is usually recommended, and should be commenced as early as two weeks previous to the night before the contemplated journey. Podophyllin, aloes, rhubarb, and the salines have been used. Drastic cathartics, however, should not be administered. Various sedatives, analgesics, and hypnotics have been employed. Bromides (ammonium, potassium, sodium, strontium) are often given in doses of from ten to thirty grains three times a day. Beard advocated mild bromization and prescribed large doses of sodium bromide for three or four days before starting, keeping this up while at sea, until there is well-grounded reason to believe that all danger is over. Chloral hydrate, in doses of five or ten grains, has been used alone or in combination with the bromides. Chloroform is sometimes employed. Charteris prescribes "chlorobrom," a solution of chloralamid and potassium bromide, for three nights in hypnotic dose—a tablespoonful for women and a tablespoonful and a half for men, or a teaspoonful every ten minutes until the full dose has been given. Nelken gave half a grain of morphine twice a day. Cannabis indica, in doses of half a grain, has been employed. Antipyrin has been given in doses of from five to fifteen grains. Chloralamid, chlorodyne, paraldehyde, sulphonal, and the like, have also been used. Personally, I have seen benefit only from the bromides—of which strontium is the best—and morphine when needed. Sometimes the association of atropine or scopolamine with the morphine enhances the good effect and diminishes the liability of untoward sequels. It is quite possible that the addition of a good preparation of cactus (night-blooming cereus) or of anhalonium (mescal) would further improve the net result.

Certain so-called neuromuscular agents have proved useful. According to Skinner, they increase the activity of the nerve cell and of the unstriated muscular fiber, as well as that of the striated, and thus cause an elevation of the arterial blood pressure. The theory is of dubious worth, but the practice is useful. Cocaine, caffeine, strong black coffee, thin and strong infusion of black tea constitute this group. I have seen much good from fluid extract of erythroxylon coca and from wine of coca. Other remedies that act in a similar manner are theobromine, guaranine, kolaine, and preparations of kola. Strychnine and atropine have been used. Skinner employed them simultaneously in order to raise the blood pressure by acting upon the nervous centers and the unstriated muscle fibers. On account of the frequent vomiting

in seasickness he preferred the hypodermic method of administration, giving to an adult from 0.5 milligram to 1 milligram of atropine, and 1 milligram of strychnine, dissolved in mint water. This he repeated in two hours if the patient was not well, and even again two hours later. He never exceeded three injections in one day. Amyl nitrite has been lauded by some writers. I have seen benefit from strychnine arsenate, 0.5 milligram (gr. $\frac{1}{120}$) hourly by the mouth, and also from picrotoxin—which acts like a combination of strychnine and belladonna—in about the same dose. Crude adrenal preparations have failed in my hands, but it is probable that epinephrin absorbed from the tongue or hypodermic injections of adrenalin chloride solution or of an effective preparation of the posterior lobe of the pituitary body, may be useful in many cases.

Agents used for their supposed effect on the stomach are spirit of chloroform, diluted hydrocyanic acid, tincture of iodine in drop doses, cerium oxalate, cocaine, sodium bicarbonate in doses of ten to twenty grains, creosote or phenol in drop doses given every hour, eucalyptus rostrata, the digestive ferments, the dilute mineral acids, Worcestershire sauce in teaspoonful doses, and preparations of Peruvian bark, calumbo, and quassia. The older writers gave emetics on the advent of vomiting, using infusion of chamomile, peppermint or ginger, or even sea water. Lemonas recommended quinine to combat the hypothetic miasmatic intoxication. I have seen no recommendation of specific serum—neither of an antitoxin from an acclimated human being or lower animal, nor of an artificial combination of chemical salts!

As a rule, if patients (*a*) keep on deck, (*b*) keep their bowels clean, (*c*) do not overeat, (*d*) sponge or bathe daily with cold water—or with hot water, if preceded by cooling of the head and neck and followed by a cold friction or by a shower or general douche of cold water—and (*e*) are subjected to cheerful rather than to depressing suggestion, they will recover quickly without medicines. I have seen severe attacks cut short by a calomel purge followed by thorough saline irrigation of the bowel. Solomon Solis Cohen.

Naval Hygiene.—Naval hygiene is the branch of hygiene that deals with the factors and conditions which concern the preservation, promotion, and improvement of health, and the prevention of disease in a naval personnel. It seeks to prevent premature death and to secure health and happiness in a navy under essential service conditions. The naval human being has relation to natural conditions surrounding him that are intensified by concentration, but he also has social relations that, in view of special circumstances, require special consideration; and he has, as all mankind, thoughts, feelings, and desires which require self-regulation and control. Naval hygiene, then, involves a study of the man himself in the navy, as well as of his surroundings, under essential service conditions. It involves an understanding of the practicable circumstances that tend, under good discipline, to increase moral tone and to produce contentment.

Naval sanitation is that division of naval hygiene that acquires and applies knowledge necessary for the control or abolition, under essential service conditions, of those factors in the *environment* of the naval personnel that tend to produce premature death by causing disease. But predisposing causes are often as influential in producing disease as exciting or vital causes. While microscopic work has placed sanitation on a scientific basis, filth, foul air, insufficient food, insufficient work or exercise, insufficient recreation, lack of object in life, excesses of all kinds, immorality, and the like, while less striking in their effects because of the slowness with which they often produce apparent results, are more harmful in the long run than those epidemic diseases that come infrequently but take lives with great rapidity.

During much of the eighteenth century, a fleet, on account of scurvy and fever, was often unable to keep the sea for more than a few weeks. Yet it was by diet that scurvy was practically abolished from the sea (1796); and about 1815, when the general use of soap became a feature of naval life, typhus fever began to decline and ultimately disappeared. If citric and other organic acids can be regarded as preventive of the one disease, soap properly employed (body, clothes, and surroundings) may be regarded as almost of equal force in the other, in spite of its transmission by the *Pediculus vestimenti* against which special measures are urgently required in presence of the disease. Moreover, some students of the history of communicable diseases claim relationship between the increased personal cleanliness of communities, incident to the more liberal use of soap, and the practical disappearance of leprosy itself from large areas of the earth's surface.

It is also worthy of note that until rather recent years the Japanese navy was crippled to the point of inefficiency by beriberi. Prior to 1884 the average admission rate of beriberi in that service was 324.5 per 1,000 of strength, but since that date it has been practically eliminated by diet; and all this was accomplished at a time when it was generally believed that beriberi was a communicable disease. It is not clear that something of the same sort will not be evolved in relation to pellagra.

However, it is surely not the intention to decry the prevention of disease by destruction of vital causes. It is the intention to emphasize that, just as in the days of yore, men strongly tend to foul, by their own excreta, the ships within which they live, and that it is as necessary for the naval medical officer to know the ways of preserving and promoting the health of, and preventing disease among men concentrated in naval vessels, by, among other things, the proper disposal of the excreta from the skins, lungs, kidneys, and intestines of those very men, as it is to prevent access to them of the causes of disease, directly or indirectly, from other men.

In fact, the routine care of men involves measures based upon recognition that prophylaxis is a series of methods or procedures whereby disease is restricted or prevented as much by suppressing or removing its predisposing causes or conditions as by destroying or modifying the exciting causes. It, therefore, includes, for instance, a proper ration as well as an uninfected ration, a proper amount and use of water as well as uninfected water, a proper amount and renewal of air as well as uninfected air, and proper kind and care of clothing as well as uninfected clothing. And yet, man himself and other animals are the principal source of infection; their excreta, the primary principal vehicles, and other animals, air, and water, the secondary principal vehicles. Therefore, the proper disposal of man's excreta, as well as protection of man from other animals, such as infected mosquitos and fleas, or flies and other insects carrying infective agents, is essential in preventing infection, although in the presence of epideme disease disinfection or the destruction of agents causing infection becomes of first importance.

But naval life is unnatural and in its personnel requires sufficiently good material in proper proportions to stand the stress incident to unusual requirements. Therefore, while naval hygiene requires a proper adjustment between the spaces within the ship, which constitute the naval man's immediate environment, and those outside conditions, which are the ship's surroundings, there is necessarily a certain physical and mental struggle inseparable from the life itself for which the individual must be naturally capable. The navy is not a sanatorium any more than it is a reform school. It is a life of necessary strains and

stresses requiring from the beginning good material. Therefore, it is a dictum that the health of any navy is primarily in the hands of the medical officers at the recruiting stations. The importance of recruiting duty cannot be overestimated in a naval service and it cannot be too clearly understood that it is one of the most difficult and one of the most responsible duties a naval medical officer can be called upon to perform.

And, in connection with the hygienic work of any navy, it is essential to secure for that navy information of its health from thorough study of dependable vital statistics. The vital statistics of a navy are the results obtained by the application of mathematics to the health records of the naval personnel. They do not include any relation to births, marriages, and differences of sex, but are strictly confined to men in the navy, their condition on coming in, the various diseases from which they suffer or die or are discharged, and those influences that affect vitality, or conditions attending naval life that relate to physical usefulness or efficiency. Therefore, it is quite clear that they represent an analysis which is necessarily at the very foundation of all inquiry of sanitary conditions and sanitary progress. Such statistics must be gathered with very great care, never regarded as having mathematical accuracy, and interpreted with full knowledge of all methods employed in their collection and of the conditions under which the data were collected. They must represent reasonable approximations and be then regarded as similar to other important results in applied mathematics which also very frequently depend upon data not mathematically true.

Thus it appears that in any reasonable study of naval hygiene certain subjects occupy places of essential importance. Such subjects are: the vital statistics of the navy and conclusions therefrom in relation to prophylaxis; the air without the ship; the air within the ship, whether battleship, cruiser, or submarine; the contained air of the diver's helmet, especially in deep-water diving; light without and light within the ship; the ship's water supply and drainage; the navy's food, including also poisonous fishes; the navy's clothing; disinfection on the ship; and naval recruiting. With such subjects in view, only a brief exposition of each is possible here.

The Vital Statistics of the Navy.—In naval vital statistics there are employed such terms as admission rate, percentage of sick, death rate, and invaliding rate. Death rate, invaliding rate, and admission rate are each expressed in ratio per thousand of average strength, which is the daily average number of persons in the service during the year or period under examination. Percentage of sick is the daily average of patients expressed in percentage of the average strength.

Results in such terms are of great value when expressed for each disease and for all diseases during a given period, but their value depends chiefly upon their place as a basis for subsequent mathematical work. Systematic or well-adjusted effort to improve the health of a navy depends primarily upon knowledge of the *damage* it receives from each disease, and from all diseases, and the varying amount of damage from year to year; and such terms as percentage of sick, death rate, and invaliding rate, while each expressing a variety of damage, are *unlike* quantities which, therefore, cannot be combined by addition to form a total expressing *damage*. A man may own houses, land, and horses, each a variety of property, but they cannot be added to give the value of the property. Unlike terms have to be expressed in some common standard.

In a naval service the common standard of damage is loss of service; and percentage of sick, death rate, and invaliding rate are the three terms in naval statistics that involve loss of service. Therefore, if percentage of sick expresses loss of service in definite terms, it is evident that the total loss of service or damage can be obtained if death rate and invaliding rate can be expressed in terms of percentage of sick; and it is equally evident that if a death or disability discharge can be shown to represent a definite loss of service, the total damage can also be represented if percentage of sick can be expressed as death rate or invaliding rate.

Now it can be shown that the death or invaliding of one man at the beginning of the year is equivalent in loss of service to the death or invaliding of two men throughout the year, the average death or disability discharge being assumed to occur on the midday of the year and to involve the loss of service, during that year, of one-half the year. It follows then that four deaths or discharges for disability occurring during the year represent the same damage as that caused by a disease that keeps two men on the sick list every day of the year. Consequently, if the damage from death or from invaliding is expressed in rate per 1,000, it can be expressed in percentage of sick by dividing the ratio by twenty. It is equally evident that damage expressed by percentage of sick can be expressed in ratio per thousand of strength by multiplying it by twenty.

Utilizing the method indicated, it is quite practicable to arrange for any navy a table showing its list of diseases and the total damage caused by each and by all during any given period. There is thus declared the importance of each disease as measured by the damage it inflicts and, by comparison with other years, the varying amount of damage from year to year. And such a list will generally show that certain diseases attracting little attention, because causing few or no deaths, are more damaging to a naval service than some of those having a relatively large case mortality. For instance, tonsillitis damages a naval service much more than nephritis or dysentery, and quite as much as pneumonia; and the ordinary cutaneous diseases, such as abscess, ulcer, eczema, and furuncle together cause a very much greater damage than measles, mumps, scarlet fever, smallpox, yellow fever, and cholera together. In fact, all these epidemic diseases do not damage a naval service as much as abscess, a single disease of the cutaneous apparatus.

Such comparisons disclose the directions in which special hygienic efforts are required. For instance, in regard to the ordinary suppurative diseases of the skin, while it is recognized that the staphylococci and streptococci are the active causes of suppuration, and that cocci are common on the skin, though generally in some attenuated form, it does not seem to be so generally recognized that, aside from the virulence of infective bacteria, their number is an important consideration and that undoubtedly cleanliness of skin and clothing limits the tendency to suppurative processes and to wound infection, as has been demonstrated in naval warfare. In this connection there is also seen the necessity for steam laundries in a naval service, increased facilities for bathing, careful arrangement of wash rooms, avoidance of use of towels in common, frequent airing of clothing and bedding, and strengthening of vital resistance by life in good general surroundings and by improvement in ration. Some of the vital causes of diseases of the skin are inoperative if their action is exerted against a skin not only in good health from direct attention, but also from the good condition, or favorable condition, of the body as a whole. Besides, a pus case, especially of hands or feet, however trivial it may be, is worthy of close attention on a ship where concentration of men is necessarily great and handropes, oars, and other parts of the equipment so frequently come in contact with human bodies.

In the latest statistics (1913) of the United States Navy the percentage of sick from disease was 2.4304; the death rate, 2.215; and the invaliding rate, 18.9.

Applying the method indicated above, the damage in percentage of sick is found to be 3.4861, and the damage in terms of death rate or invaliding rate is 69.922. As the average strength or number of persons in the Navy and Marine Corps was 65,926, the damage is represented in terms of percentage of sick by 65,926 × 0.034861 = 2,304.84; and, in terms of death rate or invaliding rate, by 65.926 × 69.922 = 4,609.68. In other words, the total damage from *disease* in the United States Navy during the year indicated was equivalent to 2,304 men on the sick list every day of the year with no deaths and no discharges for disability during the year, or to 4,609 deaths during the year with no sick at any time. The total damage would be represented by the total loss in action on the first day of the year of 2,304 men, or the crews of two or three battleships, the service to remain without disease during the rest of the year. About twenty per cent. of this damage was due to the venereal diseases and ten per cent. to tuberculosis. The total death rate (diseases and injuries) was only 3.82, and the damage from injuries was a little more than one-eighth of that from disease.

Such degree of damage should not be regarded as greater than that of other navies, the British navy, for instance, or even as showing greater prevalence of venereal diseases than in the case of unattached men in more or less like circumstances in civil life. It does show that the extensive prophylactic measures undertaken on naval ships and stations has had little effect in preventing such diseases. In contrast is the result obained in typhoid prophylaxis. Formerly, typhoid fever caused about two per cent. of the total damage from disease in the United States navy, but in 1913 that percentage was reduced to less than three-tenths of one per cent. Such a result is very striking and promises the practical abolition of one of the chief death dealers from the naval service. While the same cannot be stated of tuberculosis, that disease has shown no increase in relative number of cases incident to naval service, the relatively large damage the navy receives from that source being due in great part to retention of men for treatment in special hospital.

A navy in which during the year 1913 the death rate from disease was only 2.215, and from all causes only 3.82, would seem to be not only under certain hygienic influences, but also under good medical and surgical effort. In fact, it is common knowledge that a man in the navy is in much more danger from disease when ashore on liberty than when on his ship.

The Air without the Ship.—The atmosphere is commonly recognized as a mechanical mixture of gases, and thus without fixed composition. Water is a chemical compound of gases and, therefore, is designated by a chemical formula. From a given amount of water a certain amount of H and O can always be obtained, but every specimen of air varies, although the tendency to uniform composition, when considered dry, is remarkable as it depends upon the phenomenon of diffusion of gases. Molecules, especially gaseous molecules, have the power of moving among each other. Diffusion is the intermixture brought about by that power. Thus gases rise in opposition to gravitation and when mixed always remain so. But the rate of diffusion varies inversely as the square roots of their relative weights. Thus hydrogen diffuses four times as fast as oxygen; and CO_2, being half as heavy again as atmospheric air, has a low diffusion rate and, therefore, tends to accumulate in confined spaces in which it may have source, and to show different degrees of concentration in different parts of such spaces, especially when there are facilitating differences of temperature. Thus, in a submarine during submergence, there is, when *uninfluenced by fans*, a more or less natural tendency of the CO_2 to accumulate in the lower parts of the vessel.

Undoubtedly, pure air, as pure water, is not found in nature. Water is a solvent of gases and of many solid materials. The atmosphere is in most intimate contact with earth and water. It receives gases of putrefaction, combustion, and evaporation. It is more eager for water than water is for air, and, as it sweeps the earth, it gathers, as water does, solid material of innumerable kinds. Air is always found in water; it is forced out by heat. Water is necessary and always found in the atmosphere; it is forced out by cold. Water without air is insipid and thus unsuitable for consumption, and air without water vapor unduly dries the exposed tissues of the body, acts as an irritant, and is unfit for respiration. Water vapor is necessarily the most varying constituent of the atmosphere, for, though air is almost always seeking water, it cannot always find it in a given locality, or may not remain in contact long enough to satisfy its nature.

Considering the average amount of water vapor at the sea-level as about 1.4 per cent., the following may be taken as the average percentage composition by volume of pure air surrounding ships:

Nitrogen (argon, helium, etc.)	77.90600
Oxygen (ozone, 0.00015)	20.65955
Water vapor (a gas)	1.40000
Carbon dioxide	0.03360
Ammonia	0.00080
Nitric acid	0.00005

At sea the CO_2 may be as small as 0.02 per cent., but will usually be found to be about 0.03, yet in harbors, where ships of the navy are more than half the time, it is apt to be nearer 0.04. Therefore, as a working standard, pure dry air may be assumed to have the following percentage composition by volume:

Nitrogen	79.01
Oxygen	20.95
CO_2	0.04

The purity of the atmosphere surrounding a naval vessel is rarely in question. It is the air within the ship, where there is marked concentration of men, that threatens health. However, when at, or in dock, the purity of outside air may not be a matter of indifference. In dry dock, barnacles and vegetable matter, scraped from a ship's bottom and undergoing putrefaction, may cause disagreeable odors. Ship's water-closets, situated in the eyes of a ship, will, with insufficient flushing, give rise to odors that may directly dominate not only the ship's contained air, but also outside air. Then location of a ship near the discharge of a sewer may cause uneasiness from fear of resulting sickness.

The direct influence of foul odors in causing disease has been very much overrated, to say the least. Sewage commonly contains the germs of disease, but its gases are practically free from microorganisms. Odor is a physical property and not a vital property. Yet, if water from over the side is utilized for washing decks and paint work, the transference of infective material to air breathed by men can be accomplished, or the men engaged in such work can become directly infected. And the ordinary gases of putrefaction, if in sufficient concentration, can interfere with nutrition, and can cause physical and mental depression, lassitude, headache, nausea, and giddiness. The history of the stench from the Thames in 1858 and 1859 shows this very clearly.

In battle the air without the ship may be very seriously modified by the gases it receives from the explosion of the enemy's shells. During the battle of the Sea of Japan in May, 1905, a Japanese shell exploded on board, or immediately above, a Russian vessel and the gases gained access to a dressing station and caused unconsciousness in medical officers and hospital corps men located there. This situation may become a factor in the artificial ventilation

of ships during action, and may lead to the recirculating of contained air.

The CO_2 in atmospheric air is of no direct use to man. It is one of his own excreta that he entrusts to the atmosphere for removal from him. He begins to feel respiratory discomfort when its concentration exceeds three per cent., and this discomfort goes on to suffocation, unconsciousness, and death as the percentage concentration increases. It is diffusion that defends man from suffocation by carbon dioxide so far as the atmosphere is concerned, although even there that force is greatly assisted by actual movement of air, as in wind. Yet, diffusion, even without assistance, is sufficient to keep the gases of the atmosphere in practically uniform proportion. However, it is much too slow in its action to be entrusted with work necessary to effect the more or less rapid changes of air required in the ventilation of compartments occupied by men. To depend upon diffusion for the ventilation of a ship would be like trying to make a fire by exposing wood to sunlight. While the total amount of heat from the sun is enormous it cannot be trusted to warm a house much less to start a fire.

The atmosphere in sweeping the earth acquires innumerable particles of dust—particulate bodies. These floating particles may be bits of wings, seeds, débris of vegetation, pollen, spores of moulds, bacteria, manure dust, salt, fragments of wood, hair, straw, and the like. Such dust in air is comparable to sediment in water. Its effect on the health of man is largely a question of source. Water near the habitations of man requires close examination to establish purity; and air in or near the habitations of man may transport the cause of disease even when its solid impurities are in small amount. However, in the open air, floating particles are under the influence of the light and heat of the sun and under the free influence of the drying effect of air in motion seeking water. There is also subsidence by rain or into water. And the number of so-called air-borne diseases has been remarkably diminished. At any rate the atmosphere can be trusted not to introduce into a ship the cause of specific disease except by insects carrying infection. The danger is in the contained air which should be kept clean by ventilation, cleanliness of surfaces without dust, and proper disposal of all excreta.

The weight of air is as essential to the existence of man as its composition. Man lives at the bottom of an air-ocean of great weight. The instrument used to measure the pressure at different depths of the air-ocean is called a barometer. The standard height of the mercurial column at the sea-level is 29.922 inches, or 760 millimeters. This represents a pressure of 14.64 avoirdupois pounds per square inch. It is calculated that a man of average size sustains at sea-level a total pressure of about fourteen tons, exerted equally in all directions.

Varying atmospheric pressures cause corresponding variations in atmospheric density. The volume of a gas is inversely proportionate to pressure (Boyle's Law). A cubic foot of air at one atmosphere (29.922 inches) becomes one-half a cubic foot at two atmospheres. Therefore, if a sample of air is collected when the barometer stands at 29.90 inches, its volume becomes $\frac{29.90}{29.92}$ of the original volume when expressed at standard (29.92 inches). When going from a smaller pressure to a greater the volume must be less, and in going from a greater pressure to a less the volume must become greater.

Such considerations are of immediate value when a sample of air is collected for examination, say for a CO_2 observation. In all such cases each determination must be with reference of volume to standard in order that one determination may be compared with another. For instance, the bottle in which the air is collected may hold 3,000 c.c., but, if it is filled when the barometer is 29.90, the volume at standard (29.92) is only 2,997.99, inasmuch as 29.92 : 29.90 : : 3,000 : x.

But a volume of air has to be considered not only with reference to pressure, but also to temperature. Air not only expands when heated, but the increase in volume is definite (Charles' Law). Air expands a certain constant fraction of its volume for each degree of temperature added. This fraction is called the coefficient of expansion. The coefficient is 0.003667, or nearly $\frac{1}{237}$, for each degree centigrade; and 0.0020361, or about $\frac{1}{491}$, for each degree Fahrenheit. A given volume of air at a given temperature above or below standard (0° C. or 32° F.) should always be considered to have been a certain volume at standard which, if above standard, has been expanded to a given volume, or, if below standard, has been contracted to a given volume. Therefore, in calculating any change in volume of air incident to change in temperature, the first step is always to bring the volume to standard (0° C. or 32° F.) if it is not already there.

One unit of air (cubic centimeter, cubic foot, cubic yard) at 32° F. becomes 1 + 0.0020361, or $1 + \frac{1}{491}$, at 33° F., and 1 + 2 (0.0020361), or $1 + \frac{2}{491}$, at 34° F. Then, any number of volumes becomes that number of volumes multiplied by 1 + (0.0020361 × the number of degrees Fahrenheit it is to be raised).

For example, if 3,000 c.c. of air are at 32° F., what would the volume be at 82° F.?

$$3{,}000 \times 1.101805 = 3{,}305.415.$$

If 3,305.415 c.c. of air are at 82° F., what would the volume be at 32° F.?

$$\frac{3{,}305.415}{1.101805} = 3000.$$

If 40,000 cubic feet of air at 50° F. enter a ship's compartment per hour, how many cubic feet would leave it each hour if the contained air were heated to 70° F.?

40,000 cubic feet of air at 50° F. become $\frac{40{,}000}{1+\frac{18}{491}}$ at 32° F.; and that volume at 32° becomes at 70° $\frac{40{,}000 \times 529}{509} = 41{,}571$ cubic feet.

There are many interesting studies of air depending upon the amount of watery vapor it contains. The driest air obtainable in nature contains water. The deposit of water on the outside of a glass filled with cracked ice demonstrates that well-known fact.

To secure the data for the calculation of degree of air humidity, a psychrometer or indirect hygrometer is employed on ships.

The thermometer with its bulb covered with wick, kept moist by capillarity from the cistern of distilled water below it, is called the wet bulb, and the other thermometer is called the dry bulb. The difference between the readings of the two thermometers is a measure of the rapidity of evaporation, or the thirst of the air, or the drying power of the air. This is true because the more rapid the evaporation the lower is the standing of the wet bulb. When water evaporates there is a change in its physical state from a liquid to a gas and consequently a disappearance of heat—an abstraction of heat necessary for the maintenance of the gaseous state. Therefore, the drier the air coming in contact with the moist wick the greater will be the difference between the thermometer readings.

The readings of these thermometers at any given time are the only additional data necessary for the determination of the degree of humidity at that time,

the fixed data being a table of Glaisher's Factors, a table of Maximum Tension of Aqueous Vapor, and certain formulæ which can either be taken on trust or readily deduced.

GLAISHER'S FACTORS.

Dry Bulb.	Factor.	Dry Bulb.	Factor.	Dry Bulb.	Factor.	Dry Bulb.	Factor.
10	8.78	33	3.01	56	1.94	79	1.69
11	8.78	34	2.77	57	1.92	80	1.68
12	8.78	35	2.60	58	1.90	81	1.68
13	8.77	36	2.50	59	1.89	82	1.67
14	8.76	37	2.42	60	1.88	83	1.66
15	8.75	38	2.36	61	1.87	84	1.65
16	8.70	39	2.32	62	1.86	85	1.65
17	8.62	40	2.29	63	1.85	86	1.64
18	8.50	41	2.26	64	1.83	87	1.64
19	8.34	42	2.23	65	1.82	88	1.63
20	8.14	43	2.20	66	1.81	89	1.63
21	7.88	44	2.18	67	1.80	90	1.62
22	7.60	45	2.16	68	1.79	91	1.62
23	7.28	46	2.14	69	1.78	92	1.61
24	6.92	47	2.12	70	1.77	93	1.60
25	6.53	48	2.10	71	1.76	94	1.60
26	6.08	49	2.08	72	1.75	95	1.60
27	5.61	50	2.06	73	1.74	96	1.59
28	5.12	51	2.04	74	1.73	97	1.59
29	4.63	52	2.02	75	1.72	98	1.58
30	4.15	53	2.00	76	1.71	99	1.58
31	3.60	54	1.98	77	1.70	100	1.57
32	3.32	55	1.96	78	1.69		

TABLE OF MAXIMUM TENSION OF AQUEOUS VAPOR AT DIFFERENT TEMPERATURES.

Temp. F.	Inches of Mercury.	Temp. F.	Inches of Mercury.	Temp. F.	Inches of Mercury.	Temp. F.	Inches of Mercury.
32	0.181	48	0.335	64	0.596	80	1.023
33	0.188	49	0.348	65	0.617	81	1.057
34	0.196	50	0.361	66	0.639	82	1.092
35	0.204	51	0.374	67	0.661	83	1.128
36	0.212	52	0.388	68	0.684	84	1.165
37	0.220	53	0.403	69	0.708	85	1.203
38	0.229	54	0.418	70	0.733	86	1.242
39	0.238	55	0.433	71	0.759	87	1.282
40	0.247	56	0.449	72	0.785	88	1.323
41	0.257	57	0.465	73	0.812	89	1.366
42	0.267	58	0.482	74	0.840	90	1.410
43	0.277	59	0.500	75	0.868	91	1.455
44	0.288	60	0.518	76	0.897	92	1.501
45	0.299	61	0.537	77	0.927	93	1.548
46	0.311	62	0.556	78	0.958	94	1.596
47	0.323	63	0.576	79	0.990	95	1.646

The first step in determining relative humidity is the determination of the dew-point. If D.B. equals temperature of dry bulb; W.B. temperature of wet bulb in Fahrenheit; and F. factor standing opposite dry-bulb temperature in Glaisher's table, then the formula for ascertaining the dew-point is as follows:

Dew-point = D.B. − F. (D. B. − W.B.)

For instance, dry-bulb temperature is 80° F. and wet-bulb 75° F. Dew-point = 80 − 1.68 (80 − 75) = 71.6° F.

As the dew-point is that temperature at which the air in question is saturated, or has a relative humidity of 100, or is at its point of maximum tension, the relative humidity, or percentage of possible humidity (saturation) of the air designated by its actual or dry-bulb temperature, is obtained by use of the table of maximum tension and following formula:

$$\text{R.H.} = \frac{\text{Tension at dew-point} \times 100}{\text{Maximum tension at dry-bulb temperature}}$$

In the case above (D.B. = 80 and W.B. = 75) the relative humidity would be:

$$\text{R.H.} = \frac{\text{Maximum tension at 71.6° F.} \times 100}{\text{Maximum tension at 80° F.}} = \frac{0.774 \times 100}{1.023} = 75.6.$$

Therefore, the air in question would contain 75.6 per cent. of all the aqueous vapor it is possible for air to contain at its temperature (80° F.).

The sling psychrometer or whirling hygrometer is a more convenient instrument for use in a series of ship's berthing compartments, than the stationary psychrometer, as there is no cistern of water and consequently no necessity for waiting each time until its contained water has acquired the temperature of the surrounding air.

The wick-covered bulb is dipped into a cup of distilled water, at temperature of compartment, until thoroughly saturated. The psychrometer is then whirled fifteen or twenty seconds like the spoke of a wheel with the handle as an axis. This is repeated until there are two successive readings of the wet bulb that agree. The humidity is then found from relative humidity table specially constructed to accompany this instrument.

FIG. 4053.—Psychrometer.

The question of relative humidity is a very important one in naval hygiene, having close relation to clothing, heating and ventilation. It is not practicable to show such relation here in detail. However, the very properties of air upon which the action of clothing depends are ability to take up water and ability of air particles, when in motion, to carry heat. It is the quiet warm day of high relative humidity that causes distress from heat, as the evaporation of perspiration is less and loss of heat by convection is also small. It is the blustering cold day of high humidity that causes distress from cold, as moving air has its power of convection increased by cold and such air when damp can carry away heat from the body more rapidly than cold dry air.

The amount of aqueous vapor air can hold increases with its temperature. But the longer air is left in contact with a moist surface the nearer it comes to saturation. Movement of air, therefore, increases its drying effect. A wet deck tends to remain wet in any ship's compartment where there is little ventilation or little movement of air. An occupied ship's compartment should not only have dry surfaces, but also be free from disagreeable drafts and have an equability of temperature. Yet, if, to avoid disagreeable drafts in artificial ventilation, heated air is supplied, it will greatly irritate mucous membrane unless water vapor is added to overcome the very low relative humidity caused whenever cold air is expanded by heat. There are steam-heated compartments in which the air is much

drier than that of the desert of Sahara. Under such circumstances not only are mucous membranes irritated, but also, in view of more rapid evaporation of perspiration, higher temperature must be maintained for general comfort—increased loss of heat by evaporation must have compensation in diminished loss by convection. This results in increased expenditure of fuel, and at the same time more sickness.

The Air within the Ship.—The contained air of a ship is a part of the atmosphere that has been modified by the ship itself and by stores, heating, lighting, and the men, who live on board and alter the quality of air chiefly by their excreta.

The modern ship is constructed of metal, material having high conductivity. Such material is opposed to the maintenance of the requisite equability of temperature as well as dryness in ships' compartments. Cold air and cold water strongly tend to rob of its heat the contained air in contact with side plates, thus lowering it to the dew-point and causing within the ship that deposition of water known as the "sweating of metal"; and the very large amount of uncontrolled or wild heat constantly generated in fire rooms seeks to invade other parts of the ship not only by means of radiating bulkheads, but also by direct transference of heated air.

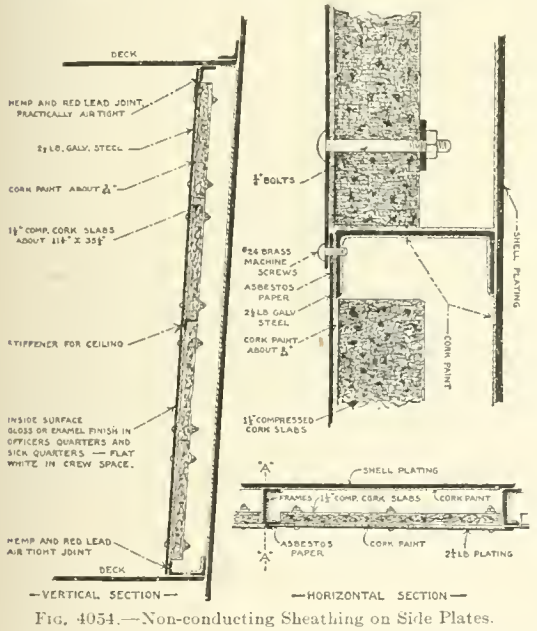

Fig. 4054.—Non-conducting Sheathing on Side Plates.

It is the wild heat of ships that has tended so often to make ship life in the tropics or in hot weather additionally depressing and debilitating, disturbing sleep and interfering with nutrition; and it is the chilling of side plates in cold weather that has often predisposed to bronchitis and like affections especially in those men sleeping in hammocks near them, the human body being intolerant of exposure of large portions of its surface to different temperatures at the same time.

In fact, the first essential from a hygienic point of view in the construction of a modern ship is the utilization of suitable material in a manner to control, limit, or abolish wild heat; and also to greatly limit the chilling of side plates. Upon such measures, together with suitable artificial ventilation, designed as much for the removal of overheated air as anything else, depends the adaptability of ship to climate. In fact, it is in large measure the wild heat of ships, so greatly in evidence in the tropics, that has necessitated the more or less general use of the plenum or supply system of artificial ventilation in naval life.

For limiting the chilling of side plates and for the control of a ship's wild heat, non-conducting sheathing or ceiling is employed in three forms or designs—the unventilated, naturally ventilated, and artificially ventilated. The unventilated, or practically air-tight sheathing, is used exclusively on side plates. It consists of an inside plating joined to side plate by channel irons, thus leaving an air space. This space is only a few inches across and is entirely cork painted when designed to protect crew's quarters, but in sick-bays additional protection is provided by one-half inch compressed cork slabs bolted within the air space to the metal sheathing. With no air movement within the space, advantage is taken of the fact that stagnant air is a very poor conductor. This is observed in any air-bound steam radiator.

Naturally ventilated sheathing is of the same general construction, but, being used solely on radiating bulkheads, it is provided with openings close to the deck and corresponding openings above, discharging into hatch casings, for instance. If there were circulation of air next to side plates there would be deposition of water, but in relation to hot bulkheads the circulating air has its temperature raised and consequently, while carrying away heat, has its relative humidity lowered.

Artificially ventilated ceiling is designed for use on the underside of protective deck in engine rooms and boiler rooms. A much larger air space is left in such sheathing; in a boiler room the space is about twenty-four inches across, but no lining, such as cork or fire felt, is provided. In the engine room ceiling one-half inch of fire felt is used instead of cork. In ventilating such spaces, connection is made with fans, in the engine room with the engine room system of ventilation and in the boiler rooms with the ship's general system, the latter discharging in the casing around the smoke pipe and the former in the engine room hatch casings.

In addition to such arrangements there is considerable limitation of wild heat at its source by non-conducting covering, such as sectional magnesia, and, at times, hair felt put on in sections. Such coverings are used on steam pipes, steam cylinders, exposed parts of boilers, and in a large number of other locations.

Yet all efforts directed to the abolition of wild heat on naval vessels simply secure a considerable limitation which is not sufficient in tropical cruising and which would make the ship intolerable as a habitation if it were not for the measures of artificial ventilation provided. This condition is accentuated by the limited use of the most common of all non-conductors—wood. Such material endangers both ship and men in battle. It greatly increases the danger of fire and, when struck by projectiles, also breaks into splinters capable of causing many wounds. Therefore, below the main deck wood is not used as deck material. The deck is formed of metal plates covered with heavy linoleum that is shellaced from time to time. Such a covering and such a treatment have many sanitary advantages. However, the linoleum, one-fourth inch thick, is laid on the metal deck made smooth by cement to which it is attached by waterproof glue, and, as it is liable to have its connection with the deck broken in places, it requires very careful supervision and prompt repair. Otherwise the contained air of the ship comes under the influence of pockets of filth, perhaps capable of showng results in the form of cerebrospinal fever, follicular tonsillitis, or even diphtheria, such filth being in part the excreta of men living together in great concentration and from which it is necessary for them to be forever parted with little delay.

A crew of 800 men at rest between decks would add to the contained air of the ship in a day about 13,440

cubic feet of CO_2, weighing 1,648 pounds, and frequently about 2,100 pounds of water of which 500 pounds would result from respiration. The 1,600 pounds of water, from skins in warm air, would contain 9 pounds of solid matter, of which three would be chloride of sodium and six organic matter. In the evaporation of sweat the solid matter would remain chiefly on bodies and in clothing, where, without the proper use of water and soap in bathing and laundry work, it would soon greatly alter the quality of the contained air. The odor relatively stagnant air acquires in occupied compartments is chiefly from the skins and clothing of occupants. Of course, there are also intestinal gases and other causes of odors, such as catarrhal conditions and decayed teeth. Sputa, if deposited on decks, can also seriously modify contained air. Any material capable of forming dust under the drying power of air is also capable of greatly adding to its particulate bodies. Certainly the contained air of ships is not free from solid material derived from respiratory passages. Such material is derived from particles of food dropped from the mouth at meals, from sputa improperly placed, from nasal secretions cast off by men not always using handkerchiefs, and from coughing and sneezing, and even talking. Moist particles reaching the air may be deprived of much of their water at once when its relative humidity is low.

Such considerations disclose the interdependence of sanitary measures. One of the objects of ventilation is to prevent concentration of air-borne excreta, including even heat from the human bodies themselves. But no little of man's air-borne excreta is derived from the concentration of material on the surfaces of his immediate environment. There is, therefore, necessity for a strict routine, such as the compulsory use of spit-kids containing water, cleanliness of person and effects, mechanical cleaning of ship without dust or too much water, and frequent airing and sunning of bedding and clothing.

Ventilation on board ship may be considered as essentially the continuous and more or less systematic renewal of air in closed spaces by a properly distributed supply of air in good condition with the object of securing a degree of air-movement itself and dryness, making up deficiency in oxygen, and removing, or sufficiently diluting, gaseous material derived from occupants and stores, overheated air, products of combustion, and particulate bodies that may be present. In this connection it is necessary to realize that a well-ventilated occupied compartment should not only have dry surfaces and comfortably dry air and be free from odor and accumulations of heated air, but also have air-movement without disagreeable draft and have an equability of temperature. A degree of air-movement is a prime necessity without regard to anything else, including air space. Any amount of stagnant air does not meet the body's requirements. The so-called freshness of air depends primarily upon movement through which air overheated by the body and air altered by respiration is more rapidly dissipated. But this must be accomplished without disagreeable drafts, or heat regulation will be seriously disturbed.

There is only one part of a well-constructed ship where there is regularly complete stagnation of air—the double bottom spaces. The air in such spaces may undergo a very peculiar change—a loss of oxygen that may render it very dangerous to man. For the integrity of the ship, the surfaces of such spaces have to be kept in good condition. They are therefore frequently inspected, though ordinarily kept air-tight. Such mixtures as red lead and linseed oil are often used on surfaces within double bottom spaces. The solidification of linseed oil is attended with absorption of oxygen. Air in double bottoms has been found to contain at times only three per cent. of oxygen. No one should be allowed to enter a double bottom, or a boiler, unless a candle burns brightly at all levels. There should be no exploration or work in double bottoms, or in ship's bilges or holds, unless portable ventilating sets are renewing air by liberal supply through canvas ducts attached to fan outlet and led into such spaces.

The practicable degree of natural ventilation on ships need not receive detailed consideration. It can be worked out on general principles. One has to think of a ship as a very large hollow spindle-shaped body partially submerged and divided by horizontal partitions, or decks, and by partial vertical partitions or bulkheads (transverse and longitudinal) into spaces. The large submerged portion, containing boilers, machinery, coal bunkers, and storerooms, can have no side openings. The side openings nearest to the water are air ports that have to be closed in rough weather. On the deck above, when there are broadside guns, large ports can be left open in good weather, but are frequently difficult to arrange in cold weather for ventilation, being much like open windows or outside doors. They are also frequently closed to keep out water. A covered deck across which wind is moving through ports will have its air renewed in a remarkably short time, perhaps 300 times an hour. Such ports are very valuable in hot smooth weather.

In the horizontal divisions, or decks, are hatches, facilitating vertical exchanges of air. When communicating directly with the external air, or when situated directly under others that do, they contribute to ventilation, especially when there is wind which may act either by perflation or downward by deflected currents. There is also more or less movement through them incident to currents established by difference of weight between inside and outside air due to difference of temperature. This is the most valuable force in natural ventilation as it is the most constant when suitable openings are left for its action.

The doors in vertical partitions or bulkheads tend to permit heat and vitiated air to travel from one compartment to another.

Wind makes a great difference in contained air of a ship. This is seen especially in fire rooms when coal fires are under natural draft. Then an enormous quantity of air enters fire rooms through large metal ventilators having in the air movable bell-mouthed cowls that are kept turned to the wind. However, such air is never distributed, as the direction of its movement is greatly dominated by the fires. Entering a hot space it drops, by virtue of greater weight, to the floor plates and forms a well-defined stream line to furnace intake where a degree of vacuum tends to exist as result of ascent of hot gases in smoke pipe, and aspirating effect of wind at top of pipe. The hot surfaces within the fire room continue to raise the temperature of all the air above the furnace intake and such heated air does not show marked tendency to leave through high openings provided, as the demands of the fires may more or less balance the tendency to vacuum by its egress. This situation is lessened by having a space between inside and middle sheets of boiler uptakes and connecting the space by openings into fire room. This causes a circulation of air from fire room along the whole length of stack to the top. Conditions can also be greatly improved by using blowers in assisted draft, or by closing all natural openings and running the fires under forced draft. Both of these measures increase coal consumption per furnace. There is, however, a system of forced draft modified by a degree of artificial exhaust that has given very satisfactory results.

When men are working in hot air they get along well so long as the wet bulb is not above 81° F., but when that bulb approaches 86 to 88° F. there is distress or, at least, strong disinclination to work. In a navy, heat prostrations often take the form of exceedingly painful cramps of the voluntary muscles.

In a navy, the term artificial ventilation is confined to the renewal of air of spaces by use of ventilating fans and pipes or ducts.

In the illustration showing the fan details is seen the character of runner or wheel employed. The wheel is installed within the casing and by electric motor is made to revolve rapidly on a horizontal axis. Air is admitted to the casing and center of the wheel on the side opposite the motor. The revolving wheel, in accordance with the law of centrifugal force, necessarily discharges air from its periphery, and then, increasing the pressure within the casing, causes air to be discharged at the fan or case outlet. Such a fan is essentially a centrifugal pump. Its best working pressure is usually about five pounds to the square foot.

The maintenance of that pressure within the fan-casing causes the air to leave the fan outlet with great rapidity, and to rapidly fill the discharge pipe which is there fitted to the casing. Such a pipe or main is led overhead from the fan into and along the space to be ventilated, and in the space it is provided with branches coming off repeatedly and each having a specially constructed terminal through which the air is discharged into the space. In order that the air so supplied may be without vitiation, another pipe terminating in the open air, is led down to the fan and fitted at the casing over the opening near the center of the wheel. Such a fan is therefore drawing air from the outside and delivering it into the space or compartment. It is therefore working on the plenum or supply system.

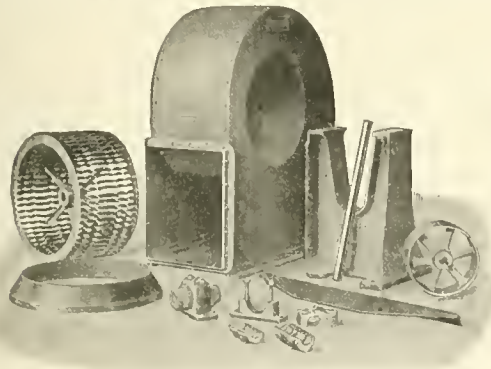

Fig. 4055.—Sturtevant Multivane Fan. Details of casing, runner, pedestal, and bearings.

However, it is quite evident that the action of the fan is reversed if the pipes at the fan are changed, the pipe from the fan outlet going to the open air and the pipe from the space going to the casing at the center of the wheel. A fan so installed draws air from the space and discharges it into the open air. With such an installation a fan works in the exhaust or vacuum system of ventilation. Such consideration declares one of the differences between a peripheral discharge fan and a disc or propeller fan. A disc fan, working to supply air to a space, can be made to extract air from the same space merely by reversing the propeller, but, as a peripheral discharge wheel or runner must always discharge or throw off air from the periphery in whatever direction it may be turned, its action in exhaust or supply depends upon leads of piping. A disc fan is not for mechanical reasons suitable for use with extensive piping.

The living spaces of a ship are ventilated by supply. A pressure at the fan outlet of five pounds gives an initial velocity in the main of 2,000 feet a minute. Early branches come off at any angle less than forty-five degrees, but the angle increases toward the end of the main until the last branch is at ninety degrees. Round piping is used as it gives the least friction for sectional area. Contractions are made in main when by effect of branches the flow has been reduced to 1,200 or 1,500 feet, such contractions being sufficient to restore original velocity (2,000 feet). The standard velocity at terminals of branches is 1,000 feet a minute. The terminals may be cone shaped in order that a greater velocity in the branch may be reduced to standard by increasing sectional area of terminal. Bends in piping are avoided as much as possible. However, any bend is made as part of a circle. Thus even a right-angle bend if properly made causes an increase in friction equivalent to only three feet additional length of the branch. The old formula, showing that a bend of ninety degrees reduces the flow to one-half, is not at all applicable under present conditions of artificial ventilation.

While the artificial ventilation of a ship is generally by supply, there are spaces under the exhaust system and other spaces under both systems. The exhaust system is necessary for water-closets to prevent the dissemination of odors, and in certain greatly overheated spaces (dynamo rooms and steering engine rooms), when there is no direct outlet into the air, both systems are installed.

With such apparatus as has been described the following are the approximate air renewals based upon gross capacity: Officers' quarters and crew's space, berth deck, outside of armor bulkheads, in from ten to twelve minutes, and inside such bulkheads in about four minutes; water-closets and crew's head, six minutes; storerooms and passages, eight to twelve minutes; magazines, six to eight minutes; engine room and steering compartments, two minutes; evaporator rooms, two and one-half minutes; dynamo rooms, three-fourths of a minute.

On a large ship there are thirty or more fans of various sizes and more than 300 louvers or branch terminals. The fans differ in full speed, varying from 400 to 2,000 or more revolutions per minute, but a controlling panel is provided by which speed can be reduced twenty per cent. The large number of fans is necessitated by water-tight bulkheads which for the safety of ship should not be pierced by air ducts. Therefore, each part of a ship divided off by such bulkheads has its own independent system of ventilation. The ventilation by independent systems gives assurance of a much better apportioned supply, as the air ducts are shorter.

To anyone who has lived on ships in tropical waters the advantage of the plenum or supply system of ventilation for living quarters is very apparent. The direct system gives very positive results not only in quality of air supply, but also in providing agreeable drafts and in removing heated air. But, in cold weather, if the air taken from outside the ship be delivered at outside temperature, the degree of ventilation will be intentionally diminished, as otherwise the draft of cold air would be disagreeable and even dangerous. Even in the tropics there is advantage in apparatus designed to cool air supplied, and certainly in cool weather there is necessity for warming the air supply.

Much of this situation depends upon the small air space per man on a vessel of war. It is not merely an adequate air supply that is required in ventilation, but also distribution of air. To man a ship in battle requires a great concentration of men. This necessarily means a crowded ship in quarters. With all hands in their billets there is frequently not so much as 200 feet net air space per man. With a watch on deck the average may be regarded as not exceeding 350 cubic feet. Lack of sufficient cubic space is the most important obstacle in any attempt at proper ventilation, especially as, even with the greatest practicable number of terminals, air for many has to pass through the 200 or more cubic feet occupied by one.

To facilitate distribution of air and limit direct drafts, adjustable elbows or terminals are used on branch ducts in living quarters.

In such a terminal all joints are arranged to be movable. Any section can be turned on any other section. Thus the curve can be reversed in part or in whole, or the elbow can be converted into a straight pipe. By this means the air can be delivered at any angle to meet either individual requirements or the demands of the space as a whole especially corners, for air distribution.

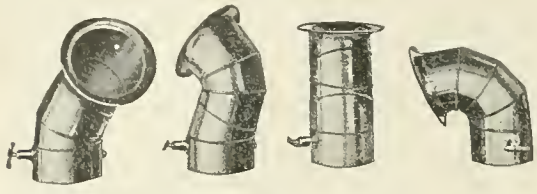

Fig. 4056.—McCreery Sectional Adjustable Elbow or Terminal.

For cooling air supply in hot weather, and also in removing dust, especially cinders that tend to collect in air ducts, an air washer or cooler can be employed.

The air is drawn through the cooler by the fan. On entering the cooler the air passes four successive curtains of spray, and then through eliminators designed to abstract free water or mist. A refrigerating coil can be used to cool the spray water, but the apparatus is intended to utilize water from over the side, constantly supplied by pump, to cool air, thus depending upon difference of temperature between the water and air.

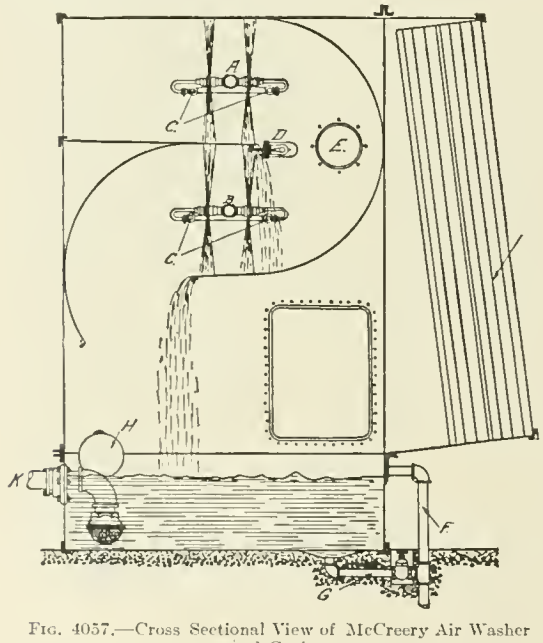

Fig. 4057.—Cross Sectional View of McCreery Air Washer and Cooler.

For heating air supply a thermo-tank is employed. The air is forced through the tank by the fan. The thermo-tank is a system of steam coils in a metal tank. There are generally independent coils, one or more being used as required by varying temperature of outside air. When air passes through such a tank its relative humidity is necessarily lowered as its temperature has been raised. Should the heating area within the tank be designed for heating the space, thus combining heating with ventilation, the supplied air would have to be raised to relatively high temperatures with corresponding dryness on delivery. The temperature at louvers or terminals would have to be higher than that of the space as a whole, and, therefore, the warm air drafts would be objectionable, not only on account of temperature, but also on account of its extremely low humidity. It is, therefore, considered that such a plant should be designed for ventilation and not for heating, with means of adding water vapor as required, and with automatic control of heating area, the air to be delivered at 65° to 70° F. and at about 55 relative humidity, or with about four grains of water in each cubic foot. If the minimum temperature of air outside of ships can safely be regarded as 0° F., then the maximum amount of water to be added to each 1,000 cubic feet of air delivered at 70° F. and 50 relative humidity would be 0.57 pound.

Various methods have been suggested for humidifying air heated in thermo-tanks. The simplest way is to utilize the coil-steam for that purpose, the control being automatic and regulated by the varying humidity itself, acting upon a suitable hygrometer. However, this question is in an experimental stage, and the thermo-tank coil steam, derived from dirty boiler water, when added to air may be liable to cause unpleasant odor. Other methods are water sprays, or dropping water on steam pipes, or securing steam from a suitable evaporator.

In determining the degree of efficiency of a ship's ventilation, the CO_2 observation is necessary, as well as calculation of air supply by use of anemometer. But such work should be associated with adjustment of crew through knowledge of number of occupants of each living compartment and of net air space per man. It is also necessary to calculate area of inlets and outlets per man and, by multiple CO_2 observations, determine whether the number and location of such inlets and outlets are proper for a distribution of the air supplied. It is distribution of air that counts in ventilation. The amount of air that goes into and out of a space is often no measure of the degree of ventilation of that space.

A method of making a CO_2 observation is as follows: Note temperature of compartment and height of barometer. Take a clean and dry glass jar of known capacity, or a number of such jars when making multiple observations, and, selecting location, renew the air in the jar with bellows. Then put into the jar 60 c.c. of clear lime water from stock. Stopper the bottle and tie over the stopper a piece of sheet rubber. Shake the jar thoroughly and put it aside for at least eight hours. At the expiration of the time, determine the alkalinity of 30 c.c. of lime water from stock by noting the number of cubic centimeters of an oxalic acid solution (2.25 grams of crystallized acid in water to one liter) required for neutralization, using a few drops of neutral phenolphthalin solution as indicator. Treat 30 c.c. of lime water from jar in same way. Take the difference in number of cubic centimeters required in each case and multiply by 0.8. The product is the number of cubic centimeters of CO_2 at standard temperature and pressure in the amount of air in the jar. It then remains to express the amount in parts per 10,000 of air at standard temperature and pressure (32° F. and 29.92 inches).

For example: Capacity of jar, 4,460 c.c. Barometer, 29.80; thermometer 72° F. Difference in alkalinity is 6.

$4{,}460 - 60 = 4{,}400$ = net capacity of jar.

$\frac{29.80 \times 4{,}400}{29.92\,(1 + 40\,(0.0020361))} = 4{,}052.31$ = corrected air in jar.

$6 \times 0.8 = 4.8$ = c.c. of CO_2 in air of jar.

$\frac{4.8 \times 10{,}000}{4{,}052.31} = 11.8$ = parts CO_2 in 10,000 of air.

In making simultaneous CO_2 observations, dif-

ferences in results give clear indications of variations in distribution of air supply that may lead to increasing number of inlets, or changes in their location. Such observations show whether pockets of foul air are present, as in corners or parts distant from inlets. They also assist in the management of adjustable terminals.

The anemometer used in a navy is like that used in civil life. It measures the velocity of air or the number of lineal feet traveled by air in a given time. Knowing the velocity and having ascertained the sectional area of inlet (or outlet), the amount of air entering or leaving is the product of one by the other.

The propeller blades of the anemometer are turned toward the air current and, in the case of terminals of four inches or less in diameter, the instrument is placed about two-fifths of the distance from the sides to secure the mean velocity, as the air at the center of the current moves with the greatest velocity. In terminals over four inches in diameter it is customary to obtain the record by shifting the position of the instrument every thirty seconds until it has occupied five different locations during the run of two and one-half minutes, as is shown in the following diagram:

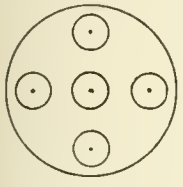

Fig. 4058.—Varying Positions of Anemometer in Louver.

In this method the difference between the readings made before and after the run is multiplied by two-fifths to get the mean velocity per minute.

Such work enables one to determine whether a given installation comes up to specifications in regard to velocity of air at terminals and also in regard to renewals of air in spaces within designated times. It also determines, as a cruise progresses, what degree of deterioration has occurred in mechanical efficiency from dust in pipes and other causes.

The condition of air as represented by vibrations or waves in production of noise or concussion is of great importance on ships during action or even during target practice. Such condition of air is capable of doing excessive damage to persons and things, the danger to the individual increasing as one tends to occupy a position in advance of the plane at the muzzle of the gun vertical to the line of fire. Under such circumstances there may be nausea with or without a ruptured drum, a cap may be blown or drawn from the head, and even cotton wool placed for protection of drum may be withdrawn by the partial vacuum following air compression.

Permanent deafness can follow exposure to the shaking caused by a single explosion, the drum being intact, the terminals of the auditory nerve having been injured. Rapid firing tends to produce tinnitus and temporary deafness even when the auditory apparatus remains intact. Long-continued repeated vibrations may cause permanent deafness.

However, as a rule, the conditions are such as to produce chiefly ruptures of tympanic membranes—a result of sufficient importance to demand serious consideration whenever a crew is going either into target practice or action.

It is undoubtedly true that absorbent cotton packed loosely in external auditory canals, greatly diminishes the number of ruptures. An artist's modeling material, known as plasticine, has also been used together with cotton wool. A piece of the dough about the size of a walnut is thoroughly kneaded with about fifty grains of the cotton wool. The mass is then halved and a piece fitted into the meatus of each ear. The Elliott's ear protector is an ingenious device of much merit. It consists of a celluloid ball and wing. The ball fits into the meatus and the wing goes back against the antihelix. Through the apparatus is a tortuous canal that allows hearing but prevents access to the drum of too direct vibrations.

The Submarine.—The submarine has now obtained a permanent place in navies. But that type of vessel is in a peculiar stage of evolution and there are certain features of its hygienic requirements that are too closely associated with military requirements for open discussion in detail.

However, during submergence the situation of each member of the crew is theoretically much like that of an animal in a corked bottle, so far as air vitiation by the animal is concerned, but in addition there are alterations of the contained air as result of battery fumes and, under conditions of accident by which buoyancy is lost from admission of salt water, there may be generation of chlorine gas. If gasoline be stored on board as fuel for surface propulsion, there is additional danger in fumes from that source. In the earlier submarines there was also serious trouble from carbon monoxide resulting from occasional back explosions in using gasoline.

The net air space per man in a submarine may be about 300 cubic feet. The CO_2 excretion per man is usually considered as 0.7 cubic foot per hour. His consumption of oxygen would be increased as the CO_2 accumulated and may be regarded as 0.9 cubic foot per hour. It is found in relation to air in a diver's suit that there is beginning discomfort when the CO_2 exceeds three per cent. The breathing would tend to become labored in a submarine as that percentage increased. If three per cent. be regarded as the ordinary maximum limit, then the 300 cubic feet initial air space would permit an ordinary submergence of about twelve or thirteen hours, if the CO_2 were more or less uniformly distributed through keeping the contained air in motion with fans.

Without regard to CO_2 content, poverty of air in oxygen as result of respiration would ultimately cause symptoms. If the oxygen be reduced to twelve per cent. by volume such symptoms can be expected. Three hundred cubic feet of air contain about 61.3 cubic feet of oxygen. If reduced to twelve per cent. the oxygen is 36 cubic feet—a loss of 25.3 cubic feet per man before there are marked symptoms of oxygen poverty. Therefore, if the withdrawal of oxygen is 0.9 cubic foot per man per hour, there could be an ordinary forced submergence of about twenty-eight hours on 300 cubic feet of net air space, if the CO_2 were removed. Consequently, the chief problem in relation to the contained air of a submarine during submergence is the removal from the air of CO_2 and other vitiating gases, such as are derived from storage batteries, rather than the addition of oxygen, which, however, can be readily supplied.

In theory the air pressure within a submarine boat could not be expected to vary greatly, but, as a matter of fact, the pressure is rather greatly increased, as a rule. In all submarines there is military necessity for a compressed air system and its pressure is so great that some leakage occurs. This mechanical defect is of hygienic value and adds to the possible length of submergence. Besides, if a submarine is compelled to prolong submergence beyond the limits dependent upon initial net air space, the compressed air system can be used, circulation being secured by pump acting against water pressure. Under such circumstances a boat could be kept in a state of submergence from forty to fifty hours, especially as the CO_2 content can reach five per cent. or more without producing unconsciousness, although causing much distress.

The storage batteries of a submarine are charged at the surface. During the process a large quantity of hydrogen is evolved, and hydrogen and air can form a highly explosive mixture. Therefore, the boat should be carefully ventilated by fan during the process of charging and also for some time after the accumulators have been charged. Bubbles of hydrogen are also set free from battery plates at other times, especially during bad weather.

Sulphuric acid fumes from accumulators have also

caused trouble during submergence, and chlorine gas has caused death during a forced submergence. If through accident or injury salt water gains access to the battery, or even comes to the terminals of any large circuit, chlorine gas will be given off.

Carbon dioxide is also regularly added to the air by storage batteries in quite appreciable amounts. The whole battery outfit may add as much as 0.7 cubic foot per hour. Some other gases, including carbon monoxide, are produced by the battery outfit in very small amounts. However, radical changes in character of battery for use in submarines are not distant.

Gasoline in submarines causes a well-recognized danger. The danger of carbon monoxide from back explosions was overcome by the lead of induction pipes into a crank chamber. Combustion gases are thus taken out of the induction tank by engine induction.

But submarines are tending toward great increase in size, and heavy oil engines are replacing gasoline engines. Besides, practicable methods are being evolved for working over the contained air during submergence by which CO_2 from persons and gases from batteries are removed. However, fuel oil itself is not free from troublesome fumes.

Increase in size of submarines leads to greater comfort of crews on surface as well as during submergence. Fortunately electricity for lighting and heating does not vitiate air, and larger conning-towers and more superstructure make for increased comfort in surface work.

However, duty on a submarine is of a character requiring men who come up to a high physical standard. The physical requirements should be about those prescribed for the diver. The work tends to develop functional nervous disorders, and the life itself is uncomfortable on account of food difficulties, the sensation of dampness caused by increasing relative humidity, the marked variations in temperature to which the body is exposed especially when the submarine is in cold water, and the effect of cold side plates upon the body during sleep. This situation should require relief crews and extensive utilization of a parent ship, as well as careful construction of the submarine itself.

The Diver.—The importance of the diver's work is rapidly increasing. The range of diving operations extends to considerable depths and relates even to submarines themselves when through accident they are unable to come to surface. Also the increased use of expensive torpedoes in practice would rather often lead to their loss but for the diver's services. These are some of the directions that have led to close study of deep-water diving, especially by a British admiralty committee which has made that service a leader in this subject of vital importance. Descents of 210 feet have been made in that navy without inconvenience under service conditions. In the United States navy much greater depths have been attained. The question relates first to air supply and then to a method of decompression that will prevent "divers' palsy" or caisson disease.

A diver is in an incompressible helmet joined below to a rubber or compressible dress having rubber wrist rings. Air is supplied by tube connecting with the helmet and, at surface, with one or more pumps. Air leaves the helmet against the water pressure and by escape valve. The valve is set so that it only opens when the air pressure within the diver's suit somewhat exceeds the water pressure without. It is then there is movement of air through the helmet—that is, ventilation. The problem is to secure a sufficient movement of air at all times. This involves the determination of the requirements at the surface and then the utilization of means to deliver to the diver that same volume of air when measured under the pressure at the bottom. In other words, the necessary air supply measured at the surface must increase in direct proportion to the diver's absolute pressure.

As the volume of a gas varies inversely as the pressure, it is evident that a pump delivering one-tenth of a cubic foot of air at the surface on each turn of its wheel would only deliver one-twentieth of a cubic foot on each turn to a diver at a depth of thirty-three feet, or at one atmosphere additional pressure. Therefore, whatever may be the requirements at the surface, the supply would have to be doubled to meet the requirements at a depth of thirty-three feet. And so at a depth of 198 feet there would have to be supplied seven times the volume required at surface. Non-recognition of this fact would defeat all attempts at deep-water diving, as it would lead to the death of the diver. A given volume of air must pass through the diver's helmet every minute or there will be unconsciousness from CO_2 suffocation. The dress must be full of air to prevent squeeze from water pressure and at the same time there must be adequate ventilation.

It appears that a diver at rest in his suit excretes 0.84 cubic foot of CO_2 per hour and about 2.7 when at work. He does not feel respiratory discomfort until the CO_2 is in excess of three per cent.

Applying such data to the well-known formula, $D = \frac{e}{p}$, it is evident that, as $e = 2.7$ and $p = 0.03$, the amount of air in cubic feet per hour required to keep the respiratory CO_2 of the diver at three per cent. of the contained air is 90. In view of the relatively small amount of air in the suit at any given moment and of the fact that the diver is sent down for the purpose of doing work, it is necessary for reasonable safety to assume that his excretion of CO_2 is the maximum and, consequently, that 90 cubic feet of air *measured at the diver's pressure* is the minimum amount per hour that should pass through his helmet.

Then, considering that the minimum air supply at the surface is 1.5 cubic feet per minute, the corresponding supply for any given depth can be computed by using the following formula: $S = 1.5\ (1 + F\ (0.0303))$. In which S is the required air supply for the depth in cubic feet per minute measured at the surface, and F is the depth of the diver's helmet in feet below the surface. For instance, what should be the minimum air supply in cubic feet per minute measured at the surface for a diver at 30 fathoms? As 30 fathoms equal 180 feet, the formula results as follows:

$S = 1.5\ (1 + 180(0.0303)) = 1.5 \times 6.454 = 9.681$ cubic feet per minute. That is, as the diver in 30 fathoms of water is under an absolute pressure of 6.454 atmospheres, there must be supplied him 6.454 times the 1.5 cubic feet per minute required at the surface in order that 1.5 cubic feet per minute may reach him when measured at his depth or pressure, the required air supply increasing in direct proportion to absolute pressure.

By using the formula given, a table showing the required air supply for each depth can be readily constructed and also in the same table can appear the number of revolutions of the fly-wheel of a standard pump, or of the fly-wheels of the required number of pumps, to furnish the calculated air supply. It is not easy to maintain more than thirty revolutions of the wheel per minute and, therefore, if a pump with two double action cylinders delivers at each revolution of the wheel two-tenths cubic feet of air at the surface it would only satisfy the requirements of a depth corresponding to six cubic feet per minute delivered at the surface, without allowance for leakage. But a pump in good condition is assumed to have a leakage of twenty-five per cent. for a depth of 132 feet, or sixty pounds excess pressure, and a proportionate leakage for depths greater or less. Consequently, while such a pump would give a

theoretical air supply on thirty turns for a depth of ninety-nine feet, it should not be considered in practice capable of delivering six cubic feet at that depth, 36.9 turns being actually required. Therefore, for that depth two pumps would be designated in the table, each to have 18.45 revolutions per minute. A metal junction piece should be provided for using two or three pumps at the same time.

It is necessary for a diver to have his suit filled with air all the time, otherwise he will be subjected to a squeeze that takes life with great rapidity. If the calculated air supply is provided the required inflation of dress is always secured. But, if a diver in going down gets ahead of his air supply, he will be subjected to a squeeze corresponding to the depth. Should a diver, for instance, working on a ship's bottom be allowed to fall several fathoms without a correspondingly rapid increase in air supply he would be subjected to a squeeze that could readily be fatal. Such a squeeze at a depth of ninety-nine feet, for instance, would be terrific, forty-five pounds to the square inch excess pressure.

Very recent work in the United States Navy has demonstrated the feasibility of using a compressed air system for supplying air to a diver descending in deep water. A reducing valve is placed between the high-pressure accumulator and the low-pressure accumulator, the air going to the diver from the latter in which, however, considerable excess pressure has to be maintained. With this method it is also necessary for the diver himself to have control over the amount of air supplied. That is accomplished by use of a needle valve (the Stillson air-control valve) placed on the diving hose and fixed to the left side of breast plate. Using such an arrangement, a depth of 274 feet was readily attained, and more recently a depth of 306 feet has been attained a number of times—a remarkable record in deep-water diving.

While a proper air supply will always allow a diver to quickly descend in deep water and perform his work without discomfort, his ascent requires careful management to avoid serious trouble resulting from time under excessive air pressure during which he has absorbed a considerable quantity of nitrogen that, in leaving him under diminished pressure, tends to form bubbles within the body and thus produce what is known as caisson disease.

The body requires about four hours to become fully saturated with nitrogen at any given pressure. Therefore, it is normally always saturated with that gas, containing about one liter measured at standard, or one atmosphere. But, in diving the body is subjected to increased air pressure and, therefore, absorbs an additional amount of nitrogen, the amount increasing directly with the pressure, provided it continues sufficiently long to permit saturation at that pressure. But the volume will remain the same so long as the pressure is continued. For instance, a diver, if saturated with nitrogen at a depth of 198 feet, will only contain one liter of that gas, but it will be one liter at seven atmospheres' absolute pressure and, therefore, that liter at surface will tend to become seven liters. He would then be somewhat like an uncorked bottle of soda water.

Different tissues of the body saturate at different rates and at saturation contain different amounts of nitrogen. Those tissues that saturate rapidly desaturate rapidly, and *vice versa*. It is the parts of the body well supplied with blood that saturate rapidly. A diver decompressed too rapidly can arrive at the surface in apparently excellent condition and later develop caisson disease, as bubbles have formed in adipose tissue and spinal cord, such tissues desaturating slowly. In all fatal cases bubbles are in the blood, and in rapidly fatal cases they appear in the right side of heart and in the pulmonary vessels. In such cases dyspnea appears as a symptom in a few minutes after reaching the surface. It is generally preceded by stomach pains, as is also often the case in the paralytic form which is ushered in by the sensation of pins and needles. In the pulmonary cases unconsciousness quickly supervenes. Nothing can be done for any of these cases at atmospheric pressure. Immediate recompression is demanded—resubmergence in sixty to ninety feet of water with outlet valve open and with air supply for depth. But all such cases should be avoided by proper decompression. Even "bends," which is the third type of caisson disease, and which, as the others, requires recompression, can be avoided to a great extent, especially by keeping the joints in motion during decompression.

The maxim in decompression is that bubbles do not form within the body unless the internal nitrogen tension is more than twice the external tension. In other words, at whatever pressure the nitrogen was acquired the diver can come up to one-half that depth without danger, and, there, working his arms and legs to facilitate desaturation, can begin to free his body of excess nitrogen to the very best advantage. It also follows from this that from a depth of about thirty-three feet a diver can come at once to the surface without danger however long the submergence may have been.

As it takes four hours for the body to become fully saturated with nitrogen at any given pressure, the details of decompression in deep-water diving will depend upon time from surface to beginning of ascent. In that relation the British Admiralty Committee on Deep-water Diving has prepared tables giving the required stoppages in minutes at different depths corresponding with each depth to thirty-four fathoms. As an example of variations depending upon time of submergence, it may be noted that a diver descending rapidly in twenty-two fathoms and starting to ascend in twelve minutes, can be brought to the surface in sixteen minutes, and only three stops would be necessary; but if he were to remain down an hour, five stops, each of longer duration, would be required, and ninety-eight minutes would be expended in order to secure safety or freedom from danger. In practice the time on the bottom should be limited to a period that permits a safe decompression in thirty minutes.

A diver should pass a special medical examination. He should be a steady man, free from obesity, and with good heart and lungs, good kidneys, and no degeneration of arteries. There must be no middle ear disease or catarrhal condition that interferes with patulousness of Eustachian tubes. He should not be older than forty-five and should not go down after a full meal or unless in good health at the time. The user of tobacco in excess is barred and also the drinker. He should know how to open his Eustachian tubes frequently during the descent. Hemorrhage, due to unbalanced pressure on drums, stops at the surface. The serious hemorrhage is that due to squeeze which may result from lack of proper attendance in relation to breast rope and pipe, or even in the management of the ascent should a diver be allowed to come up above his stopping place and be made to descend without proper air supply.

A navy should have a complete diving manual that should be the basis of thorough practical instruction. It should give the physiology of diving, the methods of testing pumps each quarter, and the management of diver and of apparatus in detail, including tables of required air supply and of decompression.

Light without the Ship.—Sunlight is capable of causing a marked disorder of the skin called "sunburn." Men working in radiant heat, as in fire rooms, acquire pallor in contrast with the tan of the deck force. Persons working between decks become pallid and show greater tendency to develop tuberculosis. Glare causes disagreeable eye reflexes. Ships should not be painted white and men should not have white uniforms for tropical work, as each thus tends to offend

the eyes of his neighbor and in landing parties becomes a good target for the enemy's fire. In the sun a dark coat acquires much more heat than one of light color. In the tropics a naval man should have clothing of some light neutral tint selected after extensive experimentation along required military lines.

A crew exercised by drills in the extreme heat and light of the tropical day will not have good health. Light drills of short duration morning and evening are beneficial, but heavy drills should be confined to early morning hours, or omitted.

Awnings in the sunlight of warm climates greatly add to a ship's welfare. But such awnings should be furled or triced up for a time in the early morning and late evening in order to facilitate movement of air within the ship. In tropical countries they are necessary to protect the crew from rain at night, not only those on deck duty, but also those who seek to sleep on deck away from the heat between decks. A double awning is advantageous in diminishing both heat and glare, especially if, with the air space secured, the lower awning is suitably tinted.

Boat keepers at booms or astern should always be under awnings in a hot climate.

Light within the Ship.—So far as natural illumination is concerned the tendency between decks is toward the diminished illumination opposed to cleanliness, good spirits, and the proper use of eyes. Air ports, hatches, gun ports, and deck lights are the usual sources of light.

Diminished light favors the life of the tubercle bacillus and increases the difficulties of securing cleanliness. It requires much greater care in the disposal of sputa, pathogenic organisms tending to flourish in dark corners. This is especially true of all parts of a ship not under continuous observation. A sailmaker's mate should not be allowed to do most of his work in a storeroom. Small stores should not be served out at storerooms. Men engaged in cleaning bilges or in breaking out storerooms should be under supervision, not allowed to chew tobacco at such times, and warned to avoid expectoration or any nuisance. Every brig should have its air port and spit-kid and have its surfaces wiped over with corrosive sublimate solution before it is occupied by another prisoner. A man in confinement requires more frequent inspection of person and locality than others.

With marked diminution in degree of natural illumination, artificial illumination of ships is of special importance. There are spaces of a ship so inadequately supplied with daylight, or so entirely deprived of it, that artificial light is required at all times. It is always a problem to use such light to best advantage with least injury to eyes, especially in crew spaces and officers' quarters. It is always a scientific subject everywhere, requiring much expert knowledge for its application in any given case.

Aside from securing light on ships without vitiation of contained air, it is evident that at the present time only a filament lamp is clearly suitable for the general illumination of a vessel of war—high-efficiency low-watt incandescent lamps which on account of their high intrinsic brilliancy, or intensity per unit of glaring surface, are a source of danger to eyes unless the filament is hidden from direct view and the light softened to the point of abolishing glare. A bare lamp should have no place in the illumination of any occupied space, and yet on a ship an indirect system of lighting is not practicable.

In an indirect system of lighting the direct light near the lamp is received by a reflector and diffused by being thrown upward upon ceiling whence it is still further scattered by reflection to walls and lower parts of the room. Such a system is of great advantage in the wards of a hospital. In direct lighting, opaque shades are placed above lamps and the light thrown directly downward, leaving the rest of the room in such comparative darkness that in looking up from work under such a lamp, or in renewing work, there are iris shocks that are opposed to the continuance of good sight. On a ship the integrity of reflectors in indirect lighting would always be in danger and the illumination lost for power expended would be too great. Nevertheless, while the artificial illumination of ships must be in great part by the direct system, it is necessary to combine with it a method of obtaining good general illumination through the diffusion of light by shades or globes of prismatic glass constructed on the Holophane system. Such shades and globes give the minimum loss of light by absorption consistent with fair diffusion, and they enable work to receive that slightly increased illumination over surrounding objects which is agreeable to the eye, and which is lacking in indirect lighting.

As the removal of the light source from the ordinary field of vision is of prime importance, there is great advantage in locating lamps relatively high, that is, above horizontal vision and thus well above all desks and mess tables. Desk lamps should be abolished. They leave too much to the discretion of users, being utilized to make up by increased illumination for defects of accommodation. They cause marked contrast and multiply the necessity for rapid iris accommodation. A lamp utilized for desk work should be operated from one position located at least three feet four inches above the desk and by calculation to furnish the required foot-candles on the work.

However, in crew spaces there is difficulty in locating a sufficient number of lamps overhead, as the deck overhead is cut up by beams and occupied by mess tables and benches suspended there when not in use, and by piping. Besides, there is reason for some bulkhead lamps for use as standing lights, or after taps when overhead lights would be very annoying, a crew swinging in hammocks from the deck above and, therefore, very close to any lights in that locality. But a deck illumination obtained largely from bulkhead lamps is undesirable, especially if the filaments are bare. The eye does not resent an intrinsic brilliancy below six candle-power per square inch, but a carbon filament has 400 and a tungsten 1,000. Even with a carbon filament in plain view in each 500 cubic feet of space, the retina shows exhaustion and objects in the space seem relatively dim. There is an expenditure of light disadvantageously and harmfully. Certainly of all lights on a ship, bulkhead lamps should be enclosed in prismatic glass. The first essential in all electric lighting is to soften the light and remove the filament from view and at the same time secure good general illumination.

In crew spaces there should be location of some overhead lamps with view to utilization of the requisite number of mess tables for playing checkers or other games and in reading or writing. The arrangement of such tables should be as much a part of the routine as the placing of lights for a band.

In officers' quarters stalactites are a good modification of the prismatic globe for illumination of mess tables, the lamps being placed overhead and arranged over the midline of the table.

In staterooms and offices and over reading tables, the satin finish prismatic bowl reflector with frosted tip tungsten lamp is a satisfactory fixture.

For all interior surfaces of living spaces it is important to have the finish in light buff, or what may be called a white stone yellow. White causes glare and any blue or red tint is harmful. In a working room any dark color causes violent contrasts and is opposed to general illumination and economy. Furniture should have the tint of the lighter woods. All such details are of very great importance.

Of the high-efficiency or low-watt lamps, the tungsten is the most satisfactory at this time for utilization in the scheme of which general outline has been given. It is operated at a stated efficiency of 1.25 watts per candle in contrast with the 3.1 watts of the carbon filament. This means more than double the light on the same expenditure. In the tungsten, candle-power is also less affected by change of voltage. It, therefore, gives a steadier light. Flickering or varying brilliancy in a lamp is deplorable. It also gives a light of better quality, being much whiter than the ordinary carbon filament. And what is of very great importance, it maintains its efficiency, as the filament burns out, as a rule, before the candle-power has dropped twenty per cent. Too often the carbon lamp is found in operation when its efficiency has dropped so low that eyes are strained as result of insufficient illumination. The tungsten thus acquires great value because it requires little or no attention in renewals. It simply has to be renewed when it burns out.

The tungsten filament is also suitable for use in a frosted bulb. No variety of carbon filament should be used in a frosted bulb, as the deposit of carbon soon greatly lowers the efficiency. A frosted carbon incandescent lamp falls to eighty per cent. of its initial candle-power in about one-half the time taken by a corresponding plain bulb lamp, although the total life of the lamp is the same.

The unit of luminous intensity in the United States is the British candle. It is a sperm candle burning

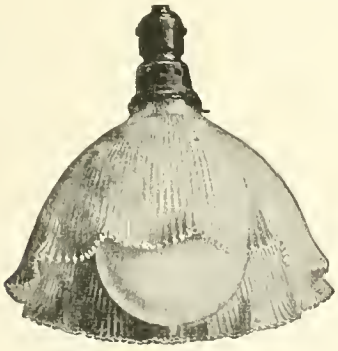

Fig. 4059.—Tungsten Lamp with One Variety of Bowl Holophane Reflector.

120 grains an hour. This is regarded as a one-candle-power light. In photometry of electric lamps it is common to take the Hefner lamp as the primary standard and to reckon 1 Hefner = 0.88 British candle.

The amount of light on a surface is expressed as foot-candles. For instance, the illumination of a point on a surface one foot distant from a standard candle, or a one-candle-power light, is one foot-candle. If it were a sixteen-candle-power light, the illumination at one foot would be sixteen foot-candles; at two feet, four foot-candles; and at four feet, one foot-candle, the intensity varying inversely as the square of the distance. A standard desk illumination is 2.6 to 3 foot-candles.

It appears that if a light is assumed to be a point emitting rays equally in all directions, the foot-candles can be readily calculated for any location, all the data required being candle-power and distance from light. But electric lamps do not give light of same power in all directions, consequently in calculating illumination for any given location it is necessary to have the distribution curve of the lamp, or the curve showing candle-power at every angle.

Fig. 4059 is an illustration of a tungsten lamp with a variety of bowl holophane reflector.

Fig. 4060 is the vertical distribution curve of such a lamp and reflector.

In the case of this fixture, suppose it is desired to know what the direct foot-candles at a given point on a desk would be, the lamp to be elevated four feet above the plane of the desk and the perpendicular from the lamp to meet the plane of the desk at a distance of two feet from the point to be illuminated and on a line making an angle of forty-five degrees with

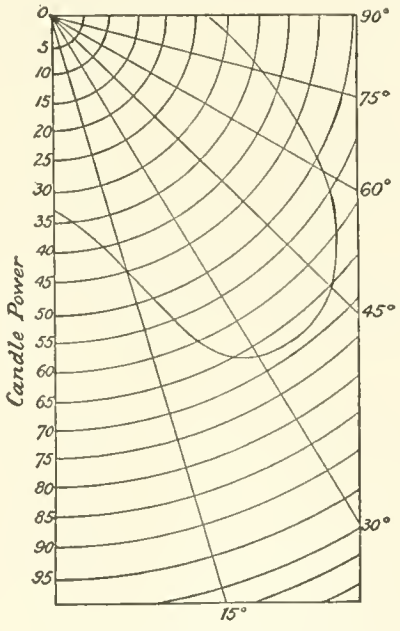

Fig. 4060.—The Corresponding Distribution Curve of the 60-watt Tungsten Lamp, Clear Bowl.

the desk front, as in the diagram (Fig. 4061) in which P is the point to be illuminated and V the point immediately under the lamp.

The distance of P from the lamp is the hypotenuse of a right-angle triangle of which the altitude is four feet and the base is two feet. Its length is therefore the square root of 20. The angle the hypotenuse makes with the perpendicular is 26.6 degrees, and, from inspection of the distribution curve, it is apparent

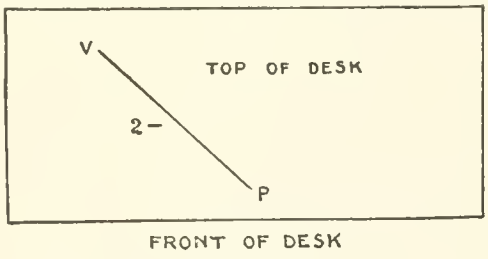

Fig. 4061.—Diagram Used in Calculating the Degree of Illumination of the Desk.

that the candle-power at that angle is sixty-five. Therefore, if the point P were on a plane *normal* to the ray leaving the lamp at that angle, the illumination would be $\frac{65}{20} = 3.25$ foot-candles. But P is a point in a horizontal plane and, therefore, its illumination is lessened by reflection, and the amount of available illumination is the percentage of 3.25 that 4 is of the square root of 20. That is $\frac{400}{\sqrt{20}} = 89.44$ per cent. And that percentage of 3.25 is 2.9, which is the number

of direct foot-candles the point *P* would receive. But the actual illumination would be well over three foot-candles and, therefore, excessive. The additional illumination would be due to reflection from walls, and its amount would depend chiefly upon size of room and coloring. In the stateroom of a man-of-war a forty-watt tungsten placed a little lower would secure, with the reflection a properly colored small room furnishes, all the foot-candles required for comfortable reading and writing.

To avoid eye strain the following must be given careful consideration: 1. Insufficient illumination. 2. Too much illumination. 3. Steady light. 4. Lamp shaded and placed to avoid brilliant points in line of vision and shadows on work. 5. General illumination by diffused light only somewhat less than that on the work itself in order to avoid marked iris accommodation and retinal shocks. 6. Lamp to be above and to left side, as a rule, and behind if practicable, to avoid regular reflection or sheen. 7. The illuminated field should be free from streaks produced by polished interior of shades. 8. Quality of light. Any colored shade is better than a bare filament, but such shades are uneconomical and, if showing any red or blue, are harmful. They also interfere with general illumination and cause marked iris accommodations.

The Ship's Water Supply and Drainage.—A ship has an unlimited amount of water available, as water is the medium of flotation. The water from over the side forms an important part of the supply, as it is suitable for flushing and fire purposes; is employed for washing gratings, open decks and outside paint work; and, as sea water, is utilized with salt water soap to some extent in scrubbing hammocks and even clothing. Then, by distilling apparatus, this water from over the side is made fresh and sterile and thus fit for drinking and cooking and all other purposes.

The inorganic salts in the water of the Atlantic average about 35,000 parts per million. The hardness is 6,652 parts per million, of which the permanent hardness is 6,157. This shows that sea water is dominated by chlorides and sulphates which, as chloride of magnesium and sulphate of calcium, render such water very unsuitable for use in a boiler, forming the hard scale that endangers integrity and causes useless expenditure of coal. This lack of fitness for steaming purposes is the most serious characteristic of sea water, as in voyages it is apt to lead to demands upon the fresh water plant for making up feed in the boiler rooms, thus limiting the amount available for washing clothes, persons, mess gear, and inside paint work.

While the chief characteristic of sea water is its well-known saline character, it is its chloride of magnesium that unfits it for use in washing clothes and the surfaces of quarters in the routine necessary for cleanliness. Sea water contains 3,341 parts of that salt per million. It is a salt that has a strong tendency to deliquesce and become damp in moist air. Consequently, while clothes can be washed in sea water with the aid of a special soap, they can never be depended upon to remain dry when taken from the lines, as they continue under the influence of atmospheric humidity all the time. The health of men depends in no small degree upon dry clothing, and, therefore, if clothing is washed in salt water it must be well soaked and rinsed in fresh water before being put on the lines.

If salt water is used to wash inside paint work there will be continued dampness in quarters during tropical cruising. The high relative humidity of the tropics is a constant enemy, and continued dampness in quarters is objectionable even when not visible as water.

While salt water bathing has its advantages in stimulating metabolism and educating the body to protect itself against the effects of variations in air temperature, such bathing is not efficient in cleaning the skins of crews. Swimming undoubtedly strengthens the organism and cultivates an art useful to the sailor. But it should not be permitted in dirty water or when the water temperature is below 70° F. Whenever a crew is to go in swimming the water-closets discharging on the port side should have been disused for a half hour or more.

Salt water may be largely used on ships as shower baths, but if a ship is at anchor in water that is too dirty for swimming it is also too dirty for use at bath fixtures. But if a crew can get fresh water for washing, there will not be much tendency to use lavatories supplied with salt water only. Yet with fresh water, the shower bath on a ship is to be greatly commended and the tub bath condemned. The same is true wherever there is concentration of men. A tiled or cement floor is found in crew's heads, water-closet spaces, bath rooms, and wash rooms.

In lavatories for firemen and crew there should be cast-iron roll-rim tip up basins, porcelain-lined. Such basins are thirteen inches in diameter and six and one-half inches deep. They are arranged over a trough and are spaced about twenty-two and one-half inches center to center. Each trough should be provided with brass strainer and a trap.

When a lavatory or shower bath enclosure is situated near the water line it should drain either into the cylinder of an automatic sewage discharger or have connection with a constantly acting electric pump.

There is certainly not sufficient washing of hands on ships. A ship's laundry cannot be better employed than in the constant washing of towels. No toilet articles, especially towels, should be used in common. Aside from water for drinking and cooking, the great object of a ship's fresh water supply is to separate men from their solid and liquid excreta and thus prevent personal and ship pollution. Towels are great retainers of the surface excreta of a crew; and hands are those parts of the bodies going to mouths and eyes.

Stationary basins of whatever type should have no place in officers' staterooms. Rings with wash bowl, ewer, and waste jar are suitable.

In warm weather there is much bathing on the open deck during the morning watch. It is also then that clothes and the deck itself are washed. Naked bodies are much in evidence and deck buckets are used to hold the required water. It is then that too much limitation in fresh water allowance would lead to utilization of same water in washing clothes of different men. The same methods in cold weather are also capable of producing large sick lists. In washing deck and clothes in cold weather, men unprovided with rubber boots may be found injuring shoes in salt water which may or may not be removed after the work is over. The wearing of damp clothes is also not unknown under such circumstances. Apart from the routine care of men on the ship, the situation declares some of the advantages of so managing the cruising of ships in time of peace that the ship routine can be carried out under comfortable climatic conditions.

The amount of fresh water available for daily issue on a ship depends upon: (1) Requirements in regard to fresh water from distiller for boilers in relation to amount of boiler water carried in double bottoms and feed tanks; (2) actual output of evaporators and distillers; (3) storage or tank capacity.

The amount ordinarily required, including drinking and cooking, is 6.7 gallons per man per day, and this is a low estimate, if one is to keep person and clothing fairly clean without a satisfactory general bath during the week, and with allowances for such use of salt water as is probable. This includes no estimate for waste, or expenditure in officers' quarters. In the tropics, where white clothing is a daily feature, 10 gallons per day per man should be allowed whenever practicable, but, considering all the factors, the mini-

mum working expenditure of fresh water on a ship should be about 7.5 gallons per person per day.

Considering the tendency to require, even if only at times, distilled water for boilers, the distiller working capacity or ordinary output should be at least 15 gallons per man per day, and the total tank capacity should not be less than 30 gallons per man. Thus, on a ship with a complement of 800 men the distiller would be capable of furnishing 12,000 gallons a day and the water tank capacity would be 24,000 gallons.

The apparatus for making fresh water on a ship consists of two connected parts, the evaporator and the distiller or condenser. In the evaporator the steam is formed and in the distiller the steam is condensed. In the construction no lead is employed.

The evaporator consists essentially of a steel shell containing pipes that receive steam from the ship's boiler. Water from over the side is pumped into the evaporator shell as required and is kept boiling by contact with the tubes or pipes. The steam so formed passes by pipe into the distiller or condenser, which is

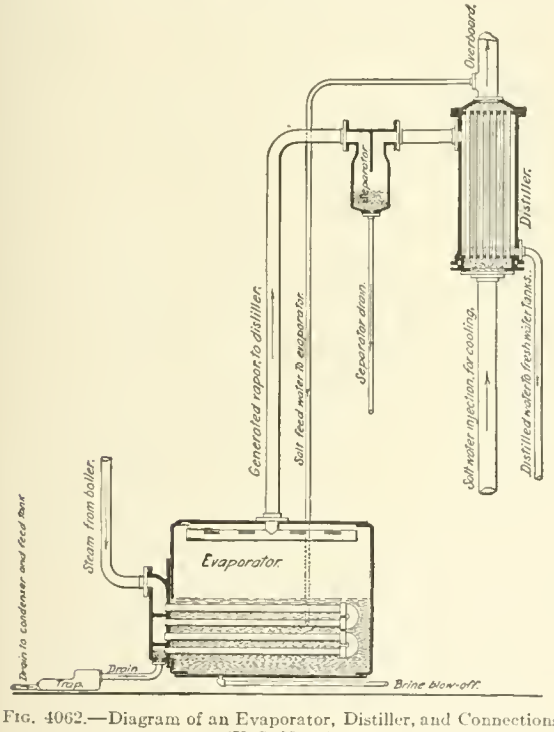

FIG. 4062.—Diagram of an Evaporator, Distiller, and Connections (U. S. Navy).

placed on a higher level than the evaporator to limit priming. Priming is the carrying over of boiling water with the steam. As an additional precaution against priming, a draw pipe is connected within the evaporator with the steam lead to distiller. There is also a separator in same lead between evaporator and distiller. As it is salt water that is evaporated, priming would cause a marked increase in the chloride content of the distillate.

The distiller, or condenser, also consists of a metal shell containing pipes; but through these pipes water from over the side is kept circulating by means of a pump. The steam from the evaporator is admitted to the distiller shell and coming in contact with the tubes is condensed. The distillate then passes by gravity or by pump into the tanks.

The placing of the evaporator between the distiller and the ship's boiler is necessitated by the oil and other substances in boiler steam. The function of the evaporator is to produce clean steam. Of course, the distiller would condense boiler steam, but the distillate would contain much oil and volatile products. Boiler water is kept dirty by returns from engines. Even a leak in an evaporator tube is soon declared by the appearance of oil in the distillate.

The chief source of danger in the whole apparatus is a leaking distiller tube. Such a leak would admit the polluted water from over the side into the distillate. And the salt water circulating through such tubes causes more or less corrosion. Like priming, a leaking distiller tube causes a marked increase in the chloride content of the distillate; but if derived from priming, the water is not injured from a sanitary point of view provided the chloride is well within amounts discoverable by taste. It is in the distiller that a danger is possible. However, at some anchorages in the tropics the water from over the side contains so much organic matter that the resulting distillate is very objectionable to the taste on account of volatile products, and may cause diarrheal disorders. Under such circumstances either the anchorage should be deserted, or feed water for the evaporator obtained by water boats from shore. It is ordinarily unsafe to take raw water from shore for drinking. The chances for contamination, including transportation in water boats, are too great. An opinion formed from rapid examination of such water is not trustworthy.

The distillate should be repeatedly tested to secure a fairly slow evaporation, and with the main object of detecting a possible leak in distiller tubes. This should be done several times during each watch at the distiller, under the instruction that chlorine in excess is an indication for special investigation. A nitrate of silver solution should be provided for the test. Such solution gives a haze with salt in fifteen parts per million. It is in harbor that the question is of chief importance, but even at sea, when anything more than a haze is produced there should be investigation to determine the source.

All water from the distiller should pass through one tank where it can be tested as a whole before it goes to other tanks.

Freshly distilled water is insipid, as it is warm or even hot, and requires aëration. Therefore, it is passed into ripening tanks and is pumped from after tanks to forward tanks and then, as required, into gravity tanks. The crew secures it for drinking at a tank called the scuttle butt, in which there are cooling coils connected with ice machine, and where, to avoid the drinking cup in common, the water is obtained from a terminal like a small bubbling fountain with controlled flow. The medical officer should consider the scuttle butt as one of the important locations for taking samples of water for examination.

Water tanks are of metal, cement lined. They are provided with manholes for cleaning. Top of tanks should be kept clean and manhole plates seldom lifted. No water should be served out at tanks and every precaution taken to limit the necessity for cleaning them.

It is necessary for the fresh water system to be free from chance of connection with any other system. Even at a bath-tub, salt and fresh water should not be delivered through an opening in common, as is hot and cold water in tubs on shore. Under such circumstances, the salt water, being under greater pressure, may back up into the fresh water pipe and contaminate water in an adjoining pantry.

Above the water line the drainage of a ship is by scuppers or short pipes, delivering above the water line where they are provided with lips and hinged valves to prevent air compression by water when a ship at sea plunges or rolls. However, such valves are not infrequently surprised, and, therefore, water-closets are of the valve type, as otherwise a water seal would be projected over the user. All water-closets, heads, and urinals should have scuppers of their own. The crew's urinals and heads are usually of the trough type with constant flush.

It is necessary to thoroughly clean bilges once each week. No ship is properly constructed from a hygienic point of view unless the bilges are accessible for cleaning. With care in cleaning, the bilges of a modern ship will not menace the health of crews.

The Navy's Food.—The ration of the United States navy is prescribed by law. It cannot be changed on the ship, but local authority can decide under the law how many times during the week the men can have fresh provisions rather than what is known as the sea ration. Therefore, accurate knowledge of all lawful variations of the ration as a whole is necessary for the medical officer acting in an advisory capacity.

The following is the wording of the ration which has remained unchanged for eight years—a fact showing that, whatever adverse criticism may be made by students of nutrition, the ration as prescribed and administered has given satisfaction to the men themselves considered as a whole.

Naval Act, June 29, 1906.—*Provided*, That sections fifteen hundred and eighty and fifteen hundred and eighty-one, Revised Statutes, be amended to read as follows:

"Sec. 1580.—The Navy ration shall consist of the following daily allowance of provisions to each person: One pound and a quarter of salt or smoked meat, with three ounces of dried or six ounces of canned or preserved fruit, and three gills of beans or pease, or twelve ounces of flour; or one pound of preserved meat, with three ounces of dried or six ounces of canned or preserved fruit and eight ounces of rice or twelve ounces of canned vegetables, or six ounces of desiccated vegetables; together with one pound of biscuit, two ounces of butter, four ounces of sugar, two ounces of coffee or cocoa, or one-half ounce of tea and one ounce of condensed milk or evaporated cream; and a weekly allowance of one-quarter pound of macaroni, four ounces of cheese, four ounces of tomatoes, one-half pint of vinegar or sauce, one-quarter pint of pickles, one-quarter pint of molasses, four ounces of salt, one-half ounce of pepper, one-eighth ounce of spices, and one-half ounce of dry mustard. Seven pounds of lard or a suitable substitute, shall be allowed for every hundred pounds of flour issued as bread, and such quantity of yeast and flavoring extracts as may be necessary.

"Sec. 1581.—The following substitution for the components of the ration may be made when deemed necessary by the senior officer present in command: 'For one and one-quarter pounds of salt or smoked meat or one pound of preserved meat, one and three-quarter pounds of fresh meat or fresh fish, or eight eggs; in lieu of the articles usually issued with salt, smoked or preserved meat, one and three-quarter pounds of fresh vegetables; for one pound of biscuit, one and one-quarter pounds of soft bread or eighteen ounces of flour; for three gills of beans or pease, twelve ounces of flour or eight ounces of rice or other starch food, or twelve ounces of canned vegetables; for one pound of condensed milk or evaporated cream, one quart of fresh milk; for three ounces of dried or six ounces of canned or preserved fruit, nine ounces of fresh fruit; and for twelve ounces of flour or eight ounces of rice or other starch food, or twelve ounces of canned vegetables, three gills of beans or pease; in lieu of the weekly allowance of one-quarter pound of macaroni, four ounces of cheese, one-half pint of vinegar or sauce, one-quarter pint of pickles, one-quarter pint of molasses, and one-eighth ounce of spices, three pounds of sugar, or one and a half pounds of condensed milk, or one pound of coffee, or one and a half pounds of canned fruit, or four pounds of fresh vegetables, or four pounds of flour.

"'An extra allowance of one ounce of coffee or cocoa, two ounces of sugar, four ounces of hard bread or its equivalent, and four ounces of preserved meat or its equivalent shall be allowed to enlisted men of the engineer and dynamo force who stand night watches between eight o'clock postmeridian and eight o'clock antemeridian, under steam.'"

Naval Act, March 2, 1907.—"Any article comprised in the Navy ration may be issued in excess of the authorized quantity, provided there be an underissue of the same value in some other article or articles."

The wording of the ration as given above shows some of the principles upon which any navy ration has to be based. The fundamental division is into a sea ration, composed of articles always available, and a ration of fresh provisions, composed in the main of articles commonly available in port. This division has relation to keeping qualities, methods of packing and questions of storage; and the articles themselves have relation to nutritive qualities, acceptability and number to permit an issue table from day to day that secures variety and contains, with amounts prescribed, the required bulk and the requisite quantity of each of the nutrients.

A ration may be well balanced in amount of nutrients and yet include articles either beyond or below their acceptability. A ration must not only be well balanced in amounts of nutrients but also in relation to the desires of the individuals. Unless the varying preferences of the men be considered, and provided for in the ration, it will be a failure because it lacks in what is called elasticity. It was to provide full elasticity that, as given above, the Naval Act of March 2, 1907, contained authority for overissues to balance underissues in money value. Such elasticity is also important in permitting considerable automatic variation during tropical cruising when there is a natural tendency to diminish consumption of fat and protein, and to increase consumption of fruit.

The amounts specified in the navy ration are those issued. They are greatly in excess of those consumed, which do not include either refuse or waste. A ration must be constructed for issue, as a certain amount of each article must leave the storeroom each day and be accounted for either as an overissue or an underissue.

Refuse is that part of a food-stuff unfit for consumption. Waste is that part of the edible portion lost through carelessness, as in leaving the pulp of the potato with its skin and in dropping material while eating, or by intention, as in leaving material on plate at table. Refuse is fixed by nature of material, such as bone, shells, etc. Waste is large among Americans generally.

One day's sea ration per man weighs 4.193 pounds, or 1,902 grams, *as issued*. It contains *as issued* 184 grams of protein, 359 grams of fat and 742 grams of carbohydrates. Its fuel value is 6,907 calories; total nitrogen, 29.47 grams; total carbon, 697.07 grams; and nitrogen to carbon, 1:23.65.

But, *as consumed* that ration is considered to contain protein, 138; fat, 269.8; carbohydrates, 556.7 grams. Therefore, its digestible protein, fat, and carbohydrates are 127, 256, and 540 grams respectively. Its fuel value is 5,180 calories and the nutritive ratio is 1:8.78.

One day's fresh provision ration per man weighs 6 pounds or 2,738 grams *as issued*. It contains protein, 193.857 grams; fat, 180.431 grams; and carbohydrates, 592.187 grams. Its fuel value *as issued* is 4,750 calories; its nitrogen, 31 grams; total carbon, 499.95 grams; and nitrogen to carbon, 1:16.12.

But, *as consumed* that ration is considered to contain protein, 145.392; fat, 135.323; carbohydrates, 444.140 grams. Its digestible protein, fat, and carbohydrates are 134, 129, and 431 grams, respectively. Its fuel value is 3,563 calories and the nutritive ratio is 1:5.38.

In calculating the fuel value of these rations the following Atwater factors have been employed in preference to those of Rubner: Each gram of protein, 4; of fat, 8.9; and of carbohydrates, 4 calories.

Under ordinary circumstances the sea ration is issued three times a week and the fresh provision ration four times a week. The usual ration *as consumed* is, therefore, considered to contain protein, 142.292; fat, 192.951; carbohydrates, 492.365 grams. Its digestible protein, fat, and carbohydrates are 131, 183, and 478 grams, respectively. The corresponding fuel value is 4,256 calories and the nutritive ratio 1:6.79.

When a ship is under steam each man of the engineer force has an additional ration which brings his *total consumption* to the following: Protein, 182; fat, 218; carbohydrates, 624 grams. The digestible protein, fat, and carbohydrates are 168, 207, and 606 grams; the fuel value, 5,174 calories; and the nutritive ratio, 1:6.3.

It is quite evident that the navy ration of the United States is one of high power. Even from At-

water standards it is amply sufficient in total amounts of nutrients. The ration for the engineer force contains more protein than that provided by Atwater for a man with very hard work. And certainly the navy ration is in direct conflict with the teachings of Chittenden. But all standards are based upon insufficient data. Knowledge of nutrition is not sufficiently definite to permit entirely satisfactory conclusions. Undoubtedly many standards are based too much upon what men consume rather than upon what they ought to consume. Yet the last word has not yet been spoken in regard to what men ought to consume under the various conditions of life. Theoretically the best diet is that combination of foods which supplies exactly what is needed with the least body burden. But nature is more or less prodigal in all directions. It wastes many a seed. It resents all human attempts to keep the body in the state of highest physical efficiency. No prize fighter would dare to keep in training all the time. And man's life relates not only to himself but also to his offspring. Besides, it is not clear that the least burden is advisable for any one organ of the body, any more than it is for the body as a whole. Work, but not overwork, the feeder and many of his ills disappear. If a normal man does not work he should not eat, at least in the amounts that make many men objects of commiseration.

The navy ration, if deprived of its meat issue, contains more protein than that advised by Chittenden. A deliberate total deprivation of meat in a navy would cause very marked discontent. And the United States navy depends upon voluntary enlistments. On board ship, even in the tropics, a large number of men maintain appetites beyond the low protein dietaries. However, in the tropics Voit's standard should give satisfactory results from the many points of view involved. However, laboratory determination in relation to food stuffs will have to be carried further before they will secure general acceptance. Beriberi has practically disappeared from the Japanese navy since it improved its ration in quality of food stuffs and in quantity of nutrients. Its consumption is about 126 grams of protein daily per man of small average weight. Scurvy disappeared from the sea as result of recognition that it was due not to deficiencies in protein, fat, and carbohydrates, but in the organic vegetable acids. And now there is observation that pellagra does not occur where the ordinary mixed diet is employed in sufficient quantity. In the United States navy there is no exhibition of rheumatism or of nephritis in excess under its high power ration.

The question of food in a navy, as elsewhere, includes inspection, preparation, and service. Health and discipline are associated with quality of food material. However, methods of examining food stuffs for adulterants or deterioration are not distinctly naval. And the scope of this article is limited.

The subject of *poisonous fishes* has a certain importance in naval hygiene in view of the seine on each ship, the tendency to use fishing lines whenever practicable, and the frequent purchase of fish from boats in the tropics. Toxic wounds are not unknown, especially perhaps when hauling seine in warm waters, and poisoning from true toxic fish caught over the side of a ship is not regarded as remarkable. Among the fishes that are poisonous either always or in certain locations or at certain times, when used as food, are the Tetraodontidæ, Monacanthidæ, Balistidæ, Clupea venenosa, Caranx latus, Trachurops crumenophthalmus, and Lutianus bohar. The last was responsible for the poisoning of twenty men on the U. S. S. Wheeling in 1904, when off Leone, Tutuila. The fish were caught by one of the crew.

In addition to true poisonous fishes there are, of course, cases of poisoning resulting from postmortem changes. Such cases are more frequent in the tropics and are apt to be caused by surface fish or those that go in schools. The Scombridæ or mackerels are remarkable for the rapidity of putrefactive changes. The Opisthonema or thread herrings are sometimes true toxic fish especially during the spawning season. In tropical waters it is best to avoid any fish of the sardine kind; and every fish when caught should be at once bled and cleaned as for the table.

Among the fish producing painful, peculiar, and even serious wounds are: Diodon hystrix, the Dasyatidæ, the Myliobatidæ, Plotosus anguillaris, Bagrus barbatus, Holocentrus ascensionis, Psettus sebæ, the Siganidæ, the Teuthididæ, the Scorpænidæ, the Cottidæ, and the Callionymidæ. In many of these fishes it is the dorsal or ventral or anal or caudal spines that are venomous. In the family Murænidæ poison is distributed in the mucus of the mouth. The Muræna infernalis, or black moray, has sharp teeth and is extremely ferocious. It is common from Florida Keys to Rio Janeiro and from Gulf of California to Panama.

In these days of relatively short voyages, from the point of view of time, and of cold storage and supply ships, fresh meat is very generally available on ships. Frozen meat, as received from supply ships, cannot at once be divided into suitable cuts for cooking and when it is divided may delay meals by additional time required in cooking. This has led at times to securing meat from supply ships the evening before it is required. Under such circumstances in the tropics, unless it is well protected, especially from flies, it may quickly acquire properties responsible for acute symptoms after ingestion. Any thawing necessary should be under water in warm climates. Meats received on supply ships should be government inspected and provided with clean cloth or muslin covering.

Each navy should have a school for cooks and bakers. The organization of the force at the galley should be as complete and efficient as that of a gun division at its work. There should be proper cutting of quarters of beef, proper preparation and cooking, cleanliness, and the service of hot food. Mess utensils should go through an electrically operated dish-washing machine, having necessary steam, water, and drain connections, and overhead tracks and trolleys. Such a machine should be installed in a general mess pantry with shelves of wire mesh. Machines should be used in the preparation of food whenever practicable, especially in the making of bread. And in the galley, steam cookers made of copper should be thoroughly tinned on the interior. Oxalic acid solution or other poisonous substances should not be used in cleaning bright work. A little poisonous pomade in the spout of a coffee kettle can cause the poisoning of all the men in that mess.

The meal hours should be respected, whenever practicable, that there may be sufficient time to ingest food without haste. A large majority of men bolt their food, and the attempt to teach proper mastication is often rather hopeless. Yet the medical officer has opportunity not only to instruct in regard to articles of diet, but also in regard to necessity for thorough mastication.

The Navy's Clothing.—Naval clothing is generally substantial in view of the marked variation in the exposure of the personnel, the way clothes are washed, and the whipping effect of wind on the lines. Even the all-cotton knit undershirt worn in the tropics causes complaint unless made of open texture. A working man in the tropics is more comfortable without undershirt and in a very loose flannel shirt made like any ordinary shirt. Wool is not suitable for underclothing in hot climates.

In using undershirts, the number supplied for

changes should be generally increased for use in the tropics. No man should ever go on watch in wet clothing or remain in wet clothing after coming off watch, and this is especially true in relation to a man's own sweat, and to members of the engineer force. In time a man's clothing wet with his own sweat may become as dangerous as if wet by rain. A drying room about the uptake space should always be provided for the engineer force.

If after sundown white clothing is found too cool for the officer of the deck it is too cool for the men on deck. Prompt changes of clothing as required have a very important relation to the health of crews.

Impermeable materials are very undesirable articles of clothing. They should be worn to meet special conditions and discarded when other conditions prevail. Rubber boots should be worn in washing down in cold weather, but so soon as that work is over there should be return to dry socks and shoes. A wet foot-covering is dangerous whether the water comes from the body or from external sources. A crew is healthiest when climatic conditions permit bare feet. But a shoe that fits well about heel and instep and has broad low heel and plenty of length and spread for the feet is essential in naval life.

Trousers should be broad at and below the knee in order to allow them to be well rolled up when washing decks, or leaving a boat in shallow water. An enlisted man cannot afford to lose much clothing and, therefore, hats must be made to be useful in the wind. The grommet gives the blue cap a dressy appearance and when discarded permits the cap to be used in the wind without danger of loss overboard. The white hat should have a fairly broad brim but with little stiffening. Its color is, however, objectionable, especially from a military point of view. And the same is true of any white outer clothing. It is especially objectionable for campaigning on shore. White outer clothing should have no place in a naval vessel.

The collarette of the jersey should be narrow that it may not come up much upon the neck. The neck is ordinarily accustomed to be uncovered in naval life and muffling the throat is a fertile cause of colds and of tonsillitis.

A man's clothing is kept in a canvas bag—even his bed clothing when not in use, as a hammock when lashed is practically a closed bag. No wet or damp clothing should be stowed in bags and no clothes-bag should ever be painted. Clothing and bags and hammocks should be frequently spread out in the sun. Bags and hammocks should be frequently changed and scrubbed. Management of clothing is of as much importance as character of clothing.

Disinfection on the Ship.—The medical officer of a ship has many important duties to perform other than the care of the sick and injured and the keeping of accurate health records. The question of the prevention of disease must always occupy a prominent place in his thought. Every person on board must always have the protection from smallpox that vaccination affords and each health record must also show that regulations relating to typhoid prophylaxis have met with strict compliance. Then, there is the constant duty to exert every reasonable effort to have the routine of ship life adjusted at all times within service exigencies to meet the requirements for the maintenance of good health. Under these exigencies a medical officer must make himself clear in regard to all measures required to maintain a crew's vital resistance—to avoid accumulations of human excreta in air or on surfaces, to keep a dry and comfortable ship in quarters, to have a clean, well-fed and well-exercised crew, drinking good water and sleeping in clean hammocks and with no members affecting unduly the storerooms and darker parts of their floating habitation. And he should have classes in personal hygiene to include specific instruction in regard to the venereal diseases. He should also inspect the entire crew once each month and whenever opportunity occurs teach the men in regard to precautions to avoid communicable diseases and communicating disease.

In any case of communicable disease on a ship the individual should be impressed with the danger of infecting others. A man with gonorrhea can be very much impressed with the danger of infecting his own eyes and, therefore, with the necessity of an immediate careful washing of hands after touching genitals. He can also understand the danger of allowing a towel to be used by another and the advisability of protecting his clothing and of securing cleanliness of the genital region. While the best general safeguard against extragenital infection by syphilis is energetic treatment, no syphilitic or gonorrheal patient should be allowed to commence treatment without a strong attempt to impress him with the fact that he is a danger to his fellows and that, of course, he does not want to be responsible for extending his trouble to anyone else. Most men are very readily impressed with the necessity of not permitting their pipes, chewing tobacco or partly consumed cigars or cigarettes to be used by others, and of refraining from tattooing others. It is best for all syphilitics, not well along in treatment, to mess together, and no person with venereal disease should act as cook or mess attendant.

Ordinarily instruments of the band are government property. A bandsman with syphilis should receive special caution, and when transferred from the ship, say to hospital, with that disease or with tuberculosis, or with other communicable disease, the instrument used by him should be disinfected. In relation to all these diseases, the use in common of the drinking cup at the scuttle butt was for many years a source of danger. All drinking cups should be free from nicks and, should men be so situated that such cups have to be used in common, the cups should be kept immersed in a weak formaldehyde solution. Lip drinking is also advisable under such circumstances.

Tuberculosis is the disease not infrequently found in ships that is most interesting from the point of view of extension. The diagnosis should be made as early as practicable, and that is true of all communicable diseases. There should be zealous investigation of the sputum whenever there is the slightest suggestion of the disease, and the case should be transferred to naval hospital at the first opportunity, being kept under direct supervision in the meantime. No person in whom the diagnosis has been clearly made should ever be returned to duty in a navy even if he appears to have recovered, unless it has been conclusively proven that he has recovered, and that cannot be shown by the absence of physical signs or by negative bacteriological examinations. When the case is found on the ship the locality in which the individual was sleeping and messing should be disinfected. When an officer is detached it should be the routine to disinfect the stateroom before it is occupied by another.

In the common epidemic diseases early recognition of the first case, isolation, and bedside disinfection are of extreme importance in limiting spread on the ship, where there is always great concentration of human beings and much susceptible material. Even the suspected case should be isolated with effects. The next important step is to remove the case and effects from the ship at the first opportunity, and then immediately disinfect locality of isolation and all its contents.

Disinfection is the destruction of agents causing infection. For its successful operation there must be consideration of the position and character of the infection and knowledge of the qualities or applicability of each disinfectant available, in order that

the proper agent of destruction may be selected and applied.

For instance, formaldehyde can never displace the use of sulphur on ships. The former can be regarded as of practically no value in relation to yellow fever and plague, as it cannot be trusted to kill vermin. The latter is an excellent insecticide. Formaldehyde, in the front rank of germicides, is, therefore, carefully placed in the rear, and sulphur dioxide is selected, when the attack is against mosquitos, rats, mice, fleas, bedbugs, or roaches.

Chemicals, whether used in solution or as gas, act as germicides by effecting chemical changes in protoplasm. Heat is influential in hastening chemical reactions and, therefore, disinfecting solutions act with much more power when hot or even warm. The chemical activity of dry gases is frequently very low, or even absent, and, therefore, in killing microorganisms they should be allowed to operate in the presence of considerable water vapor and, whenever practicable, in heated air. This is true for an additional reason in the case of formaldehyde, as it tends to polymerize in dry air and at relatively low temperatures. In this tendency to form polymerides is found the capricious behavior of this gas in disinfection. Therefore, its full power is secured at temperatures well above 60° F. and in saturated air, and when evolved very rapidly as in the formalin permanganate method which secures maximum concentration, as well as action, before much paraformaldehyde is formed.

Both fumigation and the application of solutions are important in ship disinfection. Gases are decidedly limited in penetrating power and cannot penetrate masses of infected material. Solutions can be used about the sick and in disinfection of their excreta whether on surfaces or in clothing, or in bed pans or urinals. However, in the spaces of a ship that are well closed, formaldehyde can be trusted to render suspected clothing harmless if it is so spread or hung that the gas can come in contact with all surfaces.

It is customary to rapidly wet the deck of a space with solution of corrosive sublimate (1:1,000) just prior to fumigation. This disinfects the deck and at the same time gives additional water to the air to aid in the fumigation. It is also customary to apply the same solution to all paint work after fumigation in order that sputa or masses of material may not escape. Then, too, side plates are such good conductors that with cold outside air they may chill the gas in contact to the point of inefficiency. The disinfectant solution is also necessary in relation to pockets of filth that form under broken linoleum. Frequent inspection of that deck covering should be the routine in order that any breaks may be immediately repaired; but, whenever breaks are discovered, the deck underneath should be carefully inspected with a view to the use of a disinfecting solution.

It is always wise to disinfect simultaneously as many spaces as possible of those requiring disinfection. One advantage of isolation is to confine the infection to a part of the ship. But in yellow fever or plague, originating on the ship, the infection is not confined, although in yellow fever, it is primarily important to disinfect with sulphur all that part of the ship where the individual was billeted, and to seek and make ineffective any breeding places of mosquitos, such, for instance, as division tubs.

In disinfecting against plague, as rats are in question, it is best to begin at one end of the ship and work toward the other, including in each disinfection all compartments between their water-tight bulkheads. Fortunately, in the case of yellow fever, disinfection is done in a warm climate. In the general disinfection of a ship there is often insurmountable difficulty so long as the crew is on board. The great advantage of a quarantine station is the facility afforded for disinfecting the ship as a whole.

In effecting closure of a space, air ports and water-tight doors can be tightly closed without the use of paper and paste, but strips of paper and paste should be used on ordinary doors and in relation to hatch covers. The ventilation blower affecting the compartment must be stopped, valves of terminals closed, and all louvers covered with paper held in position by paste. When fumigation is in progress, paper and paste should be used to cover all overlooked openings on the outside of the space.

The pot method is used with sulphur (five pounds per 1,000 cubic feet) and, for formaldehyde disinfection, 500 c.c. of formalin are used with 200 grams of permanganate of potassium for each 1,000 cubic feet of space. Steam is supplied in radiators in order to heat the contained air. The permanganate is placed conveniently in an ordinary agate bucket and the formalin poured over it. Such a bucket holds the amount necessary for the fumigation of 2,000 cubic feet of space and allows sufficient room for the enormous increase of volume incident to the ebullition. In fumigation it is inadvisable to have too much space allotted to one container. It is much better to multiply containers and place them in different parts of the space. In formaldehyde disinfection, 2,000 cubic feet of space to one container; and in sulphur dioxide disinfection, 5,000 cubic feet is the custom. Multiplying containers or sources secures better diffusion.

In disinfecting small spaces by fumigation, the vaporization of pastils may be utilized. Such pastils are chiefly paraform and are, therefore, converted into formaldehyde by heat. Each pastil weighs about one gram, and seventy-five are used to disinfect 1,000 cubic feet. These are placed in a cup over an alcohol flame, a special apparatus being devised for such disinfection. The method is convenient and not expensive, the pastils occupying but little space in storage, and alcohol is available as a rule. However, it leaves an open flame in the compartment, unless the alcohol is of good quality the flame may not continue long enough, the method supplies little or no moisture, the gas does not come off very rapidly, and, while in the formalin and permanganate method six hours are sufficient for the disinfection, in the pastil method twelve hours are required. Then, too, unless the alcohol flames are kept low too much heat may cause the pastils to ignite, and thus relatively little formaldehyde will be set free. However, if everything goes well, as should be the case with ordinary care, and water vapor is supplied, results are generally satisfactory although less penetration is secured than in the permanganate method.

Formaldehyde is used in solution to disinfect clothing soiled by discharges of the sick. Four parts of formalin to ninety-six of water will give about 1.6 per cent. solution of the gas. If clothing is immersed in such a solution for an hour satisfactory results are obtained.

A dram of corrosive sublimate thoroughly dissolved in a gallon of water is used in disinfection for wetting decks and paint work. Any number of men desired can be obtained for such work and it is customary, after fumigation, to apply the solution by means of swabs, as many deck buckets as may be required containing the solution. The deck is wet first and then under supervision the solution is spread over the paint work, any dirt in quantity being saturated with the solution before it is disturbed by wiping. But in a well-kept ship there should be no dirt in quantity in a sleeping compartment. The advantage of a pump and hose in doing such work is that a small number of workers is required. That is the method at quarantine stations. Bichloride solutions attack metals and, therefore, exposed metals should not be wet with them.

Such a solution should be used more frequently on ships, especially in the presence of measles, mumps, or

tonsillitis. The general disinfection of a crowded ship is not practicable as successive crops of cases of measles or mumps may appear. Clothing of a crew can be fumigated in casemates and the solution applied to surfaces, especially decks of compartments. A rigid routine in relation to sputa, careful inspection and treatment of linoleum, care of mess gear and drinking cups, if such be used at scuttle butt, and airing and sunning of bedding are measures of value. In addition, every effort should be made to discover cases early. The crew should be examined at quarters and even suspects isolated.

Solutions of chlorinated lime, of carbolic acid, and of lime are of value on ships in the disinfection of excreta. For stools, a four per cent. solution of chlorinated lime, a five per cent. solution of pure carbolic acid, or a one per cent. solution of the impure acid are satisfactory. A solution of chlorinated lime can also be used very profitably at times about urinals in a warm climate. A water-closet that requires the use of deodorants is faulty in design. However, through faulty use, woodwork and deck may require special attention to avoid odor.

One part of freshly slacked lime and eight parts of water by weight is reliable if used to disinfect stools in volume equal to that of the stool, and an exposure of two hours is allowed.

In a sick bay all sputa deposited in cups should be regarded as infected. All such cups should contain a solution of chlorinated lime and should be subjected to boiling water at stated periods. Tongue depressors should be of wood and used only once. If of metal they should be cleaned in hot water after use and kept in carbolic acid solution, as should thermometers, wide-mouth bottles being used for that purpose and surplus solution shaken off before using.

The chief physical agent used in disinfection is heat. An enlisted man can be greatly embarrassed in his financial relations to the ship by destruction of his clothing, although ultimately there is reimbursement for actual value at time of loss. Disinfectants should be selected in relation to the integrity of such material.

Boiling water should be frequently utilized each day as a matter of routine in sick bays. Boiling water almost immediately destroys the microorganisms of all the usual diseases, such organisms not being spore bearers. All cotton fabrics, whether body clothing or bed clothing, can be disinfected in this way without injury if they are not stained with blood, pus, or other albuminous material. In that case, and in the case of woolen clothing that may have been in contact with the sick, a formaldehyde solution can be employed. In the absence of appliances for using steam, the clothing of the itch case should be immersed in boiling water.

In relation to such cases, and in other relations, it is of value to have each ship provided with apparatus for disinfection by steam. In view of necessity for limitation in size and weight, a large dressing sterilizer can be made to answer many of the purposes of the larger apparatus found in hospitals and at quarantine stations.

The entire clothing outfit of an enlisted man can, with his mattress and hammock, be made to form a roll eighteen inches in diameter and thirty-six inches in length. The accompanying illustration, furnished by the American Sterilizer Company, is of a sterilizer with steam chamber having an inside diameter of twenty-four inches and a length of forty-two inches.

The steam is generated by an evaporator. The cut shows the arrangement for operating evaporator by steam, but electricity could also be readily employed for this purpose.

The apparatus is designed to operate under a jacket pressure of from fifteen to twenty pounds. The special feature of this apparatus is found in the single lever control valve "M" by means of which the steam is admitted to the chamber, withdrawn from the chamber, and a vacuum created within the chamber by operating a single lever.

Such an apparatus should be constructed with all castings of bronze or brass; exterior shell heavy, hard, cold-rolled copper; inner shell, or disinfecting chamber, of seamless drawn brass heavily tinned; evaporator of copper or brass; doors of bronze; and cage of nickeled heavy brass wire.

This apparatus should be regarded not only from the point of view of the sterilization of an individual's clothing, but also for requirements in time of war for sterilization of large quantities of dressings. It should be installed near a dressing station inside the citadel.

The disinfection of mattresses, and of individual effects in general of those sick with epidemic disease, is limited on the ship by transfer of such cases, with effects, to hospital. As has been stated, the place of isolation should always be immediately disinfected after each transfer, and, as used, all material such as mess gear. All large ships are provided with an isolation ward ventilated on the exhaust system. In a place of isolation there should be no unnecessary articles.

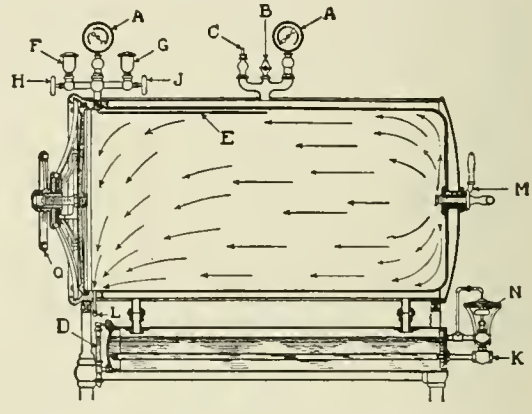

Fig 4063.—Design of a Ship's Disinfector.

A, Pressure gauges for jacket and chamber; *B*, air cock for jacket; *C*, safety valve; *D*, water gauge glass for generator; *E*, formaldehyde and ammonia pipe to chamber; *F*, formaldehyde cup; *G*, ammonia cup; *H*, formaldehyde valve; *J*, ammonia valve; *K*, steam governor; *L*, drip valve from chamber; *M*, back valve; *N*, water valve to generator; *Q*, hand wheel for locking door.

A ship on which any epidemic disease is appearing does not permit working parties or transfers of men to other ships. A ship in squadron or at navy yard seeks not only to protect itself from an epidemic disease, but also, such disease being present, to prevent its spread, not only on board, but to other persons wherever they may be.

If a case of epidemic disease is treated out on a ship, from lack of facilities for transfer, it should on recovery be removed from isolation with all the precautions customary elsewhere.

The medical officer of a naval vessel is required to keep himself informed of the health of the port in which the ship is lying. An anchorage selected at a proper distance from shore is often of the greatest importance in the prevention of malarial disease and of yellow fever. Screening of sick bays to avoid flies, or of the quarters of a ship as a whole to avoid mosquitos, is important in certain localities.

Naval Recruiting.—The vital statistics of a navy show very clearly that its health is primarily in the hands of the medical officers at the recruiting stations. Recruiting is one of the most difficult and one of the most responsible duties a medical officer can be called upon to perform.

Such work differs greatly from that of examining for life insurance in which the great question is longevity. In the United States navy a man enlists for four years and in his examination for enlistment the great question is whether he will be able to do full naval duty for that length of time. Many men are necessarily rejected for naval service who have every prospect of attaining old age. Any degree of deafness or of color-blindness, insufficient form vision, or a certain variety of flat-foot are among the causes of rejection for naval life, yet such defects may have no relation to length of life. It is quite true that all the causes of rejection for life insurance may be considered as among the causes of rejection for naval enlistment, but in naval recruiting there are many additional considerations of the highest importance from the point of view of naval efficiency.

Therefore, in the performance of such duty a prerequisite is knowledge of service requirements. It requires aptitude, but, for good results, that aptitude must be the natural outcome of experience in actual service on the ships themselves. The successful examiner must know the disadvantages in active service of even a relatively small percentage of undesirable men, the physical demands of the different ratings, the method of life on ships, and how the defect claimed to be trivial by the candidate seeking enlistment comes to be magnified by the same man dissatisfied with naval life. It is, therefore, evident that the standardization of the examiner is of quite as much importance as the standardization of the recruit. Standards of measurements in inches and pounds are of great importance, but recognition of defects from a service point of view, and knowledge of the appearance of good health and of a vigorous and healthy personality are of as much importance in securing good results. Breakdowns are closely associated with the quality of material in the human machine. And in this connection knowledge of the general appearance of the tuberculizable individual is important.

Recognition and record of all defects, even those that may seem more or less trivial at the time, are of much importance. An individual under examination for enlistment desires to enlist and, therefore, is apt to make light of any abnormality, declaring it has never given the slightest trouble. Yet, that same abnormality may assume much importance in the eyes of the dissatisfied individual and may, in not a few cases, be advanced with claim of origin in service, in the absence of record at time of enlistment. Quite a number of defects not noted at time of enlistment are liable to be considered as originating in the line of duty and, therefore, to have a pensionable status. The responsibility of the examiner is not small in this connection.

Medical surveys for "causes prior to enlistment" are not uncommon in any navy. Enuresis, defective vision, defective hearing, hernia, varices, ankyloses, flat-feet, and tuberculosis are some of the designations included from time to time in such surveys. But any cause may so appear unless the original examiner works in accordance with a system under which the large number of things that have to be done rather rapidly are done in order or regular sequence. Although some causes of disability, considered to have existed prior to enlistment or to have originated from tendencies prior to enlistment, do not show fault on the part of the examiner who accepted for enlistment. In fact there may even be fault in the medical officers making such a finding. For instance, the true case of enuresis is not unknown, but the large majority of such cases in the naval service are not true cases, and surveys can, in a sense, breed epidemics. The detection of malingering is in itself a specialty, as also is the treatment of malingering at times.

The term of enlistment in the United States navy is four years, except in the case of minors over seventeen and under eighteen years of age who are enlisted for period of minority. No one is enlisted who is under seventeen.

Table of Physical Proportions for Height, and Weight, and Chest Measurement of Adults.

Height (Barefooted).	Weight (without Clothes).	Chest, Mean Circumference.
Inches.	Pounds.	Inches.
64	128	33
65	130	33
66	132	33½
67	134	34
68	141	34½
69	148	34¾
70	155	35¼
71	162	36
72	169	36¼
73	176	36¾

The minimum height required in an adult is sixty-four inches and no adult weighing less than 128 pounds is accepted. With these limitations a variation of ten pounds in weight, or two inches in chest measurement, below the standard for adults is permissible when the applicant is active, has firm muscles, and is evidently vigorous and healthy; but no such variations are allowed for enlistment as coal passer, for that rate full standard measurements being required. No member of the deck force of a ship should be allowed to change his rating to that of coal passer unless he comes up to the standards prescribed for that rating.

Chest expansion of less than two inches in a minor or of less than two and one-half inches in an adult is cause for rejection.

For a minor the following standards are prescribed and no underweight or underheight is allowed:

	Minimum Height (Barefooted).	Minimum Weight (without Clothes).
	Inches.	Pounds.
At 17 years of age	62	110
At 18 years of age	64	115
At 19 years of age	64	120
At 20 years of age	64	125

The following conditions are prescribed as causes for rejection:

Feeble constitution, general poor physique or impaired general health or any acute disease. Any disease or deformity, either congenital or acquired, that would impair efficiency, such as: Weak or deranged intellect, cutaneous disease not of a mild type, parasites of the skin or its appendages, deformity of the skull, abnormal curvature of the spine, torticollis, inequality of upper or lower extremities, inefficiency of joints or limbs, deformity of joints or bones, either congenital or the result of disease or injury, flat-feet, evidence of epilepsy or other convulsions, defective vision (minimum 15/20 in either eye), disease of the eye, color-blindness, impaired hearing, or disease of the ear, chronic nasal catarrh, ozena, polypi, great enlargement of tonsils, impediment of speech, disease of heart or lungs or predisposition to such disease, enlarged abdominal organs or evidence of cirrhosis, tumors, hernia, undescended testicle, large varicocele, sarcocele, hydrocele, stricture, fistula, hemorrhoids, large varicose veins, disease of the genito-urinary organs, chronic ulcers, ingrowing nails, bad corns, large bunions, deformity of toes, loss of many teeth or teeth generally unsound (teeth properly filled not to be considered unsound). Every recruit must have at least twenty

sound teeth, and of these not less than four opposed incisors and four opposed molars.

No insane or intoxicated person, and no deserter from the naval or military service of the United States can be enlisted in the naval service, and no man convicted of any serious offense. No one who has ever been in the naval or military service of the United States can be enlisted without showing his discharge therefrom. A bad-conduct discharge or dishonorable discharge is a bar to enlistment.

The maximum age for enlistment in nearly all naval ratings is 30 years; but hospital apprentices are enlisted between the ages of 18 and 25, and apprentice seamen, between 17 and 25.

The applicant for enlistment should be nude during much of the time of examination and the examiner should be thoroughly familiar with the appearance of the normal body in detail and as a whole. And it is a maxim that no examiner can properly examine for any trouble within the scrotum without handling the parts. In this connection it is noted that hernia, undescended testicle, any varicocele large enough to be on the mind of the applicant, sarcocele, hydrocele, stricture, and diseases of the genito-urinary organs are sufficient to cause rejection. Then, too, a navy recognizes that at least 3.5 per cent. of applicants for enlistment show a lack of color perception that would be dangerous in a naval service; and navy regulations carefully prescribe methods for the detection of such cases. The method of conducting the examination is carefully outlined in a navy's regulations, and to carry out such instruction requires close attention to many details that cannot be enumerated here.

Finally, in a service having a certain uniform in common, everyone is interested in having that uniform a badge of good citizenship. Therefore, a navy, discharging a number of undesirable men yearly, is interested in preventing such men from reenlisting, or from remaining in the service on reenlistment. For that purpose it is necessary to identify them without delay, as well as deserters seeking enlistment under other names. Identifications are also required under many other circumstances that may be associated with violent death when away from the ship or station. Such identifications depend upon descriptive lists made at time of enlistment and including such characteristics as scars, moles, warts, birthmarks, hirsuteness, peculiarity of teeth or of eyes, tattoo marks and the like, and for some years finger prints have also been made a valuable part of the identification record. Such prints are composed of rolled and plain impressions and are filed and classified at a central office. The methods of making such impressions are contained in naval instructions, and the results form the basis of a very interesting study.

The writer of an article on naval hygiene is necessarily impressed with the very large number of details that can appear only in a comprehensive work on the subject. There are no new principles of hygiene involved but so many special applications that the study of them is continuous during the naval medical officer's official life, as, in safeguarding the health of crews, such applications are a part of his daily duties. At the United States Naval Medical School, Washington, a comprehensive course is given on this subject, and the same is true of the British Naval Medical School. The writer of this article prepared a text on "Naval Hygiene" for the Washington school and reference is made to that work, not only because this article is greatly indebted to it, all illustrations having been taken therefrom, but also because it affords a much more comprehensive view of a great naval subject. JAMES DUNCAN GATEWOOD.

Naval Medical Service.—HISTORY.—The Navy originated prior to the separation of the Colonies from the Mother Country and its organization antedates the Declaration of Independence. On Friday, October 13, 1775, the first Navy legislation was passed, an act authorizing the purchase and employment of two vessels, the *Providence* and the *Lexington*, and placing control of all nautical affairs in the hands of a Marine Committee. Medical officers were employed by this committee when considered necessary. Congress first specifically mentioned surgeons in an act passed on January 6, 1776, which designated the portion of prize money they were to receive; at this time the surgeon of a ship of 20 guns or more received $25 a month, one ration of $4 and 4 shares of the prize money; the surgeon of a ship carrying 10 to 20 guns received $21 and the same allowances. An act was passed on July 16, 1777, which directed that the pay and subsistence of surgeons should be equal to the pay and subsistence of the lieutenants of the vessels to which they were respectively attached. Surgeon's mates were employed as early as 1778; at first they performed the duties of nurses and no professional attainments were required, but later their status became similar to that of assistant surgeons and the nursing was done by men from the deck force who were detailed as baymen.

During the nine years from 1789 to 1798, the executive control of the Navy was under the Secretary of War; but on April 30, 1798, the act establishing the Department of the Navy was passed by Congress. The Department of the Navy as thus established was not divided into bureaus, as in its present organization, but consisted of a single office. On August 31, 1842, an act was passed which reorganized the Navy Department and divided it into five bureaus, one of which was the bureau of Medicine and Surgery. From the passage of this act dates the separate existence of the Medical Department.

Until the act of May 28, 1828, was passed there appears to have been no systematic procedure for the appointment and admission of assistant surgeons. This act provided that: (1) No person should receive appointment as assistant surgeon until examined and approved by a board of naval surgeons. (2) No person should receive the appointment as surgeon until he had served as assistant surgeon for at least two years at sea and been regularly examined. (3) The President might appoint to every fleet and squadron an "experienced and intelligent surgeon" then in the naval service, to act as surgeon of the fleet and to be allowed double rations while so serving. (4) Assistant surgeons who had been commissioned longer than five years should receive $30 a month and two rations. After five years they were entitled to examination and, if passed, were to receive an additional $5 a month and one ration; after 10 years an additional $5 and one ration. (5) Every "present surgeon" should receive $50 a month and two rations; after five years in that grade they should receive an additional $5 and one ration; after ten years in the grade an additional $5 and one ration, and after twenty years $70 and three additional rations. (6) Every assistant surgeon after two years' service should, while at sea, receive double rations and $5 a month, and every surgeon double rations and $10 a month, in addition to his usual compensation.

ORGANIZATION.—The President is, by the Constitution, the Commander in Chief of the Navy. The head of the Navy Department is the Secretary of the Navy. The department is divided into seven bureaus, each charged with certain specific duties and in charge of an officer of the Navy who is appointed by the President by and with the advice and consent of the Senate. The chiefs of the several bureaus are appointed for four years and hold the rank of rear admiral while performing such duty. The chief of the Bureau of Medicine and Surgery is the Surgeon General of the Navy; since the establishment of this bureau, the Chiefs

of Bureau and Surgeons General have been the following:

Wm. P. C. Barton	Sept. 2, 1842 to April 1, 1844.
Thomas Harris	April 1, 1844 to Sept. 30, 1853.
William Whelan	Oct. 1, 1853 to June 11, 1865.
P. J. Horwitz	July 1, 1865 to June 30, 1869.
Wm. M. Wood	July 1, 1869 to Oct. 31, 1871.
J. M. Foltz	Nov. 1, 1871 to June 8, 1872.
J. C. Palmer	June 10, 1872 to July 8, 1873.
Joseph Beale	July 9, 1873 to Feb. 2, 1877.
William Grier	Feb. 3, 1877 to Oct. 5, 1878.
J. W. Taylor	Oct. 28, 1878 to Aug. 19, 1879.
Philip S. Wales	Aug. 20, 1879 to Jan. 27, 1884.
F. M. Gunnell	April 1, 1884 to April 1, 1888.
J. M. Browne	April 2, 1888 to May 10, 1893.
J. R. Tryon	May 11, 1893 to Sept. 7, 1897.
N. L. Bates	Oct. 1, 1897 to Oct. 18, 1897.
W. K. Van Reypen	Oct. 23, 1897 to Jan. 25, 1902.
P. M. Rixey	Feb. 5, 1902 to Feb. 4, 1910.
C. F. Stokes	Feb. 7, 1910 to Feb. 6, 1914.
W. C. Braisted	Feb. 7, 1914, present incumbent.

For the purpose of systematizing its work, the Bureau of Medicine and Surgery is organized as shown by the outline given below. The Surgeon General is the administrative head, while the Assistant to Bureau acts as executive, coordinating the entire organization and work of the bureau. The latter also acts as Chief of Bureau in the absence of the Surgeon General.

1. Division A. (Finance, general correspondence, etc.)

Subdivision 1. Chief Clerk in charge. (*a*) Finance. (*b*) Correspondence. (*c*) Clerical force. (*d*) Files.

Subdivision 2. Pharmacist in charge. (*a*) Supplies. (*b*) Requisitions. (*c*) Public bills.

2. Division B. (Personnel). Medical officer in charge.

Subdivision 1. (*a*) Medical Corps. (*b*) Medical Reserve Corps. (*c*) Dental Corps. (*d*) Red Cross.

Subdivision 2. Medical officer in charge. Hospital Corps.

Subdivision 3. Superintendent of Nurse Corps in charge. Nurse Corps (Female.)

3. Division C. (Records and pensions.) Medical officer in charge.

Subdivision 1. (*a*) Physical qualifications of candidates for enlistment, appointment, promotion, etc. (*b*) Medical surveys. (*c*) Health records.

Subdivision 2. Pharmacist in charge. (*a*) Pensions. (*b*) Records for promotion and retirement. (*c*) Vital statistics.

4. Division D. Medical officer in charge. (*a*) Construction. (*b*) Sanitary features of ships and stations. (*c*) Legislation.

5. Division E. (Publications.) Medical officer in charge. (*a*) Annual Report of the Surgeon General. (*b*) The Naval Medical Bulletin. (*c*) Miscellaneous.

The duties with which the Bureau of Medicine and Surgery is charged are defined by the Navy Regulations as follows:

"The Bureau of Medicine and Surgery shall have charge of the upkeep and operation of all hospitals and of the force employed there; it shall advise with respect to all questions connected with hygiene and sanitation affecting the service and, to this end, shall have opportunity for necessary inspection; it shall provide for physical examination; it shall pass upon the competency, from a professional standpoint, of all men in the Hospital Corps for enlistment and promotion by means of examinations conducted under its supervision or under forms prescribed by it; it shall have information as to the assignment and duties of all enlisted men of the Hospital Corps; it shall recommend to the Bureau of Navigation the complement of medical officers, dental officers and Hospital Corps for hospital ships, and shall have power to appoint and remove all nurses in the Nurse Corps (female), subject to the approval of the Secretary of the Navy.

"Except as otherwise provided for, the duties of the Bureau of Medicine and Surgery shall include the upkeep and operations of medical supply depots, medical laboratories, naval hospitals, dispensaries, technical schools for the Medical and Hospital Corps and the administration of the Nurse Corps (female), Dental Corps and Medical Reserve Corps.

"It shall approve the design of hospital ships in so far as relates to their efficiency for the care of the sick and wounded.

"It shall require for all supplies, medicines and instruments used in the Medical Department of the Navy. It shall have control of the preparation, reception, storage, care, custody, transfer and issue of all supplies of every kind used in the Medical Department for its own purposes."

To carry out the duties enumerated above, a detail of officers and enlisted men of the Medical Department of the Navy will necessarily be found wherever the activities of the Navy lead, since the primary duty of this department is to preserve the Navy's fighting force from sickness and injury; to reduce its impairment by reason of sickness or injury to the minimum and to return men so incapacitated to active duty in the shortest possible period.

Personnel.—The personnel of the Medical Department of the Navy comprises the Medical Corps, Medical Reserve Corps, Dental Corps, Dental Reserve Corps, Hospital Corps, and Nurse Corps (female). The numerical strength of the different corps is shown by the following table:

	In service.	Allowed by law.
Medical Corps:		
Surgeon General	1	1
Medical directors	*17	15
Medical inspectors	15	15
Surgeons	85	85
Passed assistant surgeons	155	230
Assistant surgeons	43	
Acting assistant surgeons	25	25
Medical Reserve Corps	102	.....
Dental Corps:		
Acting assistant dental surgeons	20	30
Dental surgeon for duty at Naval Academy	1	1
Dental Reserve Corps	12	.....
Hospital Corps	1,450	...
Nurse Corps (female)	134	...

* Two extra numbers in grade due to special legislation.

Medical Corps.—This corps has an authorized strength of 345 officers, distributed in the grades of surgeon general, medical director, medical inspector, surgeon, passed assistant surgeon, assistant surgeon and acting assistant surgeon. A person desiring to enter the corps must be a graduate of a reputable school of medicine; not over thirty years of age; of good moral character and a citizen of the United States. Application is made in a specified form, which can be obtained from the Surgeon General, for permission to be examined for admission to the Medical Reserve Corps with a view to subsequent examination and appointment in the Medical Corps. If the application be favorably acted upon, the candidate is directed to appear before a board of examiners, these boards being in session in various cities throughout the country. By this board he is given a physical and professional examination and if found qualified is appointed an assistant surgeon in the Medical Reserve Corps. Subsequently he is ordered to duty, with full pay and allowances, in attendance upon a course of instruction at the Naval Medical School, Washington,

D. C., which begins about October 1 and terminates about April 1. Upon completion of this course he is again examined and, if found qualified, is commissioned an assistant surgeon in the Medical Corps. After serving for three years in the grade of assistant surgeon, he becomes eligible for examination and promotion to the grade of passed assistant surgeon. Promotion to the higher grades is according to seniority when vacancies occur.

Medical officers receive pay according to the following table:

Rank and length of service.	Pay per annum on shore.	Allowances per annum for quarters. †	Total pay per annum on shore.	Pay per annum at sea.
Assistant surgeons,* rank of lieutenant (junior grade)	$2,000	$432	$2,432	$2,200
Passed assistant surgeons, rank of lieutenant.	2,400	576	2,976	2,640
After 5 years in the service...	2,640	576	3,216	2,904
After 10 years in the service..	2,880	576	3,456	3,168
After 15 years in the service..	3,120	576	3,696	3,432
Surgeons, rank of lieutenant commander:				
After 5 years in the service...	3,300	720	4,020	3,630
After 10 years in the service..	3,600	720	4,320	3,660
After 15 years in the service..	3,900	720	4,620	4,200
After 20 years in the service..	4,000	720	4,720	4,400
Medical inspectors, rank of commander:				
After 15 years in the service..	4,500	864	5,364	4,950
Medical directors, rank of captain:				
After 15 years in the service..	5,000	1,008	6,008	5,500
Surgeon General, rank of rear admiral	6,000	1,152	7,152	6,600

* Assistant surgeons, Medical Reserve Corps, *while on active duty* receive the same pay and allowances as assistant surgeons, Medical Corps, U. S. Navy.

† Both within and (on shore duty) beyond the continental limits of the United States, but only when quarters are not furnished by the Government.

NOTE.—There are also liberal allowances for fuel and light on shore at home and beyond the continental limits of the United States, the amount varying according to rank, season, and the latitude of the station at which the officer is serving.

Tenure of office is for life unless sooner terminated by removal, resignation, disability, or other casualty. Officers are retired from active service at the age of sixty-two years and when retired for age or for disability incurred in the line of duty they receive annual pay for life amounting to three-fourths of their highest pay at the time of retirement. Provision is made by law for the appointment of twenty-five acting assistant surgeons when their services are needed to supplement the Medical Corps. These officers receive the same pay and allowances and hold the same rank as assistant surgeons but are not entitled to promotion to the higher grades or to retirement. Their employment is usually limited to duty at recruiting stations.

Medical Reserve Corps.—This corps was established by the act of August 22, 1912. It consists of two groups; those who are to be further examined for appointment in the Medical Corps and those who are to remain permanently in the Medical Reserve Corps. The former group has been considered under the heading of the Medical Corps; the latter forms the organized reserve. An applicant for appointment in the latter group must be a graduate of a reputable school of medicine; a citizen of the United States; of good habits and moral character and between the ages of twenty-two and forty-five years. Members of the Medical Reserve Corps have the rank of assistant surgeon; when on active duty they receive the pay and allowances of that grade and their commissions confer on them all the rights and privileges of officers of that grade except promotion. Appointment in the corps is made after thorough mental and physical examination of the candidate by a board of medical examiners composed of officers of the Medical Corps.

For the naval service this corps provides a source from which properly qualified medical officers may be obtained in emergency. From the standpoint of the physician, it furnishes the means by which he can most quickly and most efficiently place himself in his country's service in time of national stress. The Medical Department of the Navy, on a peace footing, would be totally inadequate for the demands of a war with a powerful adversary and such a war would make imperative a sudden and very great increase in the medical personnel under circumstances which would render careful selection impossible and favor confusion. Such a dangerous and difficult condition has been experienced in the past but will be obviated in the future by the existence of a large Medical Reserve Corps composed of men whose professional attainments and character have been determined in advance, and whose services will be immediately available.

When the President confers a commission in the Medical Reserve Corps of the Navy, he does so with the full realization that he is placing special trust and confidence in the ability and patriotism of the individual to whom the commission is issued and, whether in peace or in war, this medical officer enjoys the prestige and standing that result from such recognition. Officers of this corps receive no financial return except when on active duty; but it has been demonstrated, during the short time the corps has been in existence, that love of country and pride in the possession of such a commission are sufficient to influence the best among the medical profession to accept this honor and responsibility, whereby they are prepared to serve their country in time of need.

Dental Corps.—This corps was established by the act of August 22, 1912, which authorized the appointment of thirty acting assistant dental surgeons. A candidate for appointment in this corps must be a citizen of the United States between twenty-four and thirty-two years of age; a graduate of a standard medical or dental college; trained in the several branches of dentistry; of good moral character and of unquestionable professional repute. Application is made as described for the Medical Corps. The examination consists of three parts, physical, professional and collateral. Officers of the Dental Corps have the same rank and receive the same pay and allowances as assistant surgeons in the Medical Corps. After serving for three years as acting assistant dental surgeons they are eligible for examination and, if successful, are commissioned assistant dental surgeons.

In addition to the dental officers mentioned above, provision is made by law for the temporary appointment of acting assistant dental surgeons in sufficient number properly to care for the personnel of the Navy. Like the Medical Corps, the Dental Corps is supplemented by a Dental Reserve Corps.

With the passage of the act establishing the Dental Corps a successful culmination of years of effort on the part of the Bureau of Medicine and Surgery was accomplished and a means was provided of filling the need for proper dental work, a need which was at times very urgent, especially on ships which were absent on long cruises and on distant stations. During the short time it has been a working organization many well-trained and desirable men have been appointed and a great volume of dental work has been performed in a satisfactory manner, fully justifying the expectations of those who were responsible for the undertaking.

Hospital Corps.—This corps was established by an act signed June 17, 1898. Before the passage of this act it was the custom, when a ship was placed in commission, to select landsmen from the crew and send them to the sick bay to begin their duties as nurses. There was no uniform standard by which

their qualifications could be determined and those who had had previous training or experience in the care of the sick were seldom found.

Under the new law improvement was rapid and at the present time the efficiency of this corps is a source of pride to the Navy. During the operations at Vera Cruz in 1914 attention was repeatedly called to the admirable manner in which the hospital corpsmen performed their work while under fire. A number of the men of this corps, after passing rigid examinations, have gained commissions in the Medical and Pay Corps of the Navy and the Medical Corps of the Army.

In 1902 the Hospital Corps Training School was established at the Naval Hospital, Norfolk, Va. This school gave a course of instruction lasting three months and after completing the course the men were sent to the various naval hospitals for further training before being assigned to stations and cruising ships for duty. In 1907 the school was removed to the old hospital building in Washington, D. C., where it continued until 1910, when it was closed and the system which is now followed was inaugurated. The newly enlisted hospital apprentices are sent to the training stations and receive the same training as the apprentice seamen, except that Hospital Corps drill and first aid instruction are substituted for gun drills and target practice. After three months at the training stations they are sent to sea for a year and receive a regular course of graded instruction. They are then detailed to various naval hospitals where the course of instruction is completed. The Hospital Corps Training School has recently been reëstablished at the Naval Training Station, Narragansett Bay, R. I., under the direction of Surgeon F. E. McCullough, U. S. N., and the first class of about forty men is now (July, 1914) under instruction. It is intended that similar schools will be established at other training stations so that, eventually, all newly enlisted men of the Hospital Corps will receive the course before being sent out into the service. At present the following branches are being taught: Anatomy, physiology, first aid and emergency surgery, nursing, hygiene and sanitation, clerical duties, pharmacy, chemistry, materia medica, toxicology, foods and cooking, litter and stretcher drills, and academic subjects. A text-book, the "Handy Book for the Hospital Corps," has been prepared and published to facilitate the teaching.

The Hospital Corps is composed of men in the following grades: Hospital apprentices, hospital apprentices first class, hospital stewards, pharmacists, and chief pharmacists.

Hospital apprentices are examined in arithmetic, spelling, writing, geography and United States history besides undergoing a thorough physical examination, before being enlisted. As a rule, first enlistments in the Hospital Corps are made in this grade. It is expected that hospital apprentices will be prepared for an acting appointment as hospital apprentice first class at the end of the first year in the service and for a permanent appointment in that rating at the end of the second year.

Hospital apprentices first class are rated after the candidates have undergone an elaborate examination to determine their qualifications to perform the duties of the rating. These men act as nurses in charge of wards in hospitals, as assistants in dispensaries and in operating rooms and as special nurses with serious cases; on board ship they perform the bulk of the nursing work.

Hospital stewards are chief petty officers. Hospital apprentices first class are eligible for examination and promotion to this rating after having held a permanent appointment as hospital apprentice first class for one year; but few are sufficiently prepared to pass this examination before the end of the first enlistment. Hospital stewards serve under an acting appointment for one year and then, if their records are satisfactory, are eligible for permanent appointment. The duties of this grade include compounding medicines, keeping records, making returns and clerical work, maintenance of discipline, and cleanliness. The examination before promotion to the grade is thorough and includes materia medica, pharmacy, chemistry, toxicology, compounding, bandaging, and minor surgery.

Pharmacists are warrant officers, with pay ranging from $1200 to $2250 a year besides allowances. When a vacancy occurs in this grade a competitive examination is held which is open to all hospital stewadrs of ten years service in that rating. The one passing with the highest average receives the appointment.

Chief pharmacists are commissioned warrant officers with pay ranging as high as $2380 a year besides allowances. Pharmacists are eligible for promotion to chief pharmacist after serving six years in the former grade. The number of pharmacists and chief pharmacists is limited by law to twenty-five.

Nurse Corps (Female).—This corps was established by the act of May 13, 1908, and at present consists of one superintendent and about 140 nurses and chief nurses. An applicant for appointment in the corps must be unmarried and a citizen of the United States. She must be a graduate of a reputable training school giving a thorough professional education, both theoretical and practical, and requiring a residence of at least two years in an acceptable general hospital of 100 or more beds. The qualifications of the candidate are further ascertained by means of a certificate which is submitted to the superintendent of the training school from which she graduated, showing the date of graduation and the moral and professional qualifications. The physical fitness is determined by a thorough examination.

Nurses are appointed for a three year term. During the first three year period the pay is $50 a month; during the second period $55 a month; during the third $60, and after nine years service $65. When serving beyond the continental limits of the United States the pay is increased $10 a month. A chief nurse receives $30 monthly in addition to her pay as nurse. The pay of the superintendent of the corps is $1800 a year. Quarters are provided for nurses or an allowance is granted for this purpose and there is an allowance for subsistence. When travelling under orders actual expenses are allowed.

Chief nurses are not appointed from civil life but vacancies are filled by promotion from the grade of nurse. Before such promotion a nurse must have served at least one year in the Nurse Corps and must pass an examination.

After appointment in the Nurse Corps a nurse usually serves at least three months at a naval hospital in the United States and during this period receives special instruction to prepare her for nursing under the conditions peculiar to the naval service. Nurses are liable for duty at home, abroad, and on hospital ships. Up to the present time they have not been employed on hospital ships but they are on duty at most of the large naval hospitals in the United States, also in the Philippines, Guam, and Samoa. The usual tour of duty at a station is not less than two years.

Establishment of this corps involved a radical departure from long established naval customs and navies are perhaps more tenacious and less disposed to alter such customs than other communities; but women nurses are undoubtedly superior to men for much of the work of caring for the sick and their desirability in naval as well as in civil hospitals has been demonstrated and is now generally acknowledged. Nurses in naval hospitals perform, in general, the same duties as in civil hospitals; in Guam and Samoa they have also the important duty of training the

native women, small groups of whom are being instructed in the elements of hygiene and nursing so that they may be of assistance to their own people and aid in their enlightenment.

Character and Location of Duty.—For convenience of description the duty of the naval medical officer may be divided into three parts; duty at sea, duty at shore stations and naval hospitals, duty with expeditionary forces. After completing the course of instruction at the Naval Medical School, the first duty is usually a tour of sea duty of about three years duration which may be spent on a vessel of the Atlantic, the Pacific or the Asiatic Fleet, or on one of the vessels engaged in special duty. Following the cruise comes the tour of shore duty, some or all of which is spent at one of the naval hospitals. The usual proportion is three years at sea to three years on shore, the relative amount of shore duty increasing as the higher grades are reached.

Duty at Sea.—Conditions of sea duty vary widely according to the type of ship, the character of the duty in which she is engaged and the part of the world in which she may be; but the problems are, in general, the same. A modern battleship is a highly complex mechanism, a maze of steam and electric machinery, from the manipulation of which many injuries are caused. There are frequently sudden and extreme changes in climate, exposure to which, with the resulting sickness, is inevitable. Contact with civil communities provides a means of introducing transmissible disease, and the ship's complement of a thousand or more men, intimately associated and confined to the limits of the ship, favors the rapid spread of an epidemic. Usual and unusual medical and surgical conditions constantly arise and require rapid and accurate judgment. The medical officer at sea must therefore be well grounded in medicine, surgery and hygiene. He must also be able to treat those conditions which are, on shore, classed among the specialties; eye affections arising from the use of the telescopic sights of the guns or from foreign bodies; nose and throat disorders due to sudden extreme changes of temperature or inhalation of irritating gases; ear conditions caused by gunfire or swimming, and when skin eruptions appear he must be able to distinguish the contagious from the non-contagious. There are also numerous routine duties to be performed, such as physical examinations of men transferred to or from the ship; eye examinations of gun pointers and others; annual physical examinations of officers; examinations of divers and of those about to take part in boxing contests; inspection of provisions and bumboats; instruction of the hospital corpsmen and of detachments from the crew in first aid, venereal prophylaxis and personal hygiene; determinations of carbon dioxide in air and of sodium chloride in distilled water; daily inspections of cells, water closets, barber shops and galleys; weekly inspection of every part of the ship, and a great deal of clerical work consisting of official reports and returns and correspondence. The medical officer is also liable for detail as a member of various courts and boards besides having important duties during such drills as general quarters, fire drill, abandon ship, collision drill, landing force, fire and rescue party, or man overboard.

The material equipment provided for the medical department of a ship is remarkably complete. Sick quarters on the newest battleships comprise the sick bay, isolation ward, dispensary, operating room, venereal dressing room and surgeon's office. The sick bay is the ship's hospital and is fitted with folding bunks which can be turned up and out of the way when not in use. The isolation ward is an important factor in prevention of epidemics. In the dispensary facilities are provided for compounding and dispensing medicines and for performing the clerical work. The operating room has a cabinet containing a complete outfit of instruments for general and special surgical work, with a modern dressing and instrument sterilizer of a special design. Other parts of the equipment are a microscope and accessories; test case for examination of urine, water and milk and for volumetric analysis; dressings, drugs, typewriter, medical books and periodicals.

The personnel of the medical department of a battleship usually consists of two medical officers, a hospital steward and five to seven hospital apprentices and hospital apprentices first class.

Duty ashore may be at navy yards and stations, naval hospitals, recruiting stations or in the insular possessions. Navy yards are industrial establishments for the upkeep of the Navy and nearly all trades and occupations are represented among the activities carried on at the various yards. A dispensary with a quota of medical officers and hospital corpsmen is provided for each yard. The medical officer is the sanitarian of the yard and is required to inspect frequently and report on the sanitary conditions of the establishment and its surroundings. He also examines applicants for employment to determine their physical fitness and supplies medical attendance for injured workmen as well as for officers and enlisted men attached to the yard and for their families. At certain yards which are remote from naval hospitals, the dispensaries assume the dignity of small hospitals and are well equipped for medical and surgical work.

Recruiting duty is one of the most important and responsible functions of the medical officer. Many undesirables are attracted by the story-book glamour that surrounds the life of the sailor, others are mentally or physically unfit to survive in the battle with the world and are moved by an earnest desire to attach themselves to an organization which provides three meals a day, every day in the year. These must be sifted out at the recruiting station. Each man has cost the Government several hundred dollars by the time he has received his training and is qualified to perform the duties of his rating; up to this time he has returned nothing in services to the Government. Should he at any time prove to be mentally or physically defective, the whole investment would be lost and he might even become a beneficiary of the Government for life without ever performing any service. Detection and exclusion of the undesirables and defectives is therefore a most important duty and the examination must usually be made in a few minutes and often under unfavorable circumstances. An average of fifteen to twenty per cent. of applicants is found to be physically qualified for enlistment; thus it is evident that the standard is high physically; it is also high morally and mentally. A trial is now being made at one of the recruiting offices of a modification of the Binet-Simon method of mental age determination, with a view to its general adoption if it proves to be a practical method of detecting those whose mentality does not make them suitable units for a military organization.

Duty at Naval Hospitals.—The more important of the naval hospitals are the following: Naval Hospital, Portsmouth, N. H., Naval Hospital, Narragansett Bay, R. I., Naval Hospital, Chelsea, Mass. These three are "type hospitals" and were completed in 1913 at a cost approximating $300,000 each. A standard design has been adapted for the new naval hospitals which is economical, adopted for extension when necessary, and suited, with slight modifications, for Tropical as well as for Temperate Zone stations. The design of these "type hospitals" provides for a main hospital of 134 beds capacity; contagious disease building of 40 beds; a power, disinfecting and laundry plant; quarters for medical officers and for nurses; stable and greenhouse. The ground plan is "T" shaped, the central administration portion with the lateral wings forming the top and the stem being

formed by the subsistence and operating building and the solarium. The frontage is 383 feet and the four wards are in the wings, connected with the administration building by solarium corridors. These hospitals are thoroughly modern in construction and their equipment is elaborate. Naval Hospital, New York, is located on Flushing Avenue, Brooklyn. It was erected in 1838 and rebuilt with additions in 1897 and 1914. The capacity is 230 beds. Naval Hospital, Philadelphia, is located on Gray's Ferry Road and was first commissioned in 1868. In 1912 it was remodelled and extended at a cost of about $160,000. The plan conforms closely to that of a type hospital and the capacity is 165 beds. Naval Hospital, Norfolk, Va., was erected in 1832 and completely renovated with important additions in 1909 at a cost of about $440,000; it now has 340 beds. Naval Hospital, Washington, D. C., was completed in 1908 at a cost of $550,000; capacity 132 beds. Naval Hospital, Annapolis, Md., was completed in 1910 at a cost of $385,000; its capacity is 104 beds. Naval Hospital, Great Lakes, Ill., a modification of the type hospital, was completed in 1912 at a cost of $325,000 and has 90 beds. Naval Hospital, Las Animas, Colo., is the Navy's sanatorium for tuberculosis; the site was formerly New Fort Lyon, it was transferred from the Army in 1906 and about $500,000 spent in adapting it for hospital purposes. Its capacity is 232 beds. Naval Hospital, Mare Island, Cal., was erected in 1900 and several additions have since been built; it now has a capacity of 220 beds. Naval Hospital, Puget Sound, Wash., is a type hospital, completed in 1912, and has a capacity of 63 beds. Naval Hospital, Guam, Marianas Islands, was completed in 1913 and has 100 beds. Naval Hospital, Yokohama, Japan, was completed in 1909 and has 100 beds. Naval Hospital, Cañacao, Philippine Islands was completed in 1910 at a cost of $290,000 and has 172 beds. Naval hospital ships *Solace* and *Relief* are described at length in the article on *Hospital Ships*, by Surgeon R. C. Holcomb, United States Navy, which appears in Volume V of this Handbook.

Naval hospitals are located in proximity to naval stations; they receive their patients from the yards and ships, usually by motor ambulance which makes daily trips. The medical staff of a naval hospital is not permanent, effort being made to give each medical officer his share of hospital work when his time for duty on shore comes. A hospital is usually commanded by an officer of the rank of medical director or medical inspector, sometimes by a surgeon. Next below him comes the executive officer, usually of the rank of surgeon, who is reponsible for the details of administration. The number of junior medical officers varies according to the needs of the individual hospital. The junior medical officers take the medical, surgical, genito-urinary, contagious, laboratory, *x*-ray and other services in rotation, so that each one is afforded opportunity to keep in touch with the work of various branches of the profession. Nursing is done by the hospital corpsmen and the female nurses.

Duty in the Insular Possessions.—This may be in the Philippines, Guam, Samoa, Hawaii, or Porto Rico. Such duty provides splendid opportunities for study of tropical diseases and, in Guam and Samoa, there is excellent training in public health administration since these islands have a paternal form of government and naval medical officers act as quarantine officers and health commissioners. Gangosa, in Guam, has so far baffled all efforts to determine its etiology and transmission and whether it is an attenuated form of syphilis or a sequel of yaws is to be decided in the future. Animal parasitic diseases are practically universal in Guam and Samoa and their eradication is the object of administrative measures in which the medical officer is primarily concerned. Public latrines, shower baths, water works and sewerage systems are being erected in these islands; free medical attendance and hospital facilities are provided by medical officers of the Navy; reading notices containing information about personal and public hygiene and the methods of preventing disease are published in the native newspapers. These activities furnish a rich field for humanitarian as well as for medical work of an unusual nature, and so there are many requests for duty in the insular possessions.

Duty with Expeditionary Forces.—Such duty is generally with the Marine Corps, which is a distinct organization, though a part of the Navy. Detachments of marines are assigned to the larger ships and numbers of them are concentrated at certain depots on both coasts, where they are always prepared for instant response to calls for duty anywhere in the world. The Marine Corps has an enviable record for quick and efficient action. During recent years its men have seen service in China, the Philippines, Mexico, Nicaragua, Cuba, Culebra, and Santo Domingo, and always they are accompanied by naval medical officers and hospital corpsmen. Marines can be sent ashore in foreign countries to protect American citizens and interests without the formality of declaring war. This duty enables members of the Medical Department of the Navy to become familiar with the problems of camp hygiene and sanitation and military duty on shore as well as at sea.

Special Duties.—Because of their unusual advantages for experience along certain lines outside the usual scope of medical practice, the services of naval medical officers are often sought by organizations not associated with the Navy. Some of these special duties performed by the members of the Medical Corps during the last two years are lecturing in tropical medicine, parasitology and surgery in five well-known medical colleges; teaching physical training; duty with the Pellagra Commission, the Philippine Government and the Alaskan Coal Investigating Commission; investigating methods of treating tuberculosis; studies of conditions of deep diving and of the air in submarines.

The Naval Medical School.—For a short time prior to the Spanish-American War, medical officers on entering the naval service received a brief course of instruction at the Naval Laboratory connected with the Naval Hospital, New York, in order to familiarize them with the conditions of medical work peculiar to the Navy. The outbreak of that war, however, so increased the demand for medical officers that their services could no longer be spared and it was found necessary to discontinue the school.

By order of the Navy Department, dated May 27, 1902, the school was reëstablished on a more substantial footing, under the title of the United States Naval Medical School, and space in the building occupied by the Museum of Hygiene was allotted to it. The first class was assembled in October, 1902, and on April 4, 1903, twelve members were graduated. The new Naval Hospital, Washington, was later built on the same grounds and, since its completion, has added greatly to the facilities for instruction. It has as its primary object the training of recently appointed medical officers in those branches of medical science which are peculiar to naval requirements or which are of unusual importance because of naval conditions. It also maintains laboratories of bacteriology, pathology, and chemistry for research and diagnosis as well as for instruction, and there are important pathological and helminthological collections containing specimens contributed by medical officers and others from all parts of the world. A reference library is connected with the school for the use of the student officers and this is also utilized as a source from which medical officers of the service may draw medical books and periodicals for temporary use.

The faculty consists of medical officers of the Navy detailed for that purpose and aided by various specialists who give lectures or courses in their specialties. Instruction is given in the following subjects: Naval and general hygiene, naval and operative surgery, tropical medicine, pathology, medical zoology, bacteriology, serology, ophthalmology, chemistry, psychiatry, radiology, and electrotherapeutics, Hospital Corps drills, duties of medical officers and such other subjects, including naval law, epidemiology, and quarantine, as may be feasible.

At the beginning of the school year, about October first, members of the Medical Reserve Corps who desire to enter the Medical Corps are ordered to the school, with full pay and allowances, for the course of instruction. Upon completion of the session, usually about April first, they are examined to determine their fitness to enter the Medical Corps and, if successful, are commissioned in that corps, their relative standing in that corps being determined by the merit of the work done during the course and the results of the examination.

Publications.—The Annual Report of the Surgeon General is an annual report to the Secretary of the Navy covering the activities of the Bureau of Medicine and Surgery for the preceding fiscal year and the statistics of health of the Navy and Marine Corps for the preceding calendar year. It is published as a part of the Report of the Secretary of the Navy and also as a separate document.

The Naval Medical Bulletin is a quarterly publication, the first number of which appeared in April, 1907. Its purpose is the dissemination of certain highly specialized naval and medical information which is not available in any other one place, and it thus embraces a field which is in many respects unique. For the source of material it is limited almost entirely to the Medical Corps of the Navy.

Red Cross Cooperation.—Since the main purpose of the Medical Department—to maintain the supply of effective fighting men—is primarily military and not humanitarian, the services of its members are, in times of greatest military activity, not available for humanitarian work and such duties must be undertaken by other organizations. To supply the need thus created, an act approved April 24, 1912, provides that whenever in time of war or when war is imminent, the President may deem the cooperation and use of the Red Cross with the naval forces to be necessary, he is authorized to accept the assistance tendered by the said Red Cross and to employ the same under the sanitary service of the Navy.

Under authority of this act the very valuable aid of the Red Cross will be utilized in time of war to supplement the Medical Department of the Navy which will thus be free to devote its whole attention to its mission of maintaining the supply of men for the guns. Lucius W. Johnson.

References.

Dunbar, A. W.: U. S. Naval Medical Bulletin, vi., No. 4, p. 473, Oct., 1912.

Farenholt, A.: U. S. Naval Medical Bulletin, ii., No. 4, p. 99, Oct., 1908.

Gibson, W. S.: U. S. Naval Medical Bulletin, vii., No. 1, p. 39, Jan., 1913.

Manual for the Medical Department, U. S. Navy, 1914.

Oman, C. M.: Journal of the American Medical Association, lxii., No. 20, p. 1541, May 16, 1914.

Riker, G. A.: U. S. Naval Medical Bulletin, vii., No. 4, p. 533, Oct., 1913.

Necator.—*Dochmius, Uncinaria.* The genus includes a single species, *N. americanus*. This hookworm is found in India, Burmah, Philippine Islands, Africa, and America. The head is bent dorsally, the mouth is small and armed only with semilunar plates. In the female the ulva opens near the anterior end of the body. See *Nematoda*. A. S. P.

Neck, Surgical Anatomy of the.—By the neck we usually mean the space between the occipital bone and lower jaw, above, and the upper aperture of the thorax, below. For convenience of description it is advisable to divide the neck into regions, viz., two lateral, an anterior median, and a posterior.

The *lateral* region represents a quadrilateral which is divided diagonally by the great sternomastoid muscle into two triangles, the anterior (carotid) and the posterior. Each of these is again subdivided into two by the omohyoid muscle. The anterior triangle is subdivided into a superior and an inferior carotid triangle, and the posterior into an occipital and a subclavian triangle.

The *anterior median* region is divided into two spaces by the hyoid bone, the upper being called the suprahyoid or submaxillary, and the lower the infrahyoid or hyosternal region.

The *submaxillary* region is bounded posteriorly by the posterior belly of the digastric and stylohyoid muscles, and contains the submaxillary gland.

The *posterior region* includes the portion commonly known as the nape of the neck.

Surface Anatomy.—The outline of the neck varies much in different people; in stout individuals it is round and full, and the various landmarks are not easily distinguished; in thin people, on the other hand, every landmark stands out prominently, and can be made out by even the most inexperienced. The neck is, as a rule, fuller and rounder in women and children, and the *pomum Adami* is less marked. In muscular males the prominences are well seen; in old people who are thin the sternomastoid muscles and superficial veins stand out well, as does also the internal border of the platysma myoides.

Bony Points.—The most important bony point, and one of those most easily felt, is the hyoid bone, which is in the median line, a finger's breadth above the thyroid cartilage. It is opposite the fourth cervical vertebra. The cricoid cartilage is opposite the sixth cervical. Below and in front of the mastoid process, and behind and above the angle of the lower jaw, the transverse process of the atlas can be felt. In the posterior region in the middle line is a depression formed by the complexus and trapezius muscles of each side; here can be indistinctly made out the third, fourth, fifth, and sixth cervical spines, while the seventh can be easily felt, and also the spines of the first two dorsal vertebræ. These become more prominent when the head is bent forward; occasionally, when the spine of the sixth cervical vertebra is well developed, it is quite as prominent as the seventh. The transverse process of the sixth cervical vertebra can be felt on deep pressure opposite the cricoid cartilage, in the course of the carotid vessels. This is called the "carotid tubercle," and here the carotid may be easily compressed against it.

Anterior or Median Region.—In the receding angle below the chin is the hyoid bone, which can be easily felt in the fattest necks, it divides the anterior part of the neck into the suprahyoid and infrahyoid regions. In the median line of the suprahyoid region the anterior bellies and the digastric muscles cause a slight convexity; on the outer side of each anterior belly of the digastric muscle is felt the submaxillary gland lying on the mylohyoid muscle, which helps to form the floor of the mouth. This region is commonly cut into in self-inflicted wounds of the throat. About half an inch below the hyoid bone is the prominent thyroid cartilage (pomum Adami). This cartilage is prominent in deep-voiced men and people with thin necks, but in women and children it is not so distinctly seen; the notch at its upper border can be

easily felt, and is commonly situated to one side of the median line. The superior cornua of the thyroid cartilage can be traced with the finger. The space between the thyroid cartilage and the hyoid bone is called the thyrohyoid space, a membrane connecting these two structures; this membrane is covered by the muscles going to the hyoid bone from below, and is pierced by the superior laryngeal nerve and artery of each side. A cut made through the thyrohyoidean space would sever the lower part of the epiglottis. The rima glottidis is opposite the middle of the thyroid cartilage. Below this cartilage the finger sinks into a slight depression, the cricothyroid space; this is the space in which the operation of laryngotomy is performed, the opening here being well below the vocal cords. Across this space ramify two small vessels, the cricothyroid branches of the superior thyroid arteries. The next landmark of interest is the cricoid cartilage; it is a guide to many operations on the neck and air passages, and can be distinguished in the youngest and fattest neck. The cricoid cartilage is opposite the sixth cervical vertebra, and the narrowest part of the gullet is behind it; at this point foreign bodies are most likely to be arrested. The omohyoid muscle crosses the carotid vessels on a line with the cricoid cartilage, immediately above which line is the point usually selected for tying the common carotid artery. The middle cervical ganglion of the sympathetic is also on a line with this cartilage, and a little below and outside of it is the point where the vertebral artery enters the transverse process of the sixth cervical vertebra.

Below the cricoid cartilage the finger passes on to the trachea, the separate rings of which cannot be easily felt, because they are covered by the isthmus of the thyroid gland above, and below the trachea recedes from the surface. At the upper border of the sternum the trachea is one inch and a half from the surface. The isthmus of the thyroid crosses the second and third rings of the trachea.

In front of the trachea, below the isthmus, lie the inferior thyroid veins, which give so much trouble in tracheotomy. Occasionally an artery is found lying upon the trachea, on its way to the thyroid gland; it is called the thyroidea ima and generally arises from the innominate. The episternal notch is felt at the top of the sternum, and is opposite the second dorsal vertebra.

Lateral Region.—The sternomastoid muscle is the prominent landmark in this region; in thin subjects, especially, it is well seen, and stands out distinctly when the face is turned to the opposite shoulder. The inner border, which covers the carotid artery, is more strongly marked than the posterior, which is thin, only the lower portion showing through the skin. The sternal tendons are well seen in nearly everybody, the depression between them being named the suprasternal fossa. In some necks this fossa is absent, owing to the space being filled with fat. The space between the sternal and clavicular portions of the sternomastoid can usually be made out; in thin necks it is well marked. The internal jugular vein and carotid artery lie behind this space; deeper down still, we have the apex of the lung, which sometimes rises an inch and a half above the clavicle.

The sternoclavicular articulation is an important landmark; immediately behind it, on the left side, is the common carotid artery and the division of the innominate; on the right, it is opposite the point where the internal jugular joins the subclavian vein to form the innominate. The division of the innominate artery in children is higher up than the articulation; in some cases it divides in front of the trachea (see *Arteries, Anomalies of*).

The depression above the clavicle, between the trapezius and the clavicular origin of the sternomastoid, is called the supraclavicular fossa. In this fossa the external jugular vein terminates in the subclavian, after piercing the deep cervical fascia. Here also may be felt, in thin persons, the brachial plexus of nerves and the omohyoid muscle, and in the angle formed by the sternomastoid and clavicle the third part of the subclavian artery may be felt pulsating. At this point it can be compressed against the first rib. The central point of the greatest convexity of the clavicle is opposite the third portion of the subclavian artery. This is a more certain landmark than the muscle, the extent of attachment of which to the clavicle varies considerably.

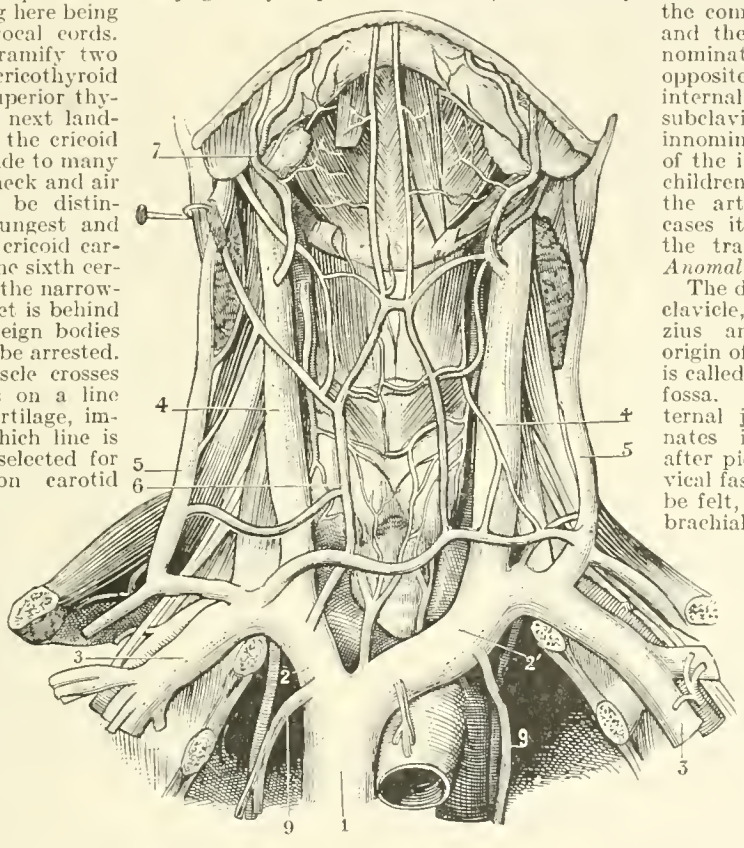

Fig. 4064.—Superior Vena Cava and Its Affluents. (From Testut.) 1, Superior vena cava; 2, trunk formed by the union of the brachial and cephalic veins on the right side; 2′, the corresponding venous trunk on the left side; 3, 3, subclavian veins; 4, internal jugular vein; 5, external jugular vein; 6, anterior jugular vein; 7, facial vein; 8, thyroid veins; 9, internal mammary vein.

The posterior border of the sternomastoid corresponds pretty closely to the outer border of the scalenus anticus muscle; this point should be borne in mind in tying the subclavian artery.

Behind the sternomastoid the chain of lymphatic glands, when enlarged, can be easily felt.

The posterior belly of the digastric muscle corresponds to a line drawn from the mastoid process to the body of the hyoid bone. When the chin is extended a prominent fold of cervical fascia can be felt going from the angle of the lower jaw, downward and outward.

The position of the tonsil corresponds externally to the angle of the jaw.

Surface Marking of Veins.—The most important of these is the *external jugular*, which can always be

seen. Its course is marked out by a line drawn from the angle of the jaw to the middle of the clavicle, at which point it pierces the deep cervical fascia to join the subclavian vein. It is occasionally joined by a vein which runs over the clavicle (see *Veins, Anomalies of*). By pressing above the clavicle, the vein is distended, and its course is easily traced.

The *anterior jugular* vein lies on the sternohyoid muscle and in front of the inner border of the sternomastoid. When the external jugular is small this vein attains considerable size.

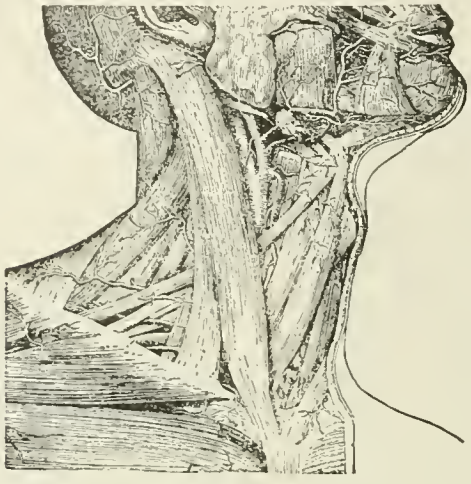

Fig. 4065.—Dissection of the Neck, showing the Triangles and their Contents. (Tiedemann.)

The surface marking of the *internal jugular* corresponds to a line drawn immediately external to the line of the artery. The *facial vein* runs from the anterior border of the masseter muscle downward and backward, and joins the internal jugular opposite the upper border of the thyroid cartilage.

The *middle thyroid vein* crosses the carotid artery opposite the cricoid cartilage.

Surface Marking of Arteries.—The *carotid* artery corresponds to a line drawn from the sternoclavicular articulation to a point midway between the mastoid process and the angle of the jaw. The *common carotid* reaches as high as the upper border of the thyroid cartilage. It can be compressed against the sixth cervical transverse process ("carotid tubercle"), which is opposite the cricoid cartilage. The *superior thyroid* artery comes off from the external carotid a little above the upper border of the thyroid cartilage. The *lingual* artery runs forward from the external carotid to the upper border of the great cornu of the hyoid bone, to which it is parallel. The hypoglossal nerve lies above the artery. The course of the *facial* artery in the neck corresponds to a line drawn from the tip of the great cornu of the hyoid bone to the outer border of the masseter muscle.

The *occipital* arteries can be felt pulsating immediately below and a little in front of the tip of the mastoid process.

Surface Marking of Nerves.—The *spinal accessory* nerve passes beneath the anterior border of the sternomastoid muscle an inch below the tip of the mastoid process, and emerges from the posterior border at a point on a level with the upper border of the thyroid cartilage; it then crosses the posterior triangle obliquely and enters the trapezius muscle on a level with the sixth or seventh cervical spines.

The *phrenic* nerve commences in the neck about the level of the hyoid bone, and runs obliquely downward over the scalenus anticus to its inner edge. In the neck the phrenic nerve is covered by the sternomastoid.

The *superficial cervical* nerves all emerge at a point corresponding to the middle of the posterior border of the sternomastoid. The *great auricular* crosses the sternomastoid on its way up to the ear; the *lesser occipital* runs along the posterior border of the sternomastoid; the *superficial cervical* crosses the sternomastoid at right angles and reaches the middle of the neck, and lines drawn from the point of emergence to the sternum, middle of the clavicle, and the acromion would mark the course of the *suprasternal, supraclavicular* and *supraacromial* nerves.

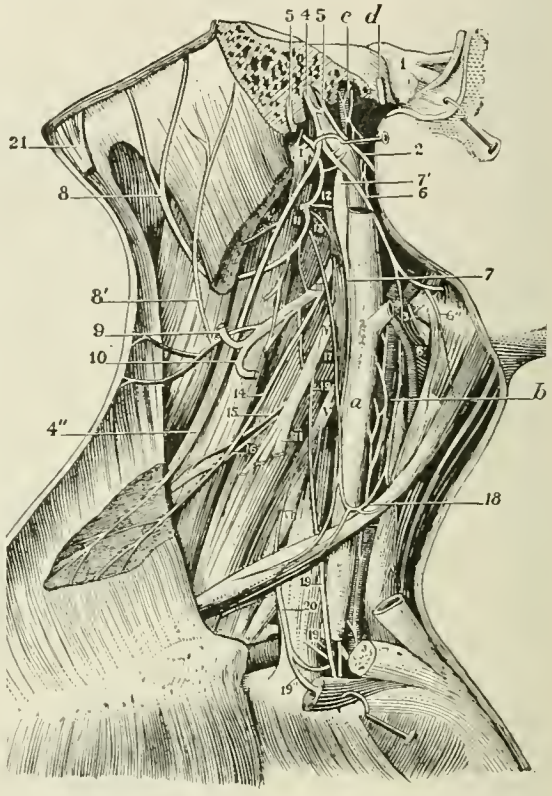

Fig. 4066.—Deep Cervical Plexus of Nerves. (From Testut.) *I, II, . . . VIII*, Anterior branchea of the eight cervical nerves.—1, trigeminal nerve, with its three branches; 2, glossopharyngeal; 3, pneumogastric, with, 3′, its branch, the superior laryngeal; 4, spinal accessory, with its two branches—4′, that which supplies the sterno-cleido-mastoid muscle, and, 4″, that which goes to the trapezius; 5, facial nerve; 6, the main trunk of the hypoglossal, with its two branches—6′, the descending ramus, and, 6″, that which supplies the thyrohyoid muscle; 7, the great sympathetic, with, 7′, its superior cervical ganglion; 8, the larger mastoid branch of the cervical plexus; 8′, the little mastoid branch; 9, the auricular branch; 10, the transverse cervical branch; 11, the subclavian and subacromial branches; 12, point of anastomosis with the great sympathetic; 13, nerve of the large anterior rectus muscle; 14, trapezian branch of the cervical plexus; 15, nerve of the levator ang. scap.; 16, nerve of the rhomboideus; 17, internal descending branch; 18, bend of the hypoglossal, with its efferent branches that supply the subhyoidean muscles; 19, phrenic nerve, with, 19′, its anastomosis with the great sympathetic, and, 19″, its anastomosis with the nerve that supplies the subclavius muscle; 20, the nerve of the subclavius muscle; 21, great occipital nerve. *a*, Internal jugular vein; *b*, the common carotid artery; *c*, the internal carotid; *d*, the middle meningeal; *e*, the subclavian artery.

The cutaneous branches of the cervical plexus are widely distributed, supplying the ear, back of scalp, cheek, parotid gland, side and front of neck, and upper part of chest and shoulder.

The facial nerve sends a branch to the neck, which supplies the platysma myoides muscle.

Topographical Anatomy.—The skin over the anterior and lateral regions of the neck is thin and lax, and in plastic operations is of great value in making flaps. The platysma is closely connected with the skin of this part of the neck. There is frequently some transverse wrinkling of the skin above the hyoid bone, and in this region in fat people there is much fat, giving rise to what is called a double chin; here also the sebaceous follicles are very abundant. In adult males this part is covered with beard.

The skin of the posterior region is very thick and adheres closely to the deeper structures; this is due to the large number of short fibrous connections between the skin and fascia. Carbuncles and boils frequently occur here and cause great pain, owing to the density of the parts and their free nerve supply.

The *nape* of the neck is often the seat of pustular and vesicular eruptions, which are due almost invariably, when localized in this part, to the presence of pediculi, these parasites finding a safe habitat in the thick hair under the prominent portion of the occipital bone. The glands in this region are frequently enlarged in sympathy with eruptions of the hairy scalp. The nape of the neck was the favorite site, in olden times, for the application of setons and issues.

Fatty tumors are often seen at the lower part of this region.

Cervical Fascia.—It is the custom to divide the deep fascia of the neck into *superficial* and *deep* processes. The superficial fascia invests all the muscles, with the exception of the platysma; and some of the veins, as the external jugular, are also superficial to it. It is attached posteriorly to the spinous processes of the cervical vertebræ and ligamentum nuchæ; passing forward it splits to enclose the trapezius and then crosses the posterior triangle; at the posterior border of the sternomastoid the fascia divides into two layers which enclose that muscle, these layers unite at the anterior border of the muscle, and the fascia passes on to the middle line of the neck, where it is continuous with that of the opposite side. It covers the anterior triangle, being attached above to the lower jaw. In the posterior triangle the fascia is attached below to the clavicle and above to the mastoid process and the superior curved line of the occipital bone; in this triangle it is pierced by the external jugular vein and some of the superficial cervical nerves. In the anterior triangle the fascia is attached above to the body of the lower jaw, and continues backward and upward over the parotid gland to be attached to the zygoma. It sends a process (the stylomaxillary ligament) between the parotid and the submaxillary glands. In front the fascia is attached to the hyoid bone and covers the thyroid gland, below which it splits into two layers; the deeper covers the sternohyoid and sternothyroid muscles, and is attached below to the posterior edge of the first piece of the sternum, behind the sternoclavicular joint; the superficial and thinner layer passes down over the sternomastoid muscles, and is attached to the anterior edge of the manubrium and interclavicular ligament. The space between these two layers is filled with cellular tissue and fat, and sometimes a small gland is found here. In this compartment are also found the sternal head of the sternomastoid and the anterior jugular vein. In tenotomy of the sternomastoid this space must be opened, and the vein is avoided by keeping the knife close to the tendon of the muscle.

This space is also cut through in performing the operation of tracheotomy, and air is sometimes driven at every inspiration into the cellular tissue beneath the deep layer, an occurrence which complicates the operation exceedingly. The process of fascia covering the posterior belly of the omohyoid and binding it down to the clavicle and first rib, is continuous with the fascia covering the depressors of the hyoid bone.

The deeper processes of cervical fascia are important; one comes off from the anterior border of the sternomastoid and forms a sheath which encloses the carotid artery, jugular vein, and pneumogastric nerve. The vein is separated from the artery by a thin septum of fascia.

A process of fascia also invests the thyroid body, passes behind the depressors of the hyoid bone, and lies in front of the trachea and deep vessels of the neck; below, this layer is continuous with the fibrous pericardium.

The *prevertebral* fascia is a layer which descends on the prevertebral muscles, separating them from the pharynx and esophagus; laterally it joins the carotid sheath and then proceeds outward covering the scalene muscles, brachial plexus of nerves, and subclavian vessels, becoming continuous with the axillary sheath. It is also connected with the costocoracoid membrane.

Although the cervical fascia influences to a certain extent the growth of tumors and collections of matter, this influence has been much exaggerated, and tumors grow and matter collects and distributes itself often quite irrespective of this fascia.

Pus in front of the trachea would tend to gravitate into the anterior mediastinum and on the side of the neck might perforate the apex of the pleural sac. An abscess in front of the vertebræ would lie beneath the prevertebral fascia, and if it did not burst into the gullet, might extend laterally and present itself outside the sternomastoid, or descend to the posterior mediastinum. In some cases these collections of pus have been known, after reaching the posterior triangle of the neck, to follow the course of the brachial plexus and present themselves in the axilla. Pus pent up between the layers of the cervical fascia has destroyed portions of not only the jugular vein, but also the carotid artery, and when the abscess cavity was opened the patient has died of hemorrhage from these vessels. S. W. Gross collected twelve cases of ulceration of the jugular veins, with hemorrhage into the sacs of closed abscesses, or into abscesses several days after their contents have been evacuated, or into acute or chronic ulcers. The majority of cases were in children who had cellulitis of the neck following scarlet fever—all the cases proved fatal.

In opening abscesses in the neck, there is some danger of wounding some of the great vessels if a too free incision be made with the knife, the vessels being pushed out of their normal position by the abscess; their exact course is difficult to determine. In such cases at first the skin only should be incised; after this the knife should be laid aside and a director should be pushed through the fascia; and when pus runs along the groove of the director, a pair of dressing forceps should be introduced, opened in the abscess cavity, and withdrawn open. This method has the advantage of being perfectly safe, and is especially adapted for opening deep-seated abscesses. It is known as Hilton's method.

Arteries of the Neck.—The two large arterial trunks which are seen in the neck are the *carotid*, which lies in the anterior triangle, and the *subclavian*, which lies in the lower part of the posterior triangle (subclavian triangle).

The *carotid* is included in a sheath of deep cervical fascia with the internal jugular vein and pneumogastric nerve. The vein lies to its outer side, and in the living subject overlaps the artery at the lower end and especially on the left side. To the inner side of the artery lie the trachea and esophagus, larynx, and pharynx, and low down the recurrent laryngeal nerve. The thyroid gland also lies to its inner side. The vagus nerve lies to the outer side and posteriorly above, and rather more in front below.

Lying on or in the sheath of the vessels is the descendens noni nerve. The great sternomastoid

muscle covers not only the common, but also the internal and external carotid arteries. In the undissected subject it is impossible to puncture the common carotid from the side of the neck without piercing the sternomastoid muscle (Richet). This fact is not sufficiently dwelt on in anatomical works, the descriptions given being applicable to dissected subjects only. The omohyoid muscle crosses the artery and vein obliquely and on a line with the cricoid cartilage. The most important structures behind the artery are the sympathetic trunk, the inferior thyroid artery, and the recurrent laryngeal nerve. The common carotid normally gives off no branches in its course. It divides into external and internal carotid opposite the upper border of the thyroid cartilage. The right and left common carotid arteries are so similar in their course in the neck that one description will answer for both. The left, however, it is well to bear in mind, arises from the arch of the aorta, and is somewhat longer than the right, which arises from the innominate opposite the right sternoclavicular articulation. The right common carotid is generally larger and not so deeply placed in the neck as the left; it is also farther away from the trachea.

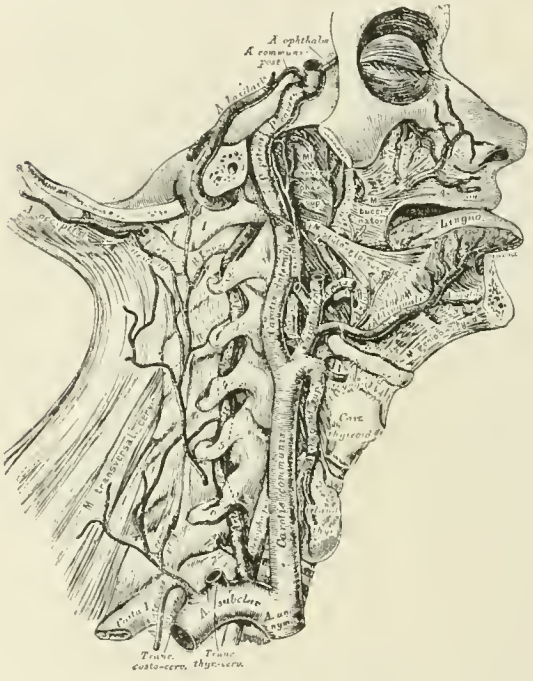

Fig. 4067.—View of the Common Carotid and Subclavian Arteries, with the Origin of their Branches and their Relations. (Heitzmann.)

As the vessels ascend the neck they become more superficial, and, having a direction somewhat backward, get farther apart as they reach their termination. The surface marking of the carotid has already been described.

The artery may be easily compressed against the transverse process of the sixth cervical vertebra.

Ligature of the Common Carotid.—A ligature may be applied to any part of the artery, except near its origin or termination. The usual point of ligature is either immediately above or below the omohyoid muscle. It is usually ligatured above the omohyoid, as here the artery is more superficial, and the operation is, in consequence, easier. An incision should be made along the inner border of the sternomastoid muscle, and the parts carefully divided until the sheath of the vessels is reached. The operation is much facilitated by drawing the sternomastoid outward and (if the superior operation be chosen) pulling inward the omohyoid. Should any veins or small branches of the superior thyroid artery come in the way, they should be divided between two ligatures. The sheath of the vessels should be opened on its inner side, so as to avoid the jugular vein, and the descendens noni nerve should be held aside to avoid injury. The aneurysm needle with the ligature should be passed from without inward; in this way the vein and vagus nerve are most easily avoided.

The lower operation is the more difficult one, for, to expose the sheath of the vessels it is often necessary to divide some fibers of the muscles covering it. Again, the vein, if large, overlaps the artery; this renders the passing of the aneurysm needle a proceeding of some difficulty. On the left side the internal jugular vein is much closer to the artery than on the right, and so the difficulty of passing a ligature around the artery is much increased. Ligature of the carotid is performed for wounds of the vessel or some of its

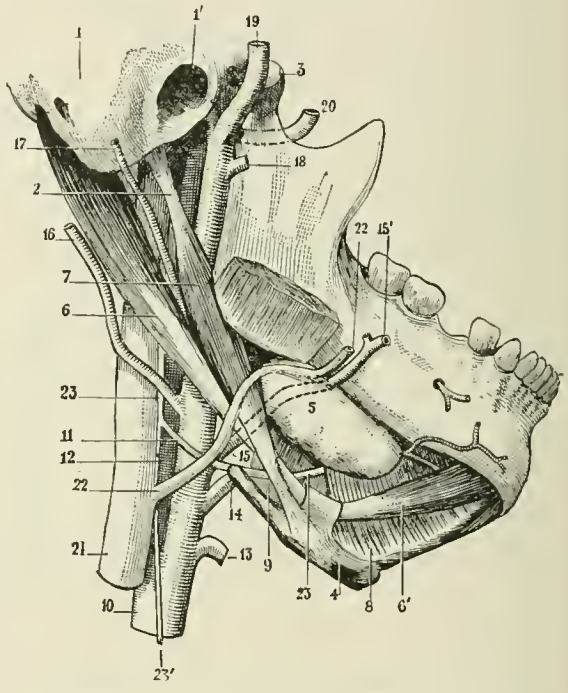

Fig. 4068.—Relations of the Two Carotids to the Styloid and Digastric Muscles. (From Testut.) 1, Mastoid process; 1′, orifice of the external auditory canal; 2, styloid process; 3, condyle of the inferior maxilla; 4, hyoid bone; 5, submaxillary gland; 6, 6′, the anterior and posterior bellies of the digastric muscle; 7, stylohyoid muscle; 8, mylohyoid muscle; 9, hyoglossus muscle; 10, common carotid; 11, internal carotid; 12, external carotid; 13, superior thyroid artery; 14, lingual artery; 15, 15′, facial artery; 16, occipital artery; 17, posterior auricular artery; 18, transverse artery of the face; 19, superficial temporal artery; 20, internal maxillary artery; 21, internal jugular vein; 22, facial vein; 23, great hypoglossal nerve, with, 23′, its descending branch.

branches, also for aneurysm. It has been ligatured for pulsating orbital tumor. A common site of carotid aneurysm is at the bifurcation of the common carotid, and the treatment is ligature of the vessel below. In aneurysm at the root of the neck the carotid has been ligatured with success above the tumor. Ligature at the distal side of an aneurysm was first proposed by Brasdor, and practised by Warddrop. The treatment of aneurysm of the arch of the aorta or innominate artery by simultaneous ligature of the carotid and subclavian arteries has been attended in a few cases with benefit.

Aneurysm at the root of the neck frequently gives rise to "pressure symptoms." When the great venous trunks are compressed there is edema and lividity, not only of the side of the face and neck, but also of the upper extremity of the same side. Not infrequently cough is produced by pressure on the recurrent laryngeal nerve, and if the pressure be great, then paralysis of the vocal cords of that side will ensue and cause a marked alteration of the voice. Dilatation of the pupil may also occur from pressure on the sympathetic trunk.

When the common carotid reaches the upper part of the larynx, it divides into two trunks, one of which, the *external*, gives off a number of branches, and is distributed to the superficial parts of the head and face and the tongue; the other, the *internal*, furnishes blood to the brain and eye. As a rule, the internal carotid has the deeper course, and lies behind the external, but not infrequently the two arteries lie side by side for some distance, the internal lying more posteriorly, and being recognized by the accompanying pneumogastric nerve. The two vessels are separated by the styloid process and stylohyoid ligament, also the styloglossus and stylopharyngeus muscles and glossopharyngeal nerve. The external trunk has two muscles and a nerve in relation to it anteriorly, viz., the digastric and stylohyoid muscles, and the hypoglossal nerve which hooks round one of its branches, the occipital. After passing behind the angle of the lower jaw the external carotid becomes embedded in the parotid gland.

Ligature of the external carotid is not a very easy operation owing to the number of branches given off from it, and the large venous trunks which lie over the lower portion may much increase the difficulties. The artery is reached by an incision in the line of the vessel, having its midpoint about the level of the hyoid bone. It is usually ligatured immediately below the digastric. It occasionally requires ligature in the course of operations for the removal of tumors about the angle of the jaw and neck.

Branches of External Carotid.—The most important branches in the neck are the superior thyroid, lingual, and the cervical portion of the occipital and facial.

The *superior thyroid* arises near the origin of the main vessel and curves downward, forward, and inward, beneath the depressors of the hyoid bone. It is distributed to the upper part of the thyroid gland, and can be readily exposed by an incision between the omohyoid and sternomastoid muscles. It sends a branch along the cricothyroid membrane which is sometimes wounded in the operation of laryngotomy. The superior thyroid artery has lately been tied with success for the purpose of arresting the growth of an enlarging thyroid body.

The *lingual* artery arises from the external carotid nearly opposite the great cornu of the hyoid bone (it may, however, arise in common with the superior thyroid and cross the hyoid bone). It runs above and parallel to the great cornu and beneath the hyoglossus muscle. It is frequently necessary to ligature the lingual previous to extirpation of the tongue.

In ligaturing this vessel the one guide which the operator must rely on is the great cornu of the hyoid bone—it can always be felt and its relation to the artery is nearly always constant. The best place to expose the artery is immediately above the great cornu. Some authorities advise ligature of the artery near its origin from the carotid; but here, owing to the large veins which cover it, the operation is more difficult, and besides we have no absolute guide as to the exact point of origin of the artery, which frequently varies. On the other hand, the relation of the vessel to the great cornu of the hyoid bone is nearly always constant. The incision should be a curved one, and should extend from near the symphysis menti to near the angle of the lower jaw. The convexity of the curve should be downward, and its lowest point ought to reach the hyoid bone. After dividing the skin, platysma, and deep fascia, the tendon of the digastric muscle should be searched for, and in the angle which the tendon forms with the hyoid bone the artery will be found running beneath the hyoglossus muscle; the hypoglossal nerve is seen running over this muscle. If the submaxillary gland cover the parts, it should be held aside with hooks. After carefully dividing the hyoglossus muscle the artery will be felt pulsating at the bottom of the wound. If the incision be carried too far back the facial vein may be wounded.

When it is necessary to remove the submaxillary gland the facial artery must be ligatured. The operation presents no difficulties and requires no special description.

The *subclavian artery* is, surgically, a very important vessel. The left subclavian lies deeper than the right and arises directly from the arch of the aorta, while the right is one of the terminal branches of the innominate and commences opposite the right sternoclavicular articulation. Each artery curves upward into the neck under the anterior scalenus muscle, and then descends into the subclavian triangle under the

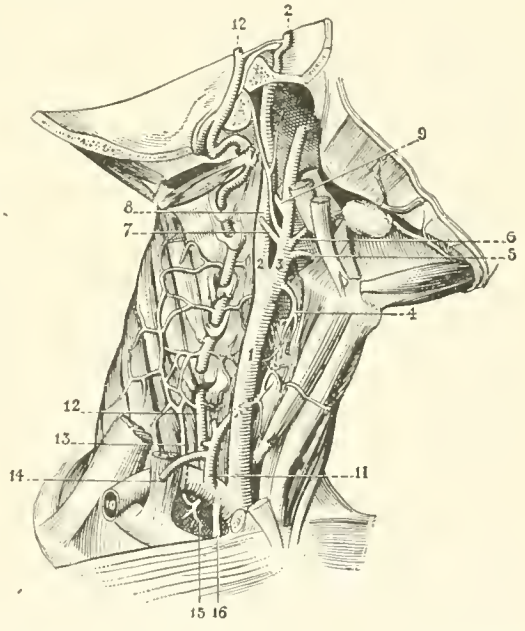

Fig. 4069.—Inferior Thyroid and Vertebral Arteries. (From Testut.) 1, Common carotid artery; 2, internal carotid artery; 3, external carotid artery and its branches; 4, superior thyroid artery; 5, lingual artery; 6, facial artery; 7, occipital artery; 8, inferior pharyngeal artery; 9, posterior auricular artery; 10, subclavian artery and its branches; 11, thyroid axis; 12, vertebral artery; 12′, posterior cerebral artery; 13, deep cervical artery; 14, subscapular artery; 15, superior intercostal artery; 16, internal mammary artery.

clavicle and over the first rib. The subclavian vein lies in front and somewhat below the artery, from which it is separated by the anterior scalenus.

The artery is divided into three portions by the scalenus anticus muscle, viz., first, portion internal to the muscle; second, portion beneath the muscle; and, third, portion external to the muscle reaching to the lower border of the first rib. Surgically, the third portion is most important. The external jugular vein crosses the artery, and the sternomastoid and the deep fascia which binds down the omohyoid muscle to the clavicle are in front of it; the brachial plexus of nerves lies above and to the outside of the third portion of the artery. Posteriorly the artery lies on the pleura

and on the scalenus medius, and finally it rests on the first rib. The third portion of the artery can be felt pulsating above the clavicle, in the supraclavicular fossa, and here it may be readily compressed against the first rib with the thumb or the handle of an old-fashioned door-key wrapped in lint. The direction of the pressure should be vertical to the axis of the body; before attempting compression the shoulder should be lowered as much as possible. In compressing this vessel pain is sometimes caused by pressing on the lowest cord of the brachial plexus, which usually lies behind the artery; this may be easily avoided by rolling the nerve away from the artery, and then the proceeding is quite painless.

Some individuals (the writer among them) can arrest the pulse at the wrist by forcibly carrying the shoulder downward and backward. In this case the artery is compressed against the first rib by the subclavius muscle and clavicle.

Ligature of the subclavian is, as a rule, confined to the third portion, or that part lying in the supraclavicular space between the sternomastoid and trapezius muscles; the other portions are so deeply placed, so thickly studded with branches, and so closely connected with such important structures as the phrenic and vagus nerves, the junction of the internal jugular and subclavian veins, and, on the left side, with the thoracic duct, that ligature is rarely attempted. On the right side it is possible to ligature the vessel between the common carotid and the internal jugular vein.

The third portion of the vessel is comparatively superficial, being covered above the clavicle by no other soft parts than the skin, fascia, and fat. In at least fifty per cent. of subjects it is branchless, and when a branch is given off from the third portion it is almost invariably the posterior scapular.

To reach the artery an incision is made between the sternomastoid and the trapezius. The skin should be drawn down and the first incision should be made upon the clavicle to avoid wounding the external jugular, which pierces the deep fascia immediately above the clavicle. The vein should be held aside, or, better still, divided between two ligatures, and the deep fascia attached to the clavicle cut through; the finger should then be introduced and the scalene tubercle of the first rib searched for; this tubercle is usually found by following down the scalenus anticus muscle, which runs in the direction of the posterior edge of the sternomastoid. Having made out the scalene tubercle, the surgeon will feel the artery pulsating beneath the finger immediately outside the scalenus anticus muscle. The aneurysm needle should be introduced from below upward to avoid the vein; it must hug the artery closely so that the lowest cord of the brachial plexus may not be included.

The operation is performed for aneurysm of the axillary artery, and also of the innominate; also before amputating the whole upper extremity. In the latter case the common carotid is also tied. In axillary aneurysm the operation is much complicated by the great distention of the veins and the great elevation of the clavicle.

Branches of the Subclavian.—The subclavian is rich in branches which are distributed in three different directions, viz., the vertebral and inferior thyroid, upward; the transversus colli and transversus humeri, outward; and the internal mammary and superior intercostal, downward. Most of the branches arise internal to the scalenus anticus; three of them, the transversus coli, transversus humeri, and inferior thyroid arise from a single trunk, the thyroid axis. The posterior scapular is frequently given off from the third part of the artery in place of from the transversus colli. The branches of the subclavian artery are subject to innumerable variations as to both their number and origin (see *Arteries, Anomalies of*). When the subclavian is ligatured, there being free anastomosis between its branches and those of the axillary artery, the nutrition of the arm is not interfered with.

The *vertebral artery*, which is the largest branch of the subclavian, arises from the upper and posterior part of the first portion, and ascends to enter the transverse process of the sixth cervical vertebra; after piercing the transverse process of the axis it makes a remarkable curve outward and upward to reach the foramen in the transverse process of the atlas, and bending backward, runs in the deep groove on the upper surface of the atlas.

Immediately above the clavicle this vessel lies very deeply between the scalenus anticus and longus colli muscles. It has frequently been ligatured here for the relief of epilepsy; the operation is a difficult one, owing to the many important structures in close relation with the vessel. An incision is made along the posterior border of the sternomastoid muscle immediately above the clavicle, the transverse process of the sixth cervical vertebra (carotid tubercle) is now searched for, and the artery is found lying between the scalene and longus colli muscles.

Drs. Bright and Ramskill state that disease of the vertebral artery, immediately before it enters the skull, may lead to pain at the back of the head. The fact that the artery is here in close relation with the suboccipital nerve, which communicates with the great occipital nerve, may explain this symptom. (Treves.)

The vertebral artery is sometimes wounded by stabs in the neck; not a few cases are reported in which the artery was injured by stabs below the mastoid process.

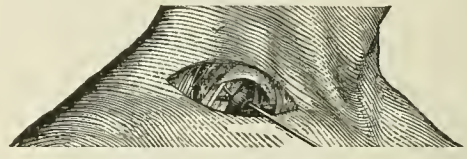

Fig. 4070.—Showing Line of Incision and Parts Exposed in Ligature of the Third Part of the Subclavian Artery. (Modified from Roser.)

Hemorrhage from wounds of the vertebral artery between two transverse processes is difficult to arrest; wooden plugs have sometimes succeeded; occasionally the artery has been successfully tied by snipping away the transverse process and applying a ligature. If this cannot be done the bleeding vessel may be secured by artery forceps, which should be left in the wound.

Traumatic aneurysms of the vertebral artery may occur after a stab in the neck; the writer on one occasion saw this follow a wound of the vessel between the second and third cervical transverse processes. These aneurysms are commonly mistaken for aneurysm of one of the branches of the carotid—as, for instance, the occipital—and the common carotid has been tied on this supposition, without avail, of course. The mistake has arisen from the surgeon finding that pulsation in the aneurysm ceased on compressing the carotid in the neck. Of course, if it is compressed below the "carotid tubercle," the circulation in the vertebral is arrested as well as in the carotid; and even if pressure is applied at this point, the vertebral may be compressed, for it frequently fails to enter the foramen in the transverse process of the sixth cervical vertebra.

The ligature placed on the carotid should be first tightened, and, if this arrests the pulsations in the aneurysm, the ligation may be completed; but if pulsation is not arrested, then it is probable that the vertebral is the artery affected, and ligature of the carotid is a useless proceeding.

The treatment of such aneurysms is very unsatisfactory; cases of cure are reported from continuous compression with shot-bag, but if this fail operative

measures are of little avail; it is useless to ligature the artery low down, as the anastomosis above is so free; and if the aneurysm is cut down upon, ligature at the seat of the aneurysm is rarely satisfactorily completed. The writer once saw the carotid tied for vertebral aneurysm due to a stab with a knife below the mastoid, and afterward the sac of the aneurysm cut down upon; but the hemorrhage could not be arrested by plugging, or otherwise, and the patient died. In this case pressure on the carotid against the sixth cervical transverse process arrested pulsations in the aneurysm, and it was supposed that the affection was connected with the occipital artery.

The inferior thyroid artery is sometimes ligatured at the same time as the superior thyroid for enlarged thyroid in exophthalmic goiter (Graves' disease). Any of the arteries may be temporarily ligatured during an operation by tying the ligature over a piece of rubber tubing placed on the vessel. The writer has done this with both the carotid and the subclavian arteries with success.

Veins of the Neck.—The *anterior jugular* vein has already been mentioned as lying along the inner border of the sternomastoid. It varies somewhat as to its course, and is sometimes double. Occasionally, the veins of the two sides are connected by a large transverse branch, which is a source of trouble in the operation of tracheotomy. The anterior jugular, if large and placed nearer the median line than usual, is liable to be wounded in tracheotomy. It might also be wounded in tenotomy of the sternomastoid for wry-neck. The two anterior jugulars may be replaced by a single trunk.

In front of the trachea and thyroid gland is a large vein, the *inferior thyroid* (vena thyroidea ima), which, when large, complicates operations on the trachea.

The *external jugular* vein corresponds to a line drawn from the angle of the jaw to the middle of the clavicle; it runs beneath the skin and platysma and over the sternomastoid muscle, and ends by piercing the deep fascia above the clavicle to join the subclavian vein. In the operation of tying the subclavian in its third part, it (the vein) must be held aside or ligatured.

The *internal jugular* vein lies to the outer side of the common carotid artery, and when distended partially overlaps it. In operations for the removal of tumors or enlarged glands of the neck, this vessel may be wounded; ligature in such accidents is the proper procedure, and is not attended by any evil after-effects. The writer has on three occasions ligatured the internal jugular with the most happy results.

The *subclavian vein* is a continuation of the axillary, and is in close relation with the clavicle; it lies in front of and below the subclavian artery, from which it is separated by the anterior scalenus muscle. On the left side the thoracic duct empties into it. The point of junction of the subclavian and internal jugular veins is opposite the sternoclavicular articulation. The wall of the subclavian vein adheres closely to the fascial sheath by which it is invested; this sheath is connected anteriorly with the costocoracoid membrane and the clavicle, and when the shoulder is carried forward the vessel becomes expanded (Quain). In operations at the root of the neck great care should be taken to avoid wounding the large veins, for air is very apt to be sucked in during inspiration. These veins are so firmly united to the bones and muscles, that when wounded they do not collapse, but, on the contrary, gape. It should be remembered that the risk of air entering is increased by movements of the upper limb, which still further open the wounded vein.

Thyroid Body.—This is a highly vascular organ consisting of two lateral lobes, one on each side of the larynx and trachea, connected by an isthmus which crosses the second and third rings of the trachea. The lobes are pear shaped, and reach from the fifth and sixth rings of the trachea to the upper border of the thyroid cartilage; the lateral lobes are covered in front by the depressions of the hyoid bone, and posteriorly are in contact with the sheath of the great vessels of the neck. Each lateral lobe measures about two inches in length, one and one-fourth inches in breadth, and from three-fourths to one inch in thickness. The weight of the thyroid body is from one to two ounces, and is greater in females than in males. The isthmus is occasionally absent, the lateral lobes being connected by fibrous tissue only, as is the case in some animals, viz., the horse, donkey, etc.

Owing to the fact that the thyroid body lies over the great vessels of the neck, when enlarged it derives from them a visible pulsation, and a distinct thrill may be felt. Such pulsating tumors have been mistaken for aneurysm, but as the thyroid body is closely connected with the larynx and trachea, it rises and falls in deglutition, and so is easily diagnosed from aneurysmal or other tumors, which are not disturbed by deglutition. When hypertrophied the tumor resulting from an enlarged thyroid is called a "*bronchocele*" or *goiter*. When a goiter grows rapidly respiration is often interfered with, and operation has to be undertaken for its relief. It is not necessary to remove the whole gland to relieve the obstructed respiration, for division and removal of the isthmus only often gives very good results. Mr. Sidney Jones has reported cases in which excision of the isthmus not only relieved the dyspnea, but a month after the operation the lateral lobes had almost disappeared.

Since the advent of antiseptic surgery the extirpation of large bronchoceles by the knife has become most common, but the operation, owing to the very important structures in relation to it, is always a most formidable one. It is very important in this operation first to ligate the vessels supplying the gland, viz., the superior thyroid above, and the inferior thyroid below, and if present, the middle thyroid. In ligating the inferior thyroid artery, care must be taken not to injure the inferior laryngeal nerve, which winds among the branches of that artery. Simple cysts may be removed by enucleation. Owing to the conditions which follow complete removal of the thyroid, viz., myxedema, and cachexia strumipriva, partial removal is the more common operation except in cases of malignant disease or when the growth becomes dangerous from pressure.

Esophagus.—This commences opposite the cricoid cartilage; it lies between the trachea and the vertebral column. At the lower end of the neck it inclines a little to the left, and for this reason esophagotomy is performed on the left side. Strictures most commonly occur at its upper part, and foreign bodies are most apt to be arrested behind the larynx. Foreign bodies, such as fish bones, mutton or beef bones, have occasionally ulcerated through the esophagus and perforated some of the large vessels with which it is in contact.

In performing *esophagotomy* for the removal of an arrested foreign body, the incision is made between the sternomastoid and trachea, the middle point being opposite the cricoid cartilage. The inferior thyroid artery and recurrent laryngeal nerve must be carefully avoided. The carotid artery is in no danger of being wounded if proper care be taken.

In *esophagostomy*, when a stricture exists high up, the incision into the esophagus is made for the purpose of feeding the patient by a tube, and so avoiding gastrostomy. The fact that the operation is performed low down makes it much more dangerous than esophagotomy, and nearly all the reported cases have ended in death within a short time of the operation from diffuse inflammation of the neck.

Hyoid Bone.—This is one of the most important landmarks in the neck, and one which can always be felt in the stoutest neck. It is the best guide for

ligature of the lingual. In old age the different portions of the bone become ossified into one piece, and in consequence it is more easily broken by direct violence due to blows or throttling. Cases are reported of fracture of the hyoid from yawning and sudden extension backward of the head. The symptoms of fracture are pain, difficulty in speaking, in movements of the tongue, and in swallowing.

Larynx and Trachea.—The *larynx* is connected above with the hyoid bone by means of the thyrohyoid membrane, and is continuous below with the trachea. Posteriorly it helps to form the wall of the pharynx. It consists of several parts, which are closely connected together by ligamentous structures, muscles, and mucous membrane; these parts are the thyroid cartilage, epiglottis, cricoid, and arytenoid cartilages. On the upper margin of the thyroid cartilage is a bursa which prevents friction as the larynx ascends beneath the hyoid bone in deglutition. This bursa is sometimes enlarged, and has to be incised. The larynx is occasionally wounded in cases of attempted suicide by cutting the throat. Between the lower border of the thyroid and cricoid cartilages is the cricothyroid membrane, where the operation of laryngotomy is performed. A small lymphatic gland is occasionally found here, which may become enlarged.

The *trachea* extends from opposite the sixth cervical vertebra to its bifurcation opposite the third

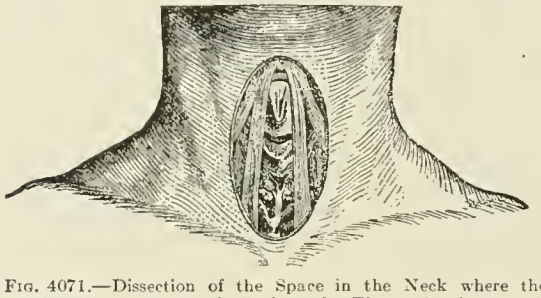

Fig. 4071.—Dissection of the Space in the Neck where the Operation of Tracheotomy is Performed. The trachea is exposed, having on each side of it the sternohyoid muscle, and lying on it below the inferior thyroid veins. (Roser.)

dorsal, where it is crossed by the arch of the aorta. It measures from four to five inches in length, and from three-fourths to one inch in breadth. It is covered by the depressors of the hyoid bone, and has on each side at its upper end the thyroid body. It is crossed by the isthmus of the thyroid gland opposite its second and third rings, and has also in front the inferior thyroid veins, and sometimes a transverse branch connecting the two anterior jugulars. When the middle thyroid artery is present it also lies upon the trachea in its course up to the isthmus of the thyroid. In children the thymus gland covers its lower portion. Laterally the trachea is in relation with the carotid artery and recurrent laryngeal nerve; posteriorly it is in contact with the esophagus. The innominate artery crosses the lower end of the trachea; this occurs higher up in children than in adults.

Foreign Bodies.—Children not infrequently swallow articles which are sucked into the larynx during inspiration; these may be arrested by the cords at the rima, or may lodge in one of the ventricles. If they pass the rima they usually lodge in the right bronchus. These bodies can frequently be seen with a laryngoscope and extracted with forceps, but very often the operation of tracheotomy is necessary to remove them.

The operation of *tracheotomy* is performed above or below the isthmus. It is required for the extraction of foreign bodies and for any obstruction to respiration having its seat in the larynx, as from diphtheritic membrane, new growths, etc. It is also performed as a preliminary to certain operations in the neck and mouth.

The distance between the cricoid cartilage and the upper border of the sternum, in ordinary individuals, is about one inch and a half (four centimeters); when the head is thrown back three-fourths of an inch more is gained; so in performing tracheotomy the neck should be extended as much as possible by placing a hard round pillow under it, and the incision should be exactly in the middle line, so as to come between the two sternohyoid muscles and anterior jugular veins. In operating there is a choice as to where the trachea is to be opened, either above or below the isthmus. Above, the parts are more superficial and blood-vessels fewer, but the space is limited and the cricoid cartilage has often to be cut; below, although the trachea is deeper and the veins are more plentiful, still there is more room for incision, and we get farther away from the disease, which is an important point in diphtheria. With our present means of arresting hemorrhage the low operation is to be preferred.

Laryngotomy is performed in cases in which it is necessary rapidly to relieve suffocation, and in adults who have chronic affections of the larynx. It is performed by cutting the cricothyroid membrane transversely.

Lymphatic Glands of the Neck.—These are large and numerous. They frequently enlarge and become inflamed, and if not excised break down and suppurate, leaving unsightly scars. In scrofulous subjects the glands of the neck are the ones most frequently enlarged. The enlargement is always the result of some irritation, either of the mucous membrane of the throat, nose, ear, etc., or of the skin of the scalp, face, or neck. The glands are more liable to enlarge in persons of a scrofulous diathesis, and in them the amount of involvement of the glands is out of all proportion to the irritating cause; this may be an eczema of the scalp or a simple sore throat. In non-scrofulous individuals the glands are frequently enlarged from some special irritating cause, as a diseased tooth, tonsillitis, malignant disease of the tongue, lip, etc., but in these individuals the affection of the glands is not so widespread, nor is the enlargement so great, and the glands do not tend to suppurate.

In syphilities the *glandulæ concatenatæ* in the posterior triangle of the neck are frequently enlarged and indurated, but they do not tend to suppurate. In tonsillitis an enlarged gland is always felt beneath the angle of the lower jaw; this is erroneously supposed by many to be the enlarged tonsil which cannot be felt from the outside.

In eczema of the scalp the glands of the neck are frequently enlarged, especially if the eczema be of the pustular variety. In delicate children pediculi not only often cause an eczema of the nape of the neck, but the irritation frequently causes enlargement of the glands in the suboccipital and mastoid regions.

Occasionally a single gland becomes enlarged over the carotid artery, and this has been mistaken for aneurysm on account of the strong pulsation communicated to the tumor by the artery; these tumors, however, cannot be emptied by lateral pressure, and when lifted away from the artery all pulsation, of course, ceases.

When one or several glands of the neck have become enlarged and show no tendency to diminish, it is much better to remove them with the knife. This can be easily done before the gland breaks down and suppurates, and so forms inflammatory adhesions to the surrounding parts. In cases of "scrofulous necks," in which nearly all the glands are enlarged, their removal is advisable, for if left to themselves they break down and suppurate, and after months and perhaps years of discomfort, heal, leaving unsightly scars. An argument in favor of early excision is that foci of infection are removed, and the patient's chance of

good health is much greater. Frequently thirty or forty glands have been removed at one operation, and the result is almost invariably good, the patient recovers rapidly, and the amount of scarring is very trifling. In dissecting out the glands in close relation to the large vessels, great care should be taken.

When the glands have suppurated and sinuses are left which will not heal, scraping the sinus and removal of the remains of the gland with a sharp spoon give very good results. Treves recommends puncture of softened caseous glands with a cautery; he also advises opening gland abscesses by the cautery highly heated.

The lymphatics of the neck are enlarged, with those of other parts of the body, in leukemia and Hodgkin's disease, and care should be taken not to confound scrofulous glands with enlarged glands in these diseases. Removal of enlarged glands in Hodgkin's disease is, except for diagnostic purposes, of course, perfectly useless.

The lymphatic glands of the neck are arranged in the following groups: *Submaxillary* (ten to twelve in number), situated beneath the base of the inferior maxilla; these also include the *suprahyoid*, which are situated between the two anterior bellies of the digastric muscle in the middle line of the neck. *Superficial cervical* (four to six) situated along the external jugular vein beneath the platysma and deep fascia. *Deep cervical* (twenty to thirty). These are subdivided into *superior* and *inferior*. The *superior* are situated about the bifurcation of the common carotid, and reach to the base of the skull, lying along the internal jugular vein. The *inferior* are grouped around the lower part of the internal jugular vein, and extend outward into the supraclavicular fossa, becoming continuous below with the axillary and mediastinal glands.

The following table, from Sir F. Treves' book on "Scrofula and Its Gland Diseases," showing the relation certain glands bear to the periphery, will be found useful:

Scalp: Posterior part = suboccipital and mastoid glands; frontal and parietal portions = parotid glands; vessels from the scalp also enter the superficial cervical set of glands.

Skin of Face and Neck = Submaxillary, parotid, and superficial cervical glands.

External Ear = Superficial cervical glands.

Lower Lip = Submaxillary and suprahyoid glands.

Buccal Cavity = Submaxillary and deep superior cervical glands.

Gums of Lower Jaw = Submaxillary glands.

Tongue: Anterior portion = suprahyoid and submaxillary glands; posterior portion = deep cervical glands (superior).

Tonsils and Palate = Deep cervical glands (superior).

Pharynx: Upper part = parotid and retropharyngeal glands; lower part = deep cervical glands (superior).

Larynx, Orbit, and Roof of Mouth = deep cervical glands (superior set).

Nasal Fossa = Retropharyngeal glands and deep cervical (superior). Some lymphatics from the posterior part of the fossa enter the parotid gland.

Parotid Gland.—This gland lies on the face in front of the ear, and extends deeply into the space behind the lower jaw; its inferior portion is situated partly in the neck behind the angle of the jaw, lying on the digastric muscles in the submaxillary region. It is connected with very important structures, being pierced by the external carotid artery and facial nerve. This gland not infrequently becomes inflamed and suppurates after fevers (as typhoid) and operations on the abdominal viscera. Cases are reported in which it has become inflamed after ovariotomy, and the writer has twice seen abscess of the parotid follow severe blows on the abdomen. These abscesses are very painful, owing to the tension caused by the investing fibrous capsule. In opening abscesses here the incision should be transverse, to avoid cutting the facial nerve, and should be in front of the line of the carotid artery. Abscesses of the parotid gland frequently burst into the external auditory meatus. There are a number of lymphatic glands in relation with the parotid, which receive vessels from the scalp, pharynx, etc. Tumors are not infrequently found in this region, the extirpation of which gives rise to very severe hemorrhage. The facial nerve is frequently unavoidably injured in the removal of these tumors, and the external carotid artery sometimes requires ligature.

Submaxillary Gland.—The submaxillary gland is situated in the submaxillary region, between the anterior and posterior bellies of the digastric muscle. It lies partly on the mylohyoid and partly beneath it. The facial artery grooves the back part and upper border of the gland. The gland is sometimes involved in malignant diseases affecting the mouth and tongue. It is separated from the parotid gland by a fold of deep cervical fascia, the stylomaxillary ligament.

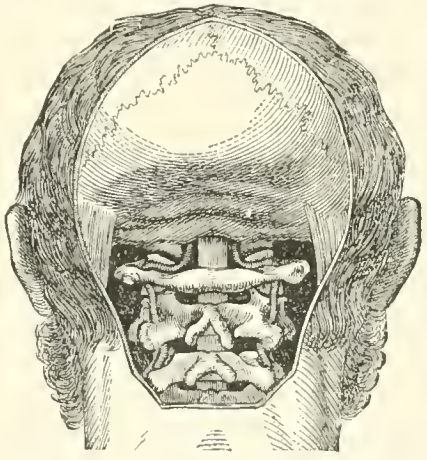

Fig. 4072.—The Superficial Tissues have been Removed to Show the Vertebral Artery Passing through the Transverse Processes of the Vertebræ, and also the Relation of the Cord to the Spinal Canal. (Roser.)

Spinal Cord and Vertebral Column.—Fig. 4072 shows well the situation of the spinal cord in the neck vertebræ. It is not so well protected against injury as in other parts, for in the space between the several arches, any sharp instrument piercing the muscular tissue could easily wound the cord. The vertebral artery, as has already been mentioned, is also liable to injury on its way from one vertebra to another. From the great mobility of this part of the spine dislocation occasionally occurs and death is caused by pressure on the cord. In caries of the upper cervical vertebræ, sudden death has taken place from the destruction of the ligaments between the atlas and axis. When this occurs—the head with the atlas inclining forward and leaving the axis in its proper position—the medulla oblongata is crushed against the odontoid process, and so instant death is the result. (Hilton.)

Caries of the spine in the cervical region is not uncommon. In its early stages the symptoms are somewhat obscure, the chief complaint being of pain in the course of the great occipital nerve, due to its implication in inflammatory exudation. The peculiar stiff way in which the patient carries his head, and the presence of a slight prominence which is excessively tender, enables the surgeon to recognize the disease. These cases occasionally result in a postpharyngeal

abscess, which has to be opened. This may easily and safely be done by an incision along the posterior border of the sternomastoid. Some advise tapping it with a trocar through the mouth.

Nape of the Neck.—The superficial anatomy of this region has already been described. The most superficial muscle is the trapezius, which is covered by a layer of thick and tough fascia and is pierced by the great occipital nerve. To the outer side of the trapezius, and separated from it as it descends, is the sternomastoid muscle; crossing obliquely the interval between them are the splenius capitis and colli muscles. On removing the trapezius, which in this region is usually very thin, the complexus muscle comes into view, also pierced by the great occipital nerve; deeper down still are seen the muscles bounding the suboccipital triangle (rectus capitis anticus major, superior and inferior oblique), where are seen the suboccipital nerve and vertebral artery. In the central line is the ligamentum nuchæ. It extends from the seventh cervical spine to the external occipital protuberance. In some animals this ligament is a very powerful elastic band which suspends the head; to it are attached muscles and fascia. The occipital artery becomes superficial midway between the mastoid process and external occipital protuberance. It runs along the outer border of the superior oblique, and is accompanied by the great occipital nerve. The lesser occipital nerve winds round the posterior border of the sternomastoid, and supplies the lateral region of the occiput; the suboccipital, being a purely motor nerve, rarely reaches the skin.

Branchial Fistulæ and Cysts.—In the mammalian embryo, at the fourth week, there are on each side of the head, behind the oral cavity, four fissures which communicate with the anterior part of the alimentary canal. These are the homologues of the clefts found in branchiate vertebrates. The third and fourth fissures in the human embryo disappear about the sixth week, and only the first remains at the end of the ninth week. This persists as the Eustachian tube, tympanic cavity, and external auditory meatus. The structures developed in the folds betweeu the clefts (branchial arches) are as follows:

First Arch (Mandibular): Meckel's cartilage, the anterior portion of which is developed into the lower jaw, and the mandibular arch is completed by the malleus bone of the ear.

Second Arch (Hyoid): Incus, stapes (Parker), styloid process, stylohyoid ligament, and lesser cornu of the hyoid bone.

Third Arch: Great cornu and body of the hyoid bone.

Fourth Arch: No permanent remains.

Sometimes the clefts between these arches remain more or less open, and this fact explains the occurrence of congenital fistulæ of the neck, as well as that of cysts and diverticula from the esophagus and larynx.

Paget says that "cervical branchial fistulæ occur as two or three minute orifices on one or both sides of the lower part of the neck, and they lead upward to the esophagus and pharynx; the lowermost being near the sternal end of the clavicle in front of the sternomastoid muscle, the next opposite the thyroid cartilage, and the highest between the thyroid cartilage and hyoid bone." When two in number, they are often symmetrical; they vary in length from one-half to one and a half inches, and barely admit a probe. They have a smooth lining membrane, which secretes a clear mucous fluid. These fistulæ can be cured by cauterizing them with the galvanocautery. It is probable that many cysts and so-called hydroceles of the neck are due to imperfectly closed embryonal fissures.

Sanguineous cysts of the neck are probably originally branchial cysts, which have communicated with the internal jugular vein. Cases are on record in which, before removal of the cyst, the vein had to be ligatured.

Branchial Dermoids.—These are occasionally seen in the neck, the most common situation being between the geniohyoglossi muscles, where the swelling projects into the submaxillary space and also into the mouth. They can usually be enucleated. A dermoid sometimes is seen under the deep fascia close to the carotid arteries.

Thyrolingual Fistulæ and Cysts.—These are met with on the tongue, at the hyoid bone, and lower down over the thyroid cartilage, cricoid, and upper rings of the trachea. They grow slowly with the growth of the individual, and are very difficult to eradicate. The cyst wall is thin and lined with columnar epithelium, perhaps ciliated. Their contents are mucoid. They sometimes burst, leaving fistulous openings which are difficult to close. Unless the cyst be entirely removed, it will recur, for if any part of the epithelial lining be left it will secrete and cause a persistence of the trouble. Thyrolingual cysts and fistulæ are the remains of the thyrolingual duct, which passes up the neck to the tongue behind the hyoid bone. The lower part becomes the isthmus of the thyroid gland, while the upper part persists as the foramen cecum of the tongue.

Tumors of the Neck.—The neck is a favorite site for tumors, fibrous, sarcomatous, and others. Sarcomatous tumors in the early stages can be removed, but they nearly always recur. Tumors of the neck, which are apparently so freely movable that their extirpation would seem to be an easy matter, are found, when cut down upon, to be intimately connected with the deep vessels and nerves. In these cases the tumor is freely movable laterally, the vessels going with them, but there is no freedom of movement in the vertical direction. It is remarkable with what impunity large tumors may be removed from the neck, especially if they are benign. It is not uncommon in these cases to ligature both the internal jugular vein and the carotid artery, and to cut through the sternomastoid muscle, and yet have the patient make a rapid recovery from the operation; the tumor, as mentioned above, if sarcomatous, almost invariably returns, for it is impossible in the neck in such cases to remove sufficient of the surrounding healthy structures.

Aneurysmal tumors at the root of the neck are comparatively common, and although in many cases these tumors may have the appearance of being connected with the subclavian or innominate arteries, yet they almost invariably proceed from the aortic arch, and push their way upward under the clavicle into the neck. Fusiform aneurysms of the aorta frequently simulate aneurysm of one of the great branches.

Tumors in connection with the thyroid gland have been alluded to in the description of that body.

Francis J. Shepherd.

Necrobiosis.—The gradual death of tissue due to slowly acting injurious agents is known as *necrobiosis* or *indirect necrosis*, in opposition to *direct necrosis* or *immediate death*. In necrobiosis the death of the cell is preceded by some other retrograde change, such as atrophy, cloudy swelling, mucous, hydropic, or fatty degeneration, or by one of the pathological infiltrations. In the case of direct necrosis death of the tissue may take place rapidly without the occurrence of preceding abnormal changes in cellular structure. The preceding retrograde change in necrobiotic processes is by some writers regarded as constituting the necrobiosis, but a distinction should be made between the preceding atrophy, degeneration or infiltration, and the molecular disintegration which constitutes the essential feature of necrobiosis. The retrogressive changes preceding this disintegration usually occur so gradually, and in themselves present such definite characteristics, as to be classed by themselves. The use of the term necrobiosis is more theoretical than practical, inasmuch as a practical distinction between

direct necrosis and necrobiosis is at times very difficult or impossible. Many writers use the terms as synonyms. Necrobiosis is, however, best conceived of as a slowly progressive or incomplete necrosis. The gross appearances of necrobiotic tissues vary according to the nature of the preceding retrograde change and the degree of necrosis present. Microscopically, in addition to the characteristic changes presented by the accompanying retrograde change, the nuclei of the affected tissue show karyorrhexis and a greater or less degree of karyolysis. The ultimate picture of necrobiosis is that of necrosis; if the necrobiotic process has been characterized by cloudy swelling, simple necrosis follows; if by fatty degeneration, soft caseation (fatty necrobiosis) occurs; if by hydropic degeneration, liquefaction necrosis results. The sequelæ of necrobiosis are essentially those of necrosis: regeneration, repair, cicatrization, calcification, and cyst formation. Likewise the causes producing necrobiosis are the same as those leading to direct necrosis: mechanical, thermal, chemical, infectious, and nutritional. The injurious agents may act separately or coincidently. As a general rule it may be stated that harmful agents of slight power but of long-continued action are more likely to produce necrobiosis than direct necrosis. Disturbances of blood supply, deficient nutrition and oxygenation, as in the case of chronic anemia, are among the most important factors leading to necrobiotic processes. Chronic intoxications and infections also play a leading rôle in the production of necrobiosis. Clinically a neuropathic necrobiosis may be distinguished. Aldred Scott Warthin.

Necrosis.—The condition of local death, the death of individual cells or groups of cells within the living body, is known as *necrosis*. If such local death occurs immediately or very quickly after the action of some injurious agent, it is termed *direct necrosis;* if, on the other hand, the death of tissue is of a slowly progressive nature preceded by other retrograde changes, the process is designated *necrobiosis* or *indirect necrosis*. In the latter case it is not always possible to draw a sharp line between degeneration and necrosis. The use of the word necrosis without modifying designation is usually taken as referring to direct necrosis. In the diseased body necrobiosis is of much more frequent occurrence than necrosis or sudden cell death.

The cellular change which marks the exact moment of the passage of life from the cell is at present beyond our knowledge; the slight histological changes taking place in cells at this moment do not permit us to determine with certainty the definite boundary between the states of cell life and cell death. Our conception of necrosis is, therefore, based upon the changes which follow necrosis rather than upon those taking place at the moment of cessation of life. The development of modern microscopical technique has, however, so perfected methods of tissue fixation that it is now possible to fix and preserve definitely the histological characteristics of the cells as they exist at the moment the tissue is placed in the fixing fluid. Our knowlege of the structure of normal living cells has been obtained from the study of cells killed and fixed by such means; and likewise our conceptions of pathological conditions are based upon the relative appearances of cells so treated. Normal living cells killed and fixed quickly should present no microscopical signs of necrosis; but it is also possible that cells already dead when put into the fixing fluid may show none of these signs. Only when these signs of necrosis are present can we say that the cells were in a condition of necrosis before fixation. The microscopic picture of necrosis is in many cases, perhaps the majority, a *postmortal* condition due to the action of ferments in the fluids about the dead cells or contained in the latter themselves (*autolysis*).

As a result of such study certain pathological criteria have been created. Of these the condition of *necrosis* is that state of the cell which is characterized microscopically by altered staining reactions of the nucleus and certain molecular changes in the cytoplasm. The disappearance of the nucleus or its failure to respond normally to nuclear stains is to be taken as the most striking feature of necrosis, inasmuch as the nucleus is to be regarded as the most essential vital element of the cell. Cells may be dead and yet retain their nuclei, but necrosis becomes evident to us microscopically only when certain changes in cell structure have occurred to distinguish the dead cell from living ones. The changes in the nucleus may occur at the moment of death or subsequently; in either case it becomes the criterion of necrosis. To the disappearance of the nucleus and its loss of staining power the terms *karyolysis* and *chromatolysis* have been applied. These changes are very frequently preceded by fragmentation of the nuclear chromatin. This change is known as *karyorrhexis* or *chromatokinesis;* it has been shown to consist of regular and definite movements on the part of the chromatin elements. Small masses and granules of chromatin may leave the nucleus and pass into the cell body. With the disappearance of the cell membrane fine chromatin granules may be scattered throughout the cell detritus of the necrotic area. As a result of such diffusion of the chromatin areas of necrosis in the early stage may stain diffusely blue. In other cases the nucleus before its disappearance contracts and becomes smaller, at the same time staining more deeply than normal (*pyknosis*). Under other conditions the nucleus may become greatly swollen and show *vacuolization*, clear spaces or droplets appear, between the separated particles of chromatin. Very frequently the nucleus retains its normal form and size, but gradually loses its staining power and fades away, both nucleus and protoplasm being converted into a homogeneous hyaline mass.

Sooner or later changes take place in the protoplasm of dead or dying cells. The protoplasm may undergo *coagulation, fermentative changes, vacuolization, changes in protoplasma granulation* (*plasmorrhexis* or *cytorrhexis, plasmoschisis* or *cytoschisis, plasmolysis* or *cytolysis*). The normal granulation of the cytoplasm may disappear and the cell undergo a hyaline change. The cell membrane ultimately disappears and the outline of the cell becomes irregular or lost altogether. Often the cell protoplasm becomes coarsely granular, the cell ultimately breaking up into a granular débris. *Vacuolation* may take place and the cell become enlarged and swollen from the imbibition of fluid (edema). As the result of such swelling, breaks in the continuity of the protoplasm may occur (*plasmorrhexis*). On the other hand, the dead cells may under certain conditions become *inspissated*. Extrusion and constriction of portions of the protoplasm may occur during the process of dying. Ameboid cells usually assume a globular form. The disintegration of the protoplasm is termed *plasmoschisis*. The ultimate result of the necrotic process is the conversion of both nucleus and cytoplasm into a granular débris; when such appearances are found microscopically, the condition is to be regarded as one of complete necrosis. The intercellular substance likewise undergoes changes in the form of swelling, fragmentation or liquefaction.

Causes of Necrosis.—The causes which may lead to local death of tissue are manifold and may be classed as follows: nutritional, mechanical, thermal, chemical, toxic, infectious, and neuropathic.

Disturbances of nutrition through interruption of the circulation are among the most frequent causes of

necrosis. Local anemia due to arterial occlusion as a result of thrombosis, embolism, compression, ligature, or arteriosclerosis may be the direct cause of local tissue death (anemic and hemorrhagic infarction). Likewise stasis due to mechanical, thermal, chemical, or trophic changes in the vessel walls or to weakened heart's action may be a primary or secondary factor of necrosis. Local asphyxia from any cause may result in cell death.

Traumatic violence may through crushing or tearing cause direct death of cells, or through damage to the blood-vessels it may cause necrosis through disturbed nutrition. Cells separated from their normal environment as a rule soon die (*disassociation necrosis*).

Elevation of temperature from 45° to 68° C. for a short period of time causes the death of tissue; excessive cold produces the same result although cells bear a lowering of temperature much better than an increase. Electricity, *x*-rays, radium, etc., may cause necrosis.

Chemical and toxic substances of various kinds may act directly upon cells and cause their death. The poison may destroy the cells directly or, through chemical union with the cell protoplasm or intercellular substance, render life impossible, or by producing changes in the blood-vessels give rise to necrosis secondarily. Most important of all as agents of necrosis are the bacterial toxins, particularly those of tuberculosis, typhoid, cholera, staphylococcus, and streptococcus infections. Chemical substances, originating within the body, may also give rise to necrosis under certain conditions.

The bile acids, uric acid, metabolic products in diabetes, pancreatic ferments, etc., may under certain pathological conditions give rise to necrotic processes. Fat necrosis is a striking example of necrosis arising from the action of a normal body product under abnormal conditions. The pancreatic juices are absorbed into the lymph and blood streams, the fat-splitting ferment, steapsin, causing necrosis of fat cells in the neighboring fat tissue, or even in such distant regions as the pericardium and fatty marrow.

The direct action of bacteria or other forms of vegetable and animal parasites may also produce necrosis of cells.

Primary lesions of the central nervous system and the peripheral nerves are considered by many writers to give rise to a trophic or neuropathic necrosis (*neurotic gangrene*). The changes following such lesions are much more to be regarded as dependent upon circulatory disturbances (vasomotor) than as trophic manifestations. As a result of lowered nutrition the normal resistance of the affected parts may be diminished and bacterial infection favored.

The causes mentioned above may act separately or coincidently. The degree of necrosis depends not only upon the nature and severity of the exciting cause, but also upon the condition of the tissue at the time of injury. Tissues of lowered vitality, in conditions of general anemia, marasmus, and cachexia, die more easily than normal tissue; hence long-continued pressure of slight degree, which under normal conditions would produce no effect, may in such conditions as typhoid fever, chronic valvular disease, etc., bring about necrosis (*decubitus, marasmic necrosis*). Necrosis occurs also in the tissues of the aged as a result of slight injuries (*senile necrosis*). In certain diseases there is a lowered resistance of the tissues predisposing to necrosis (*diabetic gangrene*, etc.).

Varieties of Necrosis.—Though the loss of the nucleus and a greater or less disorganization of the cytoplasm form the essential features of necrosis, these changes may be more or less modified or combined, or so associated with other processes as to give rise to different varieties of necrosis, recognizable either by gross or by microscopical appearances. The kind of necrosis depends upon the location and nature of the affected cells, the character and severity of the destructive agent, and the nature of the surrounding tissue, particularly with reference to the absence or presence of fluids. If the dead cells are on a surface exposed to evaporation, inspissation may take place; on the other hand, if there is an abundant supply of fluid, the cells may become hydropic and ultimately liquefy; if proteolytic ferments are present liquefaction may also result; if the factors necessary for the formation of fibrin are present, coagulation may occur either in the cells or between them. The character of the necrosis may be further modified by infection with putrefactive bacteria. It becomes therefore possible to distinguish the following varieties of necrosis, each form presenting distinct macroscopical and microscopical characteristics when occurring alone. Between these different varieties there is, however, no distinct boundary line. They are very frequently combined or may follow each other in certain cases, so that the practical diagnosis as to the original form may be difficult.

Varieties of necrosis:
1. Simple.....
2. Coagulation { Intercellular.. / Intracellular.. }
3. Liquefaction
4. Mummification
5. Moist gangrene.....
} Caseation.

Simple Necrosis.—This form of necrosis is characterized microscopically by the disappearance of the nucleus and a hyaline or granular change in the cytoplasm, the original outlines of the tissue being preserved to a greater or less extent. Usually the dead cells are somewhat larger than normal, the protoplasm being more granular and staining heavily with eosin. Less frequently the cells are hyaline and homogeneous. The protein of the cell is split up rather than coagulated; the cell is softer than normal and not firmer; there is a separation of the fluids and lipoids. The process is apparently fermentative; most of the autolytic processes are of this type. By some writers this variety of necrosis is regarded as a form of coagulation necrosis, but it seems better to restrict the latter class to those forms of necrosis in which coagulation of the protoplasm occurs or fibrin or fibrinoid substances are formed. Simple necrosis usually follows cloudy swelling; indeed, it may be regarded as a late stage of this degeneration advanced to such a degree that the nucleus has entirely disappeared. Early stages of simple necrosis may often be recognized by the presence of diffuse chromatin. The gross appearances of simple necrosis are yellowish or grayish discoloration and lessened consistency. Simple necrosis is one of the most common forms of necrosis; it occurs very frequently in the epithelium of the kidneys and liver as the result of intoxications and infections, but may be found in any of the tissues. It is the most common form of necrosis found in anemic and hemorrhagic infarcts, and in focal necroses due to various forms of intoxication and infection (typhoid, tuberculosis, diphtheria, scarlatina, etc.). A further change in tissues showing simple necrosis, so that all tissue outlines are lost and only a finely granular mass is left, results in the condition known as caseation.

Coagulation Necrosis.—This form of necrosis is characterized by the coagulation of the protein substances of the cell protoplasm or by the production, in the necrosed tissue, of fibrin or substances allied to fibrin, the so-called "*fibrinoid degeneration.*" The variety of necrosis described above as simple necrosis is by most writers regarded as a coagulation necrosis, but there is, in the writer's opinion, a distinct form of necrosis in which no coagulation of the protoplasm occurs, and this form he prefers to class as simple necrosis. Coagulation necrosis occurs in

tissues rich in proteins and under conditions favorable for the production of the factors necessary for the formation of fibrin. Two forms are distinguished—*intercellular* and *intracellular*. In the intercellular form fibrin is formed between the dying or dead cells, the granular débris of the latter finally lying in a more or less dense network of fibrin threads. By the use of the Weigert's fibrin method this network of fibrin may be easily demonstrated. The fibrin may exist also in the granular, fibrogranular, or hyaline form. The chief source of the fibrin is most probably an exudate from the blood-vessels, but some of the factors necessary for the formation of fibrin may be supplied by the disintegration of tissue cells or leucocytes. The cells may become hyaline or granular, and ultimately completely disintegrate. This form of necrosis is most frequently seen in the fibrinous inflammations of mucous and serous membranes, and is hence also called *diphtheritic, croupous,* or *membranous* necrosis. The diphtheritic membrane may be taken as the typical example of this variety of necrosis. In all so-called diphtheritic inflammations there is more or less extensive necrosis of the mucosa with the formation of granular or fibrogranular fibrin between the granules of cell detritus. Intercellular coagulation necrosis may also occur in deeper tissues, as in the follicles of the spleen or lymph glands, in the liver, kidney, etc. It is of very common occurrence in the focal necroses of toxic and bacterial origin, and is almost constantly present to some degree in tubercles. It occurs much less frequently in anemic and hemorrhagic infarction. Many chemicals cause coagulation by direct action. The toxemia of superficial burns is associated with a form of coagulation necrosis in the splenic follicles and lymph glands similar to that seen in infectious processes. The coagulation of the blood and the process of thrombosis may be regarded as a form of coagulation necrosis. Tissues showing coagulation necrosis are firmer and paler than normal, more opaque, and show slight elevations above the cut surface. The source of the fibrin in the different instances of coagulation necrosis, mentioned above is not entirely clear. A portion may result from the coagulation of vascular exudates and from escaped blood cells. In other cases it has been assumed that fibrinogenetic substances are derived from the necrosing cells or from bacterial products. The small quantity of fibrinogen found in the lymph may give rise to a portion of the fibrin produced during the necrotic process.

The intracellular form of coagulation necrosis is characterized by the coagulation of the cell protoplasm into a solid or semi-solid albuminous body which may more or less resemble fibrin. With this coagulation of cell albumins fibrin formation is not necessarily associated. The essential character is the coagulation of the albumins of the cell. Weigert applied this term to practically all forms of necrosis except liquefaction and gangrene, and his view still rules the majority of text-books on pathology. All parenchymatous cells may show this form of necrosis. It is seen in its most typical form in anemic infarcts of spleen and kidneys, and in various infective or toxic necroses (diphtheria, typhoid, etc.). Tissues showing this form of necrosis are firm, dry, light, or cream colored and increased in volume. The most common example of this process is the so-called waxy or hyaline necrosis of striped muscle, commonly known as *Zenker's necrosis*. In this change the muscle loses its striations and becomes converted into a hyaline homogeneous substance which sometimes stains like fibrin, but often does not. To the naked eye such muscle appears pearly white or grayish, semi-translucent, resembling fish flesh. The condition occurs most commonly in cases of long-continued fevers as typhoid, and is found also in anemic, thermal, and toxic necrosis of muscle. In the fevers the abdominal recti and the adductors of the femurs are most often affected. The exact chemical nature of the coagulated protoplasm is unknown. In some instances intracellular coagulation may result from the imbibition of fibrinogen-containing fluids and their subsequent coagulation. Coagulation necrosis very frequently passes into *easeation* of the firm type.

Liquefaction or Colliquation Necrosis.—In this variety of necrosis the dead cells undergo liquefaction; the dissolution may follow a hydropic degeneration or the necrotic cells may be dissolved in the tissue fluids. Ferment action, especially autolytic ferments, is probably the most common course of liquefaction following necrosis. Leucocytic ferments also play an important rôle in causing such liquefactions. As a rule, liquefaction necrosis occurs primarily in tissues freely bathed in lymph, but containing little of the fibrin-forming substances, as in the brain, cord, and skin. Burns of the second degree (blisters) are very common examples of this form of necrosis. Anemic infarction of the brain, tissue suppurations, simple softening of thrombi, atheromatous softening in blood-vessel walls, and the digestion of necrotic areas of stomach and duodenum by the gastric juice are all processes characterized by softening and liquefaction. Liquefaction is also of frequent occurrence in certain tumors. In other cases liquefaction is a secondary process following simple or coagulation necrosis. The fibrinous exudates of inflammatory processes become liquefied during the later stages of the inflammation or during the process of healing, as in the case of the resolution of croupous pneumonia (ferment action). Areas of caseation necrosis and moist gangrene may undergo a secondary liquefaction. On the other hand, coagulation may follow liquefaction, the fibrin-forming substances being produced from leucocytes. In the blebs which appear in gangrenous skin there may occur a coagulation of the fluid, and the coagula may later be dissolved. Macroscopically, liquefaction necrosis is characterized by the formation of blebs on free surfaces, or by cavities filled with softened tissue débris, varying in appearance from a thin watery fluid, as in the case of brain cysts, to thick creamy fluid in abscess cavities. The earlier stages are shown by softening and increase in the amount of tissue juices. Microscopically, the presence of fluid is shown by clear spaces or vacuoles, stringy disintegration, etc. Both gross and microscopical appearances may be altered by the presence of blood or blood pigments.

Mummification Necrosis.—Necrotic tissues exposed to the air lose their fluids quickly through evaporation, and become leathery, dry, hard, shrivelled, brownish, or black, resembling mummy tissue. The condition is also known as dry gangrene; the amount of decomposition which takes place is, however, very slight, the dryness rendering the growth of saprophytic bacteria impossible. In the very early stages before the fluids are entirely removed there is some putrefaction usually present, as shown by the fact that there is almost always some odor about mummified tissue. The process may be regarded as a moist gangrene in which the processes of decomposition are cut short by the evaporation of fluid. Senile diabetic gangrene, gangrene of the extremities following freezing are examples of this form of necrosis. Microscopically, dry gangrene is characterized by the disappearance of the nuclei, the cells being flattened or contracted into hyaline masses. Cornification may be taken as a physiological example of this form of necrosis.

Moist Gangrene.—If necrotic tissues containing fluids become infected with saprophytic organisms with resulting decomposition, the condition is known as moist gangrene (*sphacelus, gangræna humida, gangræna putrida*). The formation of gas bubbles due to the presence of gas-forming bacteria (*B. aërogenes capsulatus, B. coli, Proteus,* etc.) gives

rise to emphysematous gangrene (*gangræna emphysematosa*). The different forms of moist gangrene, though distinguished by various names, are in their essence identical, since bacteria develop only in moist tissues. As mentioned above, moist gangrene may be changed to the dry form through evaporation. Gangrenous tissues are black, greenish, or brownish in color, according to the amount of blood pigment present. If there was much blood in the tissue before death the gangrene may be *black;* if the tissues were anemic the condition is sometimes designated *white gangrene.* Such forms are also distinguished clinically by the terms *hot* or *cold gangrene.* In hot gangrene the feeling of warmth may come from an abundant blood supply in the neighboring tissues. The odor of putrefaction is always present in moist gangrene, and various gases may be formed. Ptomaines and other poisonous substances are formed in the gangrenous area, and the absorption of these may lead to sapremia. Softening and liquefaction are always present to a greater or less degree. Microscopically, moist gangrene, in addition to the essential features of necrosis, is characterized by the presence of products of decomposition in the form of fatty acid crystals, tyrosin, leucin, triple phosphate, blood pigment, etc. The general picture may be that of a simple coagulation or liquefaction necrosis, or a combination of these forms may be present. Liquefaction is always present in a greater or less degree according to the stage of the process; all elements of the tissues, even bone and fascia, ultimately becoming dissolved. Moist gangrene may be caused by external injuries, chemical action, freezing, burns, *x*-rays, pressure, disturbances of circulation with impaired nutrition, intoxications, and infections. Lesions of the central nervous system and peripheral nerves are also regarded as direct or indirect causes of gangrene (*neuropathic gangrene*). The occurrence of a true neurotic gangrene has been much disputed. Trophic nerve fibers have never yet been demonstrated; and the various forms of so-called neurotic gangrene, such as the *symmetrical gangrene of Raynaud, mal perforant du pied,* the gangrene occurring in *syringomyelia, leprosy,* etc., can be explained as due to vasomotor disturbances or to a loss of sensibility due to disease of the peripheral nerves. The tissues usually affected are those most likely to be infected with saprophytic organisms, viz., the extremities, skin, lungs, external genitals, uterus, and intestines. (See also *Gangrene.*)

Caseation Necrosis.—The term caseous is used as a gross descriptive designation for necrotic processes in which the dead areas bear more or less resemblance to cheese in color and consistency. Two forms may be distinguished, the *hard* or *firm* and *soft caseation.* Either simple or coagulation necrosis or moist gangrene may be followed by caseation; the latter condition is to be regarded as a postnecrotic change representing a more advanced stage of cellular disintegration. If coagulation necrosis is present, the caseation is usually of the firm variety; if there is much fluid in the part or if the necrosis had been preceded by fatty degeneration, soft caseation will result. Caseous areas are yellowish or grayish white, more or less firm, dry, or viscid, and on section resemble cheese in consistency. Microscopically, the outlines of tissue elements are entirely lost, nuclei are absent, and the cells broken into fine granules. Fibrin threads may be shown by proper staining; fat droplets and vacuoles may be present. Early stages of caseation may stain diffusely blue from diffused chromatin; old caseation stains red with eosin, but shows no trace of chromatin. Very old caseous material may take no stain at all with eosin and hematoxylin. The chemical nature of caseous material is unknown; it probably includes many different substances derived from the breaking down of proteids. Caseation is a constant change in tubercles and gummata, and is of frequent occurrence in old infarcts, focal necroses, rapidly growing tumors, etc. Caseous areas not infrequently become liquefied. It is probable that diffusion processes take place between the area of caseation and the surrounding tissue; in this way the former may become infiltrated with fluid.

According to clinical or macroscopical characteristics the various forms of necrosis are also described as *focal, diffuse, spreading, central, circumscribed,* etc. Of these varieties *focal necrosis* deserves special mention. The term is applied to small necrotic foci, occurring very frequently in the course of various intoxications and infections, such as typhoid, diphtheria, scarlatina, smallpox, puerperal eclampsia, tuberculosis, toxemia of burns, chloroform poisoning, etc. The foci are found chiefly in the liver, spleen, lymph glands, and kidneys. The form of the necrosis is usually simple, but fibrin is often present in the necrotic material. The later stages present the appearance of caseation. Focal necroses may not be visible to the naked eye, or they may resemble miliary tubercles or abscesses, for which they may be mistaken. At other times they may appear as small pale yellow or grayish spots barely distinguishable from the surrounding normal tissue. Microscopically, small islands of simple coagulation or caseation necrosis are found. When the necrosis has been recent, diffuse or fragmented chromatin may be present and the areas may stain deep blue. About the necrotic areas there is often a leucocyte infiltration. Many of the leucocytes become involved in the necrotic process; their chromatin becomes diffuse, giving rise to a deeply staining periphery. In the liver focal necroses are often limited to the central zone of the lobule about the central vein; hence the designation *central necrosis.* The same term is also applied to central necroses of bone. Focal necroses are due to the direct action of bacilli or to poisons acting directly upon the cells or to local asphyxia. The changes in the small capillaries of the affected tissue play a very important part. Fibrin may be first formed in the capillaries and lymph vessels, and thus shutting off the supply of nutrition, cause cell death. In other cases changes in the capillary walls may be first produced by the injurious agent; capillary thrombosis follows, and to this the cellular necrosis may be secondary. Transudation of serum through the injured capillary walls may also lead to necrosis of the surrounding cells. The sequelæ of focal necrosis are the same as those of necrosis in general.

Fat Necrosis.—The necrosis of the fat-containing cells of adipose tissue forms a condition so striking in its clinical and pathological aspects as to warrant special mention. The condition occurs most frequently in the abdominal fat in connection with pancreatitis. The necrotic areas appear in the fat as grayish or yellowish, or in some cases black, opaque areas, soft or gritty, slightly elevated and usually circular in outline. The appearance sometimes is such as to suggest that the fat had been seared by a hot iron. Microscopically, the fat cells are enlarged, the nuclei absent, the contents granular or presenting the appearance of fine needles radiating from the center of the cell. Osmic acid has no effect upon the altered fat cells. With ordinary stains the necrotic fat cells react in a variety of ways. The granular detritus in the fat cells consists of a combination of lime salts and fatty acids. If the process is old, the amount of lime salts may be great. It has been definitely shown that fat necrosis is due to the fat-splitting ferment of the pancreas, which under certain inflammatory conditions of that organ gains access to the tissues through the blood or lymph. Gallstones are very frequently associated with pancreatitis and fat necrosis; obstruction of the papilla of the common duct may be a cause of the self-digestion of

the pancreas. Experimentally, fat necrosis may be produced by injection of pancreatic extract, by ligature of the pancreatic vessels, by introduction of pieces of pancreas into adipose tissue or into the peritoneal cavity, and by the direct action of steapsin in fat tissue. Not only may the abdominal fat be affected in cases of pancreatitis associated with fat necrosis, but also the fat of the pericardium, liver cells retroperitoneal region, and bone marrow. In the majority of cases the condition is fatal, but recovery has been noted, the dead fat cells becoming calcified. A limited amount of postmortal fat necrosis in and about the pancreas is of common occurrence, and should not be mistaken for a condition of pancreatitis, occurring during life.

Sequelæ of Necrosis.—The course of the necrotic process depends upon the anatomical nature and location of the affected tissue, the course and manner of the injurious influence causing the necrosis, the condition and environment of the affected part, the amount of blood and lymph, the nature of preceding changes, the opportunity for the access of air and putrefactive agents to the part, etc. About the necrotic area there is always a more or less marked inflammatory reaction in the surrounding living tissue. As a result of such inflammation the necrotic area becomes isolated and sequestered. The process is called *sequestration*, and the area of necrotic tissue so shut off a *sequestrum*. The ultimate sequelæ will be: (1) *Regeneration* following the absorption or casting off of the dead tissue, new tissue resembling the normal being formed; (2) *cicatrization;* (3) *calcification;* (4) *cyst formation*, the dead tissue being liquefied and encapsulated; (5) *chronic abscess* or *ulcer*.

Aldred Scott Warthin.

Negri, Adelchi.—Born at Perugia, Italy, in 1876. He studied medicine at the University of Pavia and received the degree of Doctor of Medicine in 1900. Subsequently he was appointed an assistant in the Laboratory of General Pathology, under Professor Golgi of that university. In 1905 he was authorized to give instruction independently in general pathology, and in 1909 he received the honorary title of Professor of Microbiology. As early as in 1903 he began a series of researches into the nature of the infectious agent of rabies, and was soon able to satisfy himself that this agent was a living organism belonging to the Protozoa. Eventually he demonstrated that these organisms, now designated "Negri bodies," are to be found in the brain and spinal cord of all human beings or animals affected with rabies, and are not to be found under any other circumstances. The importance of this discovery may be estimated from the fact that it furnishes us with the means of making a rapid diagnosis of the nature of the suspected disease by subjecting the dog who inflicted the bite to an appropriate histological examination.

Fig. 4073.—Adelchi Negri.

From 1908 to 1910 Negri carried on a series of further researches into the nature and behavior of the Sarcosporidia, and was the first to demonstrate the manner in which the spores of the Sarcocystis muris divide and also the possibility of infecting certain animals with these parasites by way of the stomach. Finally, he was the first to demonstrate the fact that vaccine virus may be caused to pass through a filter. He died at Pavia on Feb. 19, 1912.

Of his published writings the following deserve to receive special mention: "Nuove osservazioni sulla struttura dei globuli rossi," Boll. Soc. Med. Chir., Pavia, 1899; "Di una fine particolarità di struttura delle cellule di alcune ghiandole dei mammiferi," Boll. Soc. Med. Chir., Pavia, 1900; "Esperienze sulla filtrazione del virus vaccinico," Nota 1ª. Gazzetta med. ital., n. 13, 1905; "Osservazioni sui sarcosporidi," Rendic. R. Acc. Lincei, vol. xvii., serie v, f. 8. Nota 1ª, "Contributo allo studio dell' eziologia della rabbia," Boll. Soc. Med. Chir., Pavia, 1903, n. 2; "Sull'eziologia della rabbia, La diagnosi della rabbia in base ai nuovi reperti," Boll. Soc. Med. Chir., Pavia, 1903; "Sull'eziologia della rabbia, La dimostrazione del parassita specifico nell'infezione rabica degli uccelli," Boll. Soc. Med. Chir., Pavia, 1904; "Sulla morfologia e sul ciclo del parassita della rabbia," Rend. R. Acc. Lincei, 1909.

A. H. B.

Nélaton, Auguste.—Born at Paris, France, on June 17, 1807. He began the study of medicine in his native city in 1828, and in 1836 received the degree of Doctor of Medicine. The title of his graduating thesis was: "Recherches sur l'affection tuberculeuse des os." In 1839 he was made Agrégé, and the full title of Professor de la clinique chirurgicale was not conferred upon him until 1851. For many years he was Malgaigne's colleague in the surgical work at the Hôpital Saint-Louis. In 1867 he resigned his professorship. He died on Sept. 21, 1873.

Fig. 4074.—Auguste Nélaton.

Nélaton made relatively few contributions to medical literature. Of his published writings the following deserve to receive special mention: "Traité des tumeurs de la mamelle," 1839; "Éléments de pathologie chirurgicale," 5 volumes, Paris, 1844–1860; and "Parallèle des divers modes opératoires dans le traitement de la cataracte," 1850.

Credit should be given to Nélaton for having introduced the following procedures into surgical practice: the tying of both ends of the divided artery in primary and secondary hemorrhages; the investigation of nasopharyngeal polypi; the more accurate determination of the seat, mode of origin, and symptomatology of what he terms "retrouterine hematocele;" certain plastic procedures in the surgery of the nose, penis, etc.; the employment of direct compression in varicose aneurysm; the employment of coagulable injecting fluids in the treatment of pelvic aneurysms; the employment of enterotomy in the treatment of intestinal stenosis; certain modifications in the manner of cutting for stone in the bladder; and the introduction of the porcelain-tipped ("Nélaton's") probe, for use in exploring bullet wounds—as in the case of a bullet lodged in Garibaldi's ankle.

A. H. B.

Nemathelminthes.—A phylum of worm-like unsegmented animals, covered with a cuticle, and without appendages. An alimentary canal is usually present and the sexes are separate. Many are free living and a great number are parasitic. The larva may be

free and the adult parasitic, or *vice versa*. There are four classes which may be distinguished as follows:

1 (4) Anterior end without armed proboscis; intestine present.....2
2 (3) Adult with an anterior mouth and at least the anterior portion of an alimentary canal.....Class Nematoda.
3 (2) Alimentary canal always atrophied anteriorly in the adult. "Horse-hair snakes." Class Gordiacea.
4 (1) Anterior end with an armed proboscis; no digestive system. Class Acanthocephala.

See *Nematoda*. A. S. PEARSE.

Nematocera.—A group of dipterous insects which includes the following families: *Culicidæ*, mosquitos; *Corethridæ*; *Chironomidæ*, midges; *Simulidæ*, the sand-flies or black-flies; *Psychodidæ*; *Blepharoceridæ*, etc. The antennæ are composed of more than six segments, all of which are similar, except the first two; without arista. The palpi are four or five segmented. See *Insects, parasitic*. A. S. P.

Nematoda.—The class of the Nematoda or round worms constitutes a large, rather uniform, and clearly demarcated group, which by most recent authors has been regarded as of the rank of a phylum, in which case the name Nemathelminthes has been applied. The group is characterized by a cylindrical body, often filiform even in its attenuation, and by the heavy cuticular investment which carries in some cases small bristles, hooks, or spines, but which is consistently without appendages and manifests at most surface striation, but never true segmentation. The body cavity is extensive, but unprovided with a peritoneal epithelium, and the sexual and excretory systems do not stand in any connection with it. According to Goldschmidt mesenchymatous cells fill the space and leave only vacuolated areas or irregular

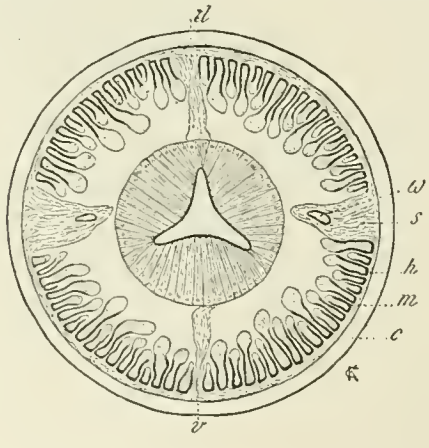

FIG. 4075.—Transsection of *Ascaris lumbricoides* at level of esophagus. *c*, Cuticula; *h*, hypoderm; *m*, muscle layer; *d*, dorsal, *s*, lateral, *v*, ventral lines; *w*, excretory canal. (After Hertwig.)

lacunæ within the cells and hence there is not a true body cavity but a pseudocoel. Another striking feature is the entire absence of cilia in all stages of development.

An alimentary canal is present, at least in some stage of the life history of all forms. It is with rare exceptions a permanent structure in the members of the subclass of true round worms, or Eunematoda; but in the subclass of the hair-snakes or Gordiacea, the alimentary canal is greatly reduced in the adult, in that the mouth is closed and a delicate solid string of tissue is the only vestige of the anterior portion of the canal. The posterior region still retains its cavity and functions in connection with the reproductive organs of both sexes, which have with it a common outlet. In the Eunematoda, on the other hand, the male organs join the alimentary canal to form a common cloaca, but the female system is entirely unconnected with the alimentary system, and the vulva occupies a variable position in the midventral line. The sexes are separate, though in rare instances parthenogenesis or hermaphroditism modifies the usual balance.

EUNEMATODA.—By far the largest number of forms belongs to the Eunematoda, which will be considered first, while the Gordiacea and, as an appendix, the Acanthocephala will be discussed subsequently. The tendency is unmistakably to separate from the true Nematoda both of these groups, and most of all the latter, as independent subdivisions not closely related to the former. Among the Eunematoda the better known forms are parasitic, though some are free living and an occasional species is capable of making use of both types of environment. The free-living species are uniformly insignificant, but among parasitic forms one finds the microscopic blood parasites and the meter long guinea worm. In respect to location also there obtains great variety, and one finds these parasites in all regions of the alimentary, respiratory, circulatory, excretory, and muscular systems, and in connective tissue and serous cavities.

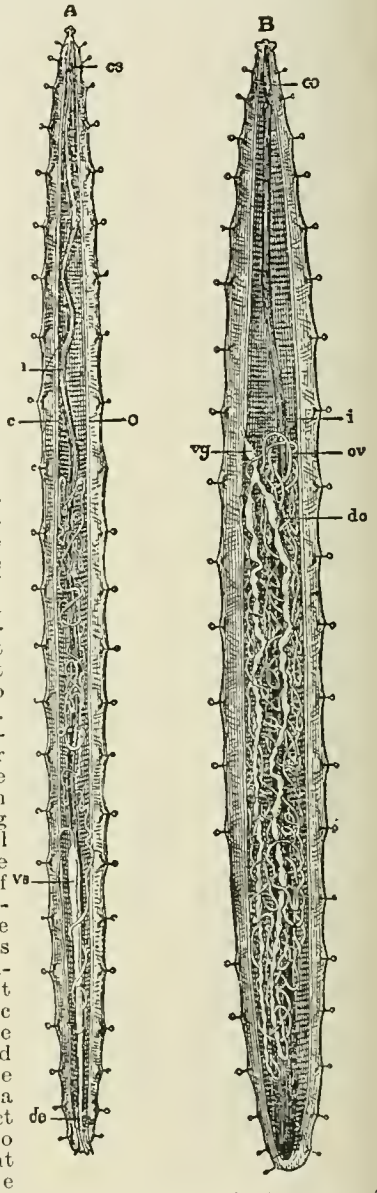

FIG. 4076.—Internal Anatomy of *Acsaris lumbricoides*, opened along dorsal line. *A*, Male; *B*, female; *c*, lateral line; *de*, ductus ejaculatorius; *do*, uterus; *i*, intestine; *œ*, esophagus; *ov*, coiled ovary; *vg*, vagina; *vs*, seminal vesicle. (After Delafond.)

The greatly elongated cylindrical form tapers as a rule more or less toward both ends, though generally speaking the head is truncated and the tail acute. The chitinous cuticula invests the entire body, and is introverted a short distance at all orifices. It bears rarely unjointed spines and bristles and is marked

often by delicate surface striations. In cross-section (Fig. 4075) the body appears circular, and shows beneath the cuticula a thin hypodermal layer, which is without cell boundaries and hence a syncytium, prominently thickened at four points. Of these the lateral lines, fields, or areas, as they are called, are largest, and are visible in surface view as delicate longitudinal stripes (*c*, Fig. 4076). The dorsal and ventral median lines are much less prominent and are distinguishable ordinarily only in sectional views.

Directly below the hypodermis is the muscular layer which is interrupted by the lines already noted, and hence appears as four muscular fields. The muscle cells (*m*, Fig. 4077) are of a peculiar type in that a protoplasmic body is distinct from the contractile fibrillar portion. All of the muscle fibers in the dermal layer are longitudinal. A few oblique fibers are found in various special regions. No circular layer is found. The main trunks of the nervous system occupy the dorsal and ventral areas, while the lateral areas contain each a delicate canal, which has been interpreted as part of the otherwise unexplained excretory system; with the latter are associated, however, certain stellate cells of peculiar character, which project from the lateral fields into the body cavity and are known as phagocytic organs.

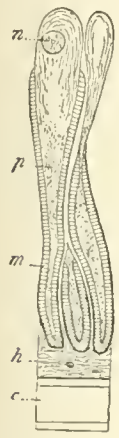

Fig. 4077.—Section of Body Wall of a Nematode. Highly magnified. *n*, Nucleus; *p*, protoplasmic body of muscle cell, *m*; *h*, hypoderm; *c*, cuticula.

The alimentary canal (*i*, Fig. 4076) is a straight simple tube extending from the mouth, which is always terminal, to the anus, which varies in location from the posterior end to a position on the ventral surface, some little distance removed from it. Various features connected with the canal are of great systematic importance. About the mouth are found a number of lips and papillæ characteristic of the genus or family. The buccal or pharyngeal cavity, an enlargement at the outset, the muscular esophagus with a triangular lumen (Fig. 4075) and a terminal enlargement which may be indistinctly marked, or may partake of the form of a distinct bulb, or even to such, with a valvular apparatus, the intestine proper followed by the rectum and cloaca in the male—these constitute the distinct parts of the alimentary system.

The sexual organs have the form of a long coiled tube, in the attenuated distal end of which the sexual cells are produced, while the proximal portions afford storage for the perfected germ cells before they are discharged from the body. In the female the system is regularly bifid, although one horn of the uterus may be undeveloped to a greater or less extent, while in the male only a single tube is present. The varied debouchment of the system in the two sexes has already been noted. About the vulva chitinous lips often of notable thickness are developed, and on the external surface near the male orifice numerous papillæ characteristic of the genus or species, and at times a sucker also are to be found; these function as accessory copulatory apparatus, while in the same category are included expanding folds of the body wall known as the bursa and awl-shaped chitinous structures called spicules. The bursa varies from a pair of simple folds lateral to the cloaca to a cup or bell surrounding it and the posterior end of the body. The spicules, either one or two in number, with an accessory guiding piece in some instances, are developed in a dorsal evagination from the cloacal wall and provided with special musculature for extrusion and retraction. Their form varies greatly in different species, and with the bursa and circumanal papillæ constitutes the means for determination of the species.

The Eunematoda are oviparous, but in some cases the eggs are retained long enough in the uterus to contain when laid a partly or fully developed embryo; and in a few species the embryo deserts the shell before it is extruded from the body. All stages in the development of this ovoviviparous habit may be observed.

Ordinarily the eggs which undergo development external to the body of the host are provided with a heavy shell to resist the action of an unfavorable environment. In case the eggs undergo development while still in the uterus, the shell is thin. Some species develop directly, *i.e.* without a change of host, though a certain stage in the life history at least is passed in the outer world; in other cases the immature worm lives in another animal, known as the intermediate host, than that which harbors the adult, or rarely in a different part of the body of the one host. In a few species a parasitic generation alternates with a free-living generation of such different form as to have been regarded as another species; and the alternating generations differ radically in method of reproduction. In one case at least (*Trichinella*) the entire life history is passed within the host and transportation to a new host depends upon the carnivorous habit. In other cases also (blood filariæ) the life history is passed within two hosts and no part takes place externally; but in most instances there is a free living stage and infection is brought about primarily through the drinking-water. Some prominent exceptions to this general statement are noted later.

The family of the Anguillulidæ contains mostly free nematodes of small size, transparent, filiform, and tapering to both ends. The mouth contains a chitin stilletto, or two teeth. The esophagus is inflated or has one or two bulbs at the posterior end. The female possesses double symmetrical uteri and short reflexed tubular ovaries, with vulva at or behind the center of the body, with few, large ova, and with development rapid, often ovoviviparous. The male has two equal chitinous spicules, with or without one or more accessory pieces. The type genus is

Anguillula Ehrenberg 1826.—Buccal cavity very minute; esophagus cylindrical with two bulbs, the posterior having a valve apparatus; vulva behind center of body; male without bursa; accessory piece single, fan shaped. Uterus asymmetrical. The best known species is the vinegar eel, which has been found as a parasite of man.

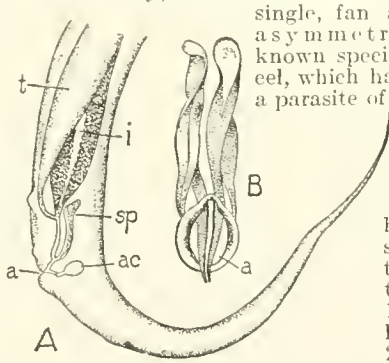

Fig. 4078.—*Anguillula aceti*. *A*, Tail of male; *ac*, accessory piece; *sp*, spicules; *a*, anus; *i*, intestine; *t*, testicle; *B*, *a*, spicules partially protruded from anus. Magnified. (After Stiles.)

Anguillula aceti Müller (Fig. 4078). — Cuticula very, finely striated body tapering slightly anteriad; tail greatly attenuated. Male, 1.35 to 1.45 millimeters long by 24 to 28μ wide. Spicules 38μ long, similar, twisted; accessory piece slightly caudad; no bursa; papillæ at least two preanal and one postanal. Female, 1 to 2.4 millimeters long, by 40 to 72μ in diameter, contains embryos 0.22 millimeter long by 12μ in diameter.

This worm, which is everywhere common in vinegar, has been found by Stiles and Frankland in the rôle of a human parasite. The specimens were taken in great numbers from the urine of a female patient,

and were present during a period of thirty-three days. The urine was always very acid and once had a marked odor of vinegar. In this sample the worms lived two months, and individuals then removed to vinegar became vigorous and bred rapidly.

Pathology.—The patient had chronic parenchymatous nephritis of a degenerative type, and the urine frequently contained albumin, but not while the parasites were present. No symptoms traceable to them were observed, and their presence in the bladder remained unexplained. The suspected use of vaginal douches acidulated with vinegar was denied by the patient, and no grounds existed for questioning the truth of the statement. Evidently this parasite might be present in the vagina if such a practice were followed. Billings and Miller have reported two other cases from the United States in which, however, the source of the parasite was not demonstrated beyond question.

Rhabditis Dujardin 1845.—Buccal cavity without teeth. Esophagus with two bulbs, the posterior one carrying teeth. Nerve ring anterior to posterior bulb. Lateral lines not seen. Two short spicules, with accessory piece.

Rhabditis niellyi R. Blanchard 1888.—(Syn.: *Anguillula leptodera* Nielly; *Leptodera niellyi* R. Bl. 1885.

This species is known only in the larval form, in which it measures 333μ in length and 13μ in breadth. The alimentary canal was the only internal organ described; it displayed two enlargements in the pharynx, the second pharyngeal bulb having a dentate armature.

The worms were discovered by Nielly in 1882 in a young man, fourteen years of age, who was born near Brest, and had never been out of that region. A dermal eruption, much like craw-craw, of about five or six weeks' standing, affected chiefly the patient's limbs. In the fluid of each papule were found several worms, and the blood showed on microscopical examination at the outset of the malady many small nematoda, which, however, could not be found later; at no time were they found in feces or urine.

The method of the introduction of the parasite was unknown, but it was remarked that the lad had been in the habit of drinking from brooks. It is easily surmised that the eggs of the worm were swallowed in drinking, and that the embryos, hatching out in the alimentary canal, bored their way into the circulation and thus reached the skin. Their presence both in the blood and in the papules is thus easily explained. They may have been, however, larvæ of some imported filaria, though dermatosis caused by larval nematoda has been observed in dog, fox, and horse in Europe by many investigators.

In this connection it is important to compare the records of various other investigators on somewhat similar cases. Whittles reports the discovery of nematode larvæ in a nineteen-year patient who had never been away from Birmingham where he had also found nematode larvæ repeatedly in the blood of persons suffering from dermal irritation and believed they were introduced through troops that had returned from South Africa.

Rhabditis pellio A. Schneider 1866.—(Syn.: *Leptodera pellio* A. Schneider 1866; *R. pellio* Bütschli, 1873; *R. genitalis* Scheiber 1880.) Male, length, 0.8 to 1.5 millimeters; cordiform bursa with seven to ten ribs on each side; spicules 27 to 33μ in length, nearly alike. Female, length, 0.9 to 1.3 millimeters, posterior extremity long and pointed, vulva a little behind the center of the body; ovary not paired; eggs oval, 60 by 35μ.

Scheiber found this species at Stuhlweissenburg, Hungary, in the urine of a native woman suffering from pyelonephritis, pneumonia, and acute intestinal catarrh. During the entire illness the worms were found in the vagina in all stages of development. Several other authors have found what is closely related, if not the same form, in the urine in cases of hematuria, but the parasitism is probably accidental, since Oerley has shown that *R. genitalis* Scheiber must be referred to *R. pellio*, a common free living form found in moist earth and putrefying substances, and also that worms of this species will multiply in the vagina of white rats. There is further to be noted both the habit of Hungarian peasants in employing moist earth for poultices and the record of Scheiber, that patient and clothing were earth stained, rendering it altogether likely that such a poultice had been applied near the vulva, and that from it the free living worms had successfully colonized the vagina.

Leptodera A. Schneider 1866.—Esophagus with two bulbs, the posterior with or without valves. Male with or without bursa, often six to ten papillæ on the bursa or on the median line; two short spicules and a single accessory piece. Some species are hermaphroditic. A somewhat indistinct genus, difficult to separate from that last described and perhaps identical with it.

Leptodera terricola Dujardin 1845.—(Syn.: *Rhabditis terricola* Duj. 1845; *Pelodera teres* Schneider 1866; *P. setigera* Bastian 1879; *R. cornwalli* Cobbold 1879.) Mouth with six lips, anterior bulb of pharynx fusiform, posterior spherical. Male, length, 1.3 millimeters; tail attenuated, slightly longer than the bursa. Female, 2 millimeters in length and over; posterior extremity sometimes regularly attenuated, sometimes sharply rounded and provided with a very fine tail; vulva about the middle of the body; ovoviviparous; eggs 60 by 40μ.

This typical free-living species should be listed as a pseudo-parasite of man by virtue of its occurrence in cadavers, and, in one case at least, its confusion with trichina. The facts in this celebrated case are as follows: The English schoolship *Cornwall* was visited in 1879 by an epidemic which affected many cadets and killed one. The symptoms of the disease were not incompatible with trichinosis, and microscopical examination of the exhumed cadaver, undertaken two months later, demonstrated in the muscles of the abdomen many nematoda, which, with the exception of the first one examined, were dead, but not one was encysted. The epidemic was pronounced therewith trichinosis, and attracted enough attention to be brought before Parliament. Cobbold and Bastian easily showed that the worms in question had nothing to do with *Trichinella*, and Oerley established their identity with *L. terricola*, which had undoubtedly penetrated the body after inhumation.

The family of the Angiostomidæ includes small rhabditis-like nematoda which manifest in development the alternation of two types of sexual generations of which the first is dioecious, free and very similar to Leptodera, *i.e.* rhabditiform, while the second is parasitic, hermaphroditic, and of a different structure designated filariform.

Strongyloides Grassi 1879.—Parasitic generation with simple mouth in which no armature is present but is surrounded by four lips; cylindrical pharynx very long. Free generation with small oral cavity; pharynx with two bulbs, the anterior fusiform, the posterior spherical and armed; male with two small spicules similar.

Strongyloides stercoralis Stiles and Hassall 1902.—(Syn.: *Anguillula intestinolis* and *A. stercoralis* Bavay 1877, nec *A. intestinalis* Ehrenb. 1838; *Leptodera intestinalis* and *L. stercoralis* Cobbold 1879; *Pseudorhabditis stercoralis* Perroncito 1881; *Rhabdanema strongyloides* Leuckart 1883; *Str. intestinalis* Grassi 1883; *R. intestinale* Blanchard 1885.)

Parasitic generation (Bavay's *A. intestinalis*) (Fig. 4079). Female only, hermaphroditic, or parthenogen-

etic; length 2.1 to 2.2 millimeters, breadth 60 to 70μ body slightly tapering anteriorly, but terminated posteriorly by a short bluntly conical tail, with rounded and slightly dilated tip; mouth with four poorly developed lips; esophagus cylindrical, with no swellings, one-fourth the length of the body or more, distinguishable readily only in color from the intestine; vulva transverse in posterior third of the body; uterus double with five to six (nine to twenty?) ellipsoidal eggs, 50 to 59, or 65 to 70μ by 30 to 34, or 39μ and often joined in strings of two or three. Eggs segmenting when laid, develop rapidly. Embryos rhabditiform, 0.3 to 0.6 millimeter long by 16 to 22μ wide; first moult within twenty hours if in incubator.

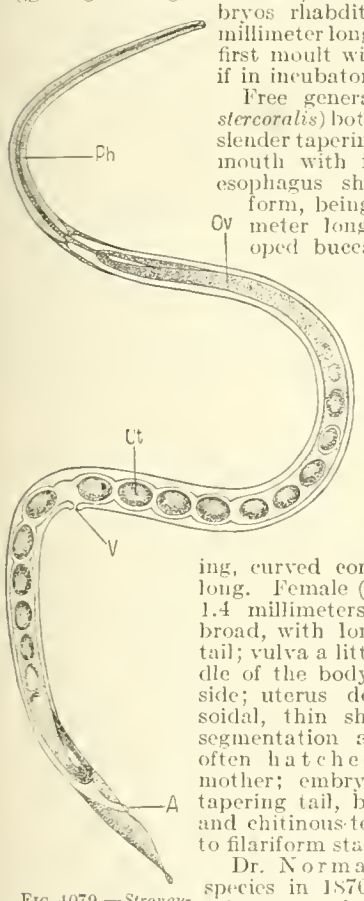

Fig. 4079.—*Strongyloides stercoralis* from Human Intestine. *ph*, pharynx; *ov*, ovary; *ut*, uterus; *v*, vulva; *a*, anus. × 80. (After Braun).

Free generation (Bavay's *A. stercoralis*) both sexes occur; body slender tapering toward the ends; mouth with indistinct papillæ; esophagus short and rhabditiform, being only 0.16 millimeter long with well-developed buccal cavity and two bulbs, the posterior of which is armed with three chitinous teeth; anus with protruding lips on right side of body. Male (Fig. 4080, *B*), 0.75 to 1 millimeter long, 35 to 66μ thick, with short recurved tail and two conspicuous protruding, curved conical spicules, 38μ long. Female (Fig. 4080, *A*), 1 to 1.4 millimeters long, 50 to 75μ broad, with long slender pointed tail; vulva a little behind the middle of the body and on the right side; uterus double; eggs ellipsoidal, thin shelled, 70 by 45μ, segmentation advanced, embryo often hatched within body of mother; embryos at first with tapering tail, bulbous esophagus, and chitinous teeth, soon changing to filariform stage.

Dr. Normaud discovered the species in 1876, when examining microscopically the stools of soldiers returned from Cochin China, who were suffering from acute dysentery. Somewhat later he found at the necropsy of soldiers who had died from Cochin China diarrhea, the other form of the species. Both of these forms were originally studied by Bavay. It was in 1882 before the connection of the two was established by Leuckart, who showed them to be phases in the life history of the same species. In life man harbors in the canal one form (*A. intestinalis* Bavay) and its young which, reaching the exterior with the feces, may be transformed then into the other adult (*A. stercoralis* Bavay); the latter transformation may also take place in the intestine after death, as in cultures made in confirming these discoveries.

Life History.—The parasitic generation, which recalls a strongylid or a filaria in general appearance, is found in the duodenum of man and consists only of females. These are hermaphroditic (Leuckart) or parthenogenetic (Rovelli and others), and so delicate that they are readily overlooked in fecal examinations. They burrow in the mucosa and deposit the majority of the eggs there. The young worms wander into the intestine and are evacuated with the feces. Eggs are only rarely found in fecal matter. They produce eggs so abundantly that from an ordinary infection more than a million embryos may be evacuated in a single stool. The embryos (Fig. 4081, *A*) measure at hatching 0.2 to 0.24 millimeter long by 12 to 16μ broad, but develop so rapidly that those in the stools have attained a length of 0.30 to 0.60 millimeter by a width of 16 to 23μ. After the first moult the structure of the embryos becomes more distinct, and one can see three or four oral papillæ and a buccal cavity, together with an anterior enlarged and median constricted region of the esophagus, which is terminated by the esophageal bulb, containing an apparatus for trituration composed of three chitinous teeth. The intestine which follows ends in a slightly protruding anus located on the right side. Also on the right side, about one-third the distance from the bulb to the tail, is the whitish lenticular portion of the sexual system.

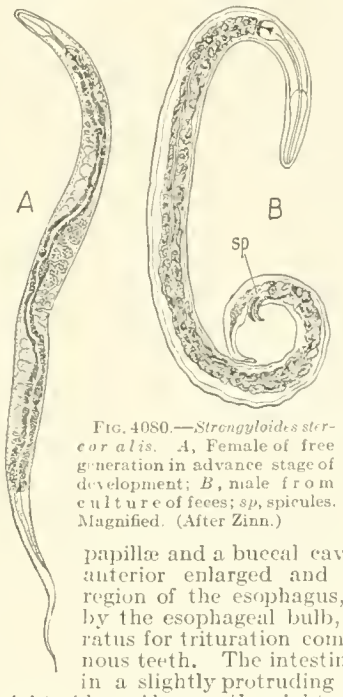

Fig. 4080.—*Strongyloides stercoralis*. *A*, Female of free generation in advance stage of development; *B*, male from culture of feces; *sp*, spicules. Magnified. (After Zinn.)

In most cases studied in temperate regions after a few days in culture, these embryos die or moult and change greatly in appearance, becoming elongate and with more tapering tails, the esophagus loses its teeth and enlargements and becomes a uniform cylinder half as long as the larva itself; these resemble young filariæ and have assumed the filariform type (Fig. 4081, *B*). These are the infective stage and for further development await their introduction into the human intestine. The development of the filariform larvæ from newly hatched rhabditiform embryos can be completed within forty-eight hours.

In other cases, primarily if not exclusively where the temperature remains high (25 to 35° C.), the rhabditiform embryos do not metamorphose into filariform larvæ but become within three days sexually mature males and females of the free living type. Each fecundated female of this generation produces only thirty to forty eggs in an advanced stage; they manifest the same rapid development as the intestinal form often hatching before being deposited in the feces in which the males and females are living. The embryos are about 0.22 millimeter long with a distinct rhabditiform esophagus; they develop there rapidly to filariform larvæ (Fig. 4082) which are as in the former case the infective stage. The eggs of the free generation are difficult to distinguish from those of the parasitic save that the former are slightly

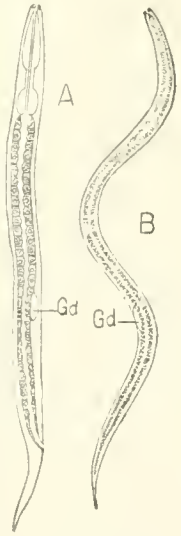

Fig. 4081.—*Strongyloides stercoralis*. *A*, Rhabditiform larva from fresh feces. × 145; *B*, filariform larva from culture; *Gd* genital cell. × 135 (After Braun.)

larger. The embryos and the filariform larvæ are apparently identical in structure, but Leichtenstern says that those produced in direct development are more resistant as the brood of the free-living generation perishes at 11° C. This accords with the occurrence of the latter in tropical regions only. The first moult occurs when they are about 0.35 millimeter long, and at an age of only thirty to thirty-six hours. They then assume the strongyloid character; the mouth has four lips, the esophagus is cylindrical, the tail is short, and bears two small lateral wings. At the end of a week the free form is no longer to be found in the cultures and all the young have assumed the filariform stage.

The method of introduction was formerly inferred to be impure water or vegetables, salads, etc., which had been contaminated by human excrement, although Normaud acquired the disease in Cochin China, while having refrained absolutely from drinking any but imported water, and was accordingly inclined to question the part played by water in its dispersal. This passive introduction of the larvæ is still held to be of significance although experimental infection *per os* has often failed to give positive results. Active migration of these larvæ through the skin was demonstrated by Van Durme and has been amply verified. One may infer that the course they follow is the same as that of the hook-worm but the evidence is not yet complete. Fülleborn observed that larvæ migrating through the skin became mature in the trachea and produced a brook of rhabditiform larvæ, but was unable to follow the life cycle further. In a case coincident with chronic pneumonia Gage found filariform larvæ in the sputum, and later at the autopsy discovered them in pulmonary nodules and in intestinal lymph vessels, as well as masses of eggs, larvæ, and adults in the intestinal cavity.

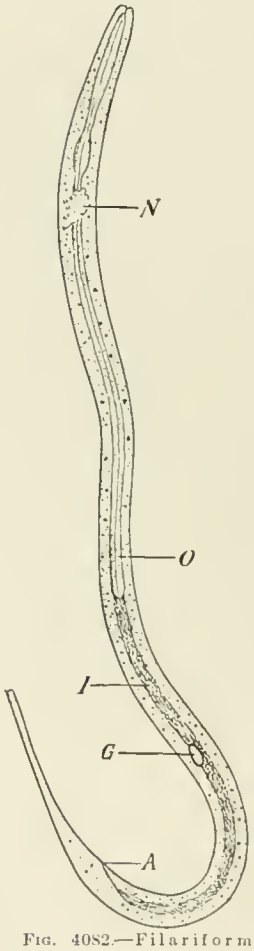

Fig. 4082.—Filariform Larva of *Strongyloides stercoralis*. (After Looss, 1914.)

Culture experiments by Wilms and others support the view that there are not two varieties of the parasite, one developing direct, the other by the indirect method but that embryos from the same lot of eggs may be developed in either fashion. It is significant that cases infected with the tropical strongyloids develop usually with the interpolation of the free sexual generation, while cases infected in temperate regions, both of Europe and America, manifest almost exclusively direct development. Many have claimed that there are concerned here more than one species of closely related and heretofore confnsed forms, which would account for some of the apparently conflicting statements. In fact the figures given by various authors, do not agree while the adult parasites as figured by Strong and Braun show numerous differences in detail. Yet most investigators incline to regard the human parasite as a single species only. Looss believes that several parasitic generations may intervene between two free-living generations. Hence individuals may be at different points in the life cycle and one may find a free-living generation at a given time, or may meet another parasitic one.

The observations of Grassi, that the alternation of generations described is not a fixed 1 : 1 ratio in the life cycle of this species, is still further of importance as explaining the enormous number of worms found in the intestine in some cases. Leuckart records an instance in which prodigious quantities of the worms were evacuated even a year and a half after leaving the locality of infection. Such evidence favors the multiplication of the parasite in the human alimentary canal, as in fact related species do so reproduce in other animals and as *Anguillula aceti* multiplies in the human bladder as noted above, but Looss regards autoreinfection as extremely improbable.

Some confusion is possible on account of failure to differentiate eggs or larvæ of this species from those of the hook-worm. In fresh feces the hook-worm larvæ are not present and the Strongyloides eggs, though rarely found, are well advanced in development while hook-worm eggs show two, four, or eight cleavage cells only. In feces that are older one may find under favorable conditions both kinds of larvæ: the hook-worm larvæ just hatched out and Strongyloides larvæ of the second generation. The diagnostic factors are (1) the characters of the head and mouth, and (2) the location of the genital rudiment. The head (Fig. 4083, b) of the Strongyloides larva is blunter and has a broader thin-walled oral cavity of relatively scant depth. In the hook-worm larva the cavity is narrow and deeper with heavy chitinous walls and shows a distinct spherical enlargement at the point of junction with the esophagus. The conspicuous genital rudiment in Strongyloides is situated close to the center of its length whereas in the hook-worm it is considerably further posteriad and also much smaller, measuring only 3μ long as against a large spindle-shaped rudiment, 33μ long in the former.

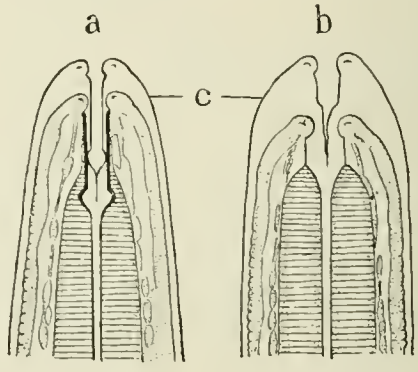

Fig. 4083.—Larval Heads. a, *Ancylostoma duodenale;* b, *Strongyloides stercoralis* in free generation. Both larvæ after first moult with old larval skin (c) still surrounding them. (After Looss, 1914.)

Distribution.—*Strongyloides stercoralis* occurs very widely. The entire tropical and subtropical zone of Africa, Asia, the Philippines, and the East Indies form apparently its original home, within which its occurrence is all but universal. More recent studies seem to show that it is equally frequent in tropical regions of both Americas, and that it occurs at times far outside of that zone. It has been recorded from Martinique, Brazil, Hawaii, Japan, Siberia, and in Europe from Sicily, Italy, and Mount St. Gothard tunnel, Spain, Russia, and among brick-workers along the Rhine and in East Prussia. First reported in the United States by Strong, it was observed and studied twice in Baltimore by Thayer, who showed its probable endemic character. For a

bibliography and discussion of previous cases consult the splendid paper by the latter author. Stiles has published three other cases among United States soldiers, and other authors have reported its occurrence from Texas to Boston and from the Atlantic seaboard to the Mississippi River.

Pathology.—Wide differences of opinion are current as to the pathological importance of this species. This was due at first in part to lack of knowledge concerning its activity and now to complications with other parasites and diseases. At first the worm was regarded as the cause of the dysentery in which it was originally discovered and with which it is usually associated. But the rarity of the worm in the intestine at the outset of the disease, its abundance in stools of convalescents, its absence in cases which have freely bilious diarrheas, and often in severe attacks of Cochin China diarrhea, and finally its frequent presence in individuals enjoying normal health, all militated against the supposed pathogenic rôle of the species; and both Grassi and Leichtenstern went so far as to proclaim the species entirely innocuous, "innocent commensals of man."

On the other hand, its presence was not regarded by all authors as harmless. Sonsino has found that in Italy excessive multiplication of the species gave rise to acute enteritis followed by dangerous anemia. Golgi and others have observed epithelial lesions which they have attributed probably with justice to the action of this parasite. Its extraordinary multiplication in the human alimentary canal must contribute to the irritation of the mucosa and to the production of the lesions of the so-called Cochin China dysentery. Observations of Askanazy served to demonstrate the pathological character of these worms, which he found to be actual parasites of the intestinal wall in the duodenum and jejunum. Here they penetrate chiefly the mucosa, being often found in the epithelium of Lieberkühn's glands. They penetrate to the muscular layer or rarely deeper than this. These migrations are in search of food, as the chyle-filled body of the worm shows, but no evidence was found to show that they ever suck the blood of their host.

The female deposits eggs in the galleries of the mucosa, which gives rise to embryos that wander out into the lumen of the intestine. In Teissier's case it was claimed that these embryos had taken a different route and had entered the circulation, perhaps by way of the chyle tubes; their presence here was accompanied by high temperature, which abated with their disappearance three days later. More probably this case represents a double infection of Filaria with Strongyloides. Strong confirmed the presence of adults, eggs, and embryos in the epithelium and in the cavity of the crypts of Lieberkühn; in these cases the epithelium was often atrophied and less frequently entirely gone. Infiltrations of small round cells were observed in some cases, but no marked inflammatory changes. This author finds the parasite capable of producing an intermittent diarrhea with intestinal disturbances. It certainly causes some mechanical injury from its attacks upon the mucosa. Precise records of serious results in individual cases are recorded by various observers in different regions. These include diarrhea, and severe dysentery, with moderate or extreme anemia, and rarely a fatal termination.

Diagnosis.—The presence of the intestinal adults is not normally to be expected in the stools. Fresh stools contain usually rhabditiform larvæ and only rarely ova whereas older stools show the filariform larvæ or the sexual free-living generation and its rhabditiform larvæ. The detection of larvæ in the stools is difficult. In cases where only a small number of embryos is present or suspected, a diagnosis can easily be reached by spreading the fecal material on a culture plate and making a small cavity at the center. This fills rapidly with water and the embryos collect in it by virtue of pronounced hydrotaxis. In pure water the embryos perish in a brief time, but in moist feces they live an unknown period after reaching the infective stage. Some data reached experimentally by Italian investigators are misleading and must be rejected as they concern frog parasites which are certainly at least a different species and the view that the frog functions as a reserve host or distributor of these human parasites cannot be accepted.

Prevention.—The consistent destruction of stools from those afflicted with this parasite appears to be the only ultimate remedy. A proper water supply and abstinence from the use of uncooked foods, such as salads, etc., are evident precautionary measures although not of such exclusive importance as once believed. The protection of the skin from the entrance of the embryos, by the use of footwear and gloves especially, is a necessary precaution for those who are called upon in infected regions to handle the earth (bricklayers, gardeners, etc.). Various observers have commented upon the immunity of natives in Cochin China toward this disease and have sought to explain it on the basis of their general use of water boiled or treated with alum. If the observations are correct they serve at best as only a partial explanation of the case.

Treatment.—The general treatment worked out for hook-worm seems to be most satisfactory here also. Male fern and thymol are most highly recommended. All methods are only partially successful; they reach effectively those parasites that are in the lumen of the canal but have no effect upon such females as have burrowed into the mucosa. Consequently a new brood of larvæ (and adults?) makes its appearance again within a short time. Thus in cases of severe infection all treatment seems to be of moderate value only, if any.

The *Gnathostomidæ* are represented among human parasites by a single rare species which is probably only an occasional parasite of man. It is very imperfectly known. The genus is easily recognizable by the numerous scale-like, many pointed, spines which cover the entire body, or at least the anterior region.

Gnathostoma siamense Levinsen 1889.—(Syn.: Cheiracanthus siamensis Lev. 1889.) Head spherical set off by a circular groove. Mouth with two lips. Vulva behind center of body. Two unlike spicules. Oviparous. Several species occur in the Felidæ, and in swine and cattle as well as in other hosts.

This is known from a single female specimen, length 9 millimeters, breadth 1 millimeter; about the head eight circles of spines. The anterior third of the body alone is covered with spines, the anterior of which are leaf-like and three-pointed, and the posterior simple. A single male has also been described. It was 10.65 millimeters and 0.6 millimeter broad. The head and anterior region are like the female. The posterior end is coiled in a spiral and bears two preanal and two postanal papillæ. Spicules are 1.1 and 0.4 millimeters long.

The first specimen, a female, was collected in Siam and came from a small tumor; when this disappeared there were found on the skin nodules the size of a pea, from one of which this worm emerged. The same symptoms were observed in two other cases; and in one of these five or six worms were expelled but were not preserved. In 1909 Leiper reported from Siam an immature male.

The family of the Filariidæ has the body greatly elongated, filiform; head straight, usually (or always?) with two lateromedian and four submedian papillæ mouth sometimes with lips and even with a buccal capsule; œsophagus long, slender, and without a bulb; male with somewhat coiled tail and a single spicule or two unequal ones. Female with double ovary and vulva near the anterior end of the body. Most species are ovoviviparous.

Up to very recent times only one genus has been generally recognized among these forms; viz., *Filaria*,

and into it has been thrown everything that could not readily be placed elsewhere. For physicians especially Filaria has been a "catch-all." As a result it has come to include an assemblage of forms often little related to each other and in the main also poorly described. Some order has been evolved out of this confusion by the work first of Stiles and then of Railliet and Henry. By this means several natural groups have been recognized as genera and set aside, but the remainder of the original group still retained under the old name filaria is as unnatural an association as before.

One species included in this family is strikingly different from the others in the structure of the embryo. This is the Guinea worm; its embryo (Fig. 4084) is stout, with a long, slender, awl-shaped tail that is very slightly coiled. The esophagus has a distinct bulb, and the anus lies only two-thirds the distance from the anterior to the posterior end. This embryo is thus distinctly rhabditiform whereas the elongated, slender type with no bulb on the esophagus and an anus located much further posteriad is commonly known as filariform from its characteristic frequence in this family. The supposed absence of the vulva in the adult female and discharge of embryos through the mouth is too vaguely known to justify its use as a diagnostic character for this genus as the type of a new subfamily to which Stiles has given the name Dracunculiinæ.

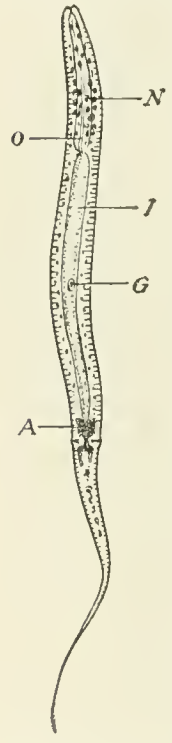

Fig. 4084.—Embryo of *Dracunculus medinensis*; *n*, nervous system; *o*, esophagus; *i*, intestine; *g*, genital anlage; *a*, anus. (Looss, 1914.)

The characters of the embryo will, however, justify that procedure. This subfamily which contains but a single genus and species, *Dracunculus medinensis*, will be considered after the other forms; it departs widely in many respects from the typical filarias. The latter constitute the subfamily of the Filariinæ. At present all the uncertain and imperfectly known forms are included here and indeed are left under the original genus, which is the type. This genus is

Filaria O. F. Müller 1787.—Very long slender worms of nearly equal caliber throughout. Mouth minute, terminal, without teeth or lips but with (six?) small papillæ. Males notably smaller than the females, with coiled posterior end, which possesses usually lateral cuticular alæ. Spicules ordinarily very different in size and form. Four preanal papillæ are almost constant; the number of postanal papillæ is, however, variable. Vulva always near the anterior end.

As the type *F. martis* is imperfectly known a satisfactory generic description cannot be written now. The species are generally parasites of the connective tissues, rarely the body cavity, lymph glands, and blood stream. The embryos are regularly found in the blood and development is accomplished by some blood-sucking arthropod which functions as intermediate host.

Some of the familiar forms appear below under new names since they have been transferred from this to new genera. While the investigations of recent years have added greatly to a knowledge of these forms, many are still imperfectly known. Those species are considered first which are relatively worked out in their main features. The imperfectly known forms are then considered. They are grouped under certain convenient generally accepted terms. As already stated all such adults are left under the old generic designation *Filaria*. The immature types which have reached the adult stage but are as yet sexually undeveloped, fall under the general name of *Agamofilaria* and the blood-inhabiting embryos classed under the term *Microfilaria*. As such forms are become better known they are to be transferred to their proper places in the general scheme of classification.

At the close of this section there will be found a brief discussion of those records which deal with so-called filarias but which in fact are not entitled for one reason or another to such an interpretation.

The designation *Microfilaria* has been introduced for the young embryos that are found in blood, lymph, or serous fluids often in enormous numbers. These were the first to come under the notice of the physician and still the most important from a diagnostic standpoint. The great confusion that ruled by virtue of the thoroughgoing similarity of these forms to each other has been eliminated by the precise studies of Fülleborn (1913) from whose work the main details of this account are taken.

The forms which are met frequently in the human host are the following common and relatively well-known species:

Embryo.	Adult.
Microfilaria nocturna.	Filaria bancrofti.
Microfilaria diurna.	Filaria loa.
Microfilaria demarquayi.	Filaria demarquayi.
Microfilaria perstans.	Ancanthocheilonema perstans.

Less frequent, or confined to certain tissues of the body or limited geographic areas, or as yet relatively unknown forms are these:

Embryo.	Adult.
Microfilaria volvulus.	Onchocerca volvulus.
Microfilaria philippinensis.	unknown.
Microfilaria powelli.	unknown.

The larva of the Guinea worm is not properly designated as *Microfilaria*, being a free-living form of a very different type.

Because of their clinical importance a brief account of the methods of study and of means of differentiation is given here. Microfilariæ are obtained by centrifuging blood, after which they are found in the blood serum. If blood is mixed with five per cent. formalin, they are preserved, or by the further addition of glacial acetic and gentian violet, they are stained at the same time. The microfilariæ are usually examined in blood smears; but the thin smear advocated for malaria

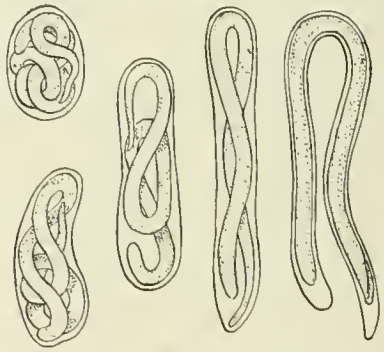

Fig. 4085.—Development of *Microfilaria nocturna*. (Looss, 1914.)

studies is less desirable than a thick mass dried rapidly to avoid shrinkage. The hemoglobin should be extracted by distilled water and the preparation fixed by five minutes' immersion in absolute alcohol. Manson recommends the study of moist preparations in which the worms move but slowly. Dark field illumination is highly commended. In order to avoid any shrinkage Looss urges that the preparations be fixed moist by letting the cover-glass smeared with fresh blood fall on alcohol at 60 to 70° C. Fixed preparations can be stained well in many ways; Fülleborn recommends

the Romanowsky-Giemsa method, and Rodenwaldt azure II. For most accurate work *intra vitam* staining is necessary.

These microfilariæ are very long and slender, not surpassing 500μ in length and 5 to 6μ in thickness, while many are only half as large. The structure is very simple but in many respects difficult to interpret. Of primary importance is the so-called sheath, present in certain forms and absent in others. It is in fact as the ovarian development of *Filaria bancrofti* distinctly shows (Fig. 4085) only the greatly expanded vitelline membrane and not the cast embryonic cuticula. The sheath is present in *M. nocturna* and *M. diurna*, and absent in *M. perstans* and *M. demarquayi*, to mention only the best known species (Fig. 4086). Within the sheath the embryo maintains an active movement but without altering greatly its position. One can distinguish readily the highly refractive cuticula of the embryo as a clear membrane sometimes finely striated and within it hardly more than a mass of nuclei. These have been interpreted as the primordia of various organs. The somewhat irregular distribution of these nuclei produces the "areas" or "spots" used by different authors in differential diagnosis. Among the most prominent of these, enumerated in order from the head posteriad, are (1) the nerve ring which may be recognized as an obliquely transverse gap in the column of nuclei; (2) the so-called excretory cell and excretory pore in the form of a small vesicle and accompanying cell (Manson's "V" spot); (3) the genital rudiment often the most conspicuous though variable in size and in the number of nuclei which can be recognized in a group or chain near it; and finally (4) the anal vesicle (Manson's tail spot, erroneously called a genital pore by Rodenwaldt) from which some think they have detected a connection with the exterior, the anus proper that in the opinion of others is not yet formed at this stage. The relative position of these regions serves to distinguish the various species definitely from each other. The location of all has not been fully marked out in all species reported but in the four conspicuous human parasites they bear the relations to each other indicated in the appended table where the figures represent average percentages based on the total length of the embryo measured. The data are taken from Fülleborn.

Embryos	Sheath.	Nerve ring.	Excretory pore.	Excretory cell.	Genital cell.	Anal pore.	Last caudal cell.	Actual length in μ.
M. nocturna	+	19 6	29..6	30..6	70..6	82..4	95..1	162–291
diurna	+	21..6	31..6	36..6	68 6	81..9	At end	152–246
volvulus	0	24 2	*	....	69 5	†	95 6	297..5
perstans	0	21..4	....	38..5	*	79 1	At end	198..9

All measurements except the last column are percentages of total length. * Not conspicuous. † About like the first two.

The rounded anterior end of the larva differs in different species, although reports on this feature are by no means in perfect agreement. Peculiarities in the more tapering caudal end are also emphasized as "short and sharp pointed" (*M. nocturna*, 2, Fig. 4086), or "long, bluntly rounded" (*M. diurna*, 3, Fig. 4086). The nuclei are also different here, extending to the very tip in *M. diurna*, and leaving a vacant space in *M. nocturna*. In general also one can detect a difference in the attitude of these embryos in blood smears; *Microfilaria nocturna* lies in elegant curves like a metal shaving, whereas *M. diurna* assumes an angular form. How these features are modified by shrinking which is usually more or less noticeable, can be determined from the figure where normal and shrunken specimens are represented side by side.

In 1879 Manson described the periodicity of these embryos, indicating thereby the characteristic variation in their presence in the peripheral circulating blood. He found first that one type, *M. nocturna*, appeared in blood during the late afternoon, reached a maximum about midnight and vanished by 8 or 9 A.M. Somewhat later he was able to show that another species, *M. diurna* had precisely the opposite habit since it is seen first at 9 A.M. reaches its maximum at 1 or 2 P.M. and disappears by 10 P.M. These periods are subject to certain individual variations, and may be modified by changes in the daily routine of the host, but the periodic swing is substantially constant. There are, however, certain species in which no such periodicity is manifested, *e.g. M. perstans* and *M. demarquayi*. On the other hand, certain so-called "varieties" of *M. nocturna* have been described that do not manifest any periodicity whatever. Until the specific identity of the form has been demonstrated, one is certainly justified in retaining a separate name on the basis of so radical a

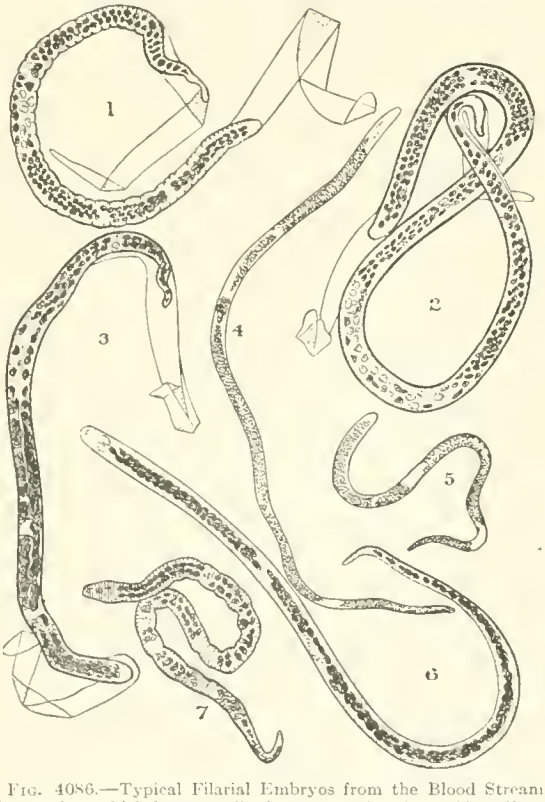

FIG. 4086.—Typical Filarial Embryos from the Blood Stream. (Drawn from thick hematoxylin dry preparations.) 1, *Microfilaria nocturna* (shrunken); 2, *M. nocturna*; 3, *M. diurna*; 4, *M. perstans*; 5, *M. perstans* (shrunken); 6, *M. demarquayi*; 7, *M. demarquayi* (shrunken). × 500. (After Fülleborn.)

difference in habit even though the microfilariæ have not yet been distinguished on morphological grounds.

The cause of the periodicity is unknown. Manson found that if the host modified his habits so as to make daytime the period of sleep and night that of work, then *M. nocturna* altered its periodicity correspondingly and changed again with any further change on the part of the host. But in *M. diurna*, Manson was unable to secure corresponding results by experimentation.

Manson considered the filarial periodicity as an adaptation of the habits of the embryo to those of the mosquito which as the intermediate host is indispensable to the existence of the parasite. Von Linstow suggested that as the tonus of the capillaries is reduced during sleep, the embryos which are too large to enter them during the day, find the way open at night because of the increase in the caliber of the vessels. According to Rodenwaldt external influences, such as light, darkness, air pressure, mealtime, tem-

perature variations, etc., have no effect and the differences in blood pressure during working and sleeping hours are determinative. This may accord with Manson's experiment in changing the periodicity by alternating the time of work and sleep; but the evident difficulties in this theory have not yet been fully cleared up. Scheube was able to show that the periodicity must have apparently a purely mechanical, external cause and according to Looss this is closely associated with the adhesiveness of the embryonic sheath. During the period when they are absent from the dermal circulation these embryos accumulate in the lungs. The microfilariæ live months, perhaps years in the circulating blood. Various experimenters have kept them three years in a dog, and in that time they have grown to double normal size. An increase in size during the stay in human blood has also been observed. They have been kept living even to six or seven weeks in cultures but all experiments have failed to transfer them successfully to other than the normal host.

The transfer is provided for in the normal life cycle by a blood-sucking insect, a mosquito or a biting fly. Taken into the stomach of such an host with the meal of blood the embryos soon desert the sheath if provided with one, bore through the stomach wall, and seek a new location. In most species it is the thoracic muscles by way of the body cavity, but in a few cases the Malpighian vessels are the goal of the migration. Once that the new location is reached the young worm undergoes a radical change in shape, becoming very much shorter and thicker ("sausage shaped," Looss) and entering upon an inactive stage. This change is the natural transition from embryo to larva although the terms are used very loosely and even in a contradictory fashion by different observers. The period of growth is followed by a second active migration when the larva, now much larger and better developed, deserts its resting place and wanders again into the body cavity. At this time it is surrounded by a cast skin like a sheath. Most of the larvæ migrate into the labium but a few go astray and are marooned in other organs. When the mosquito is biting the labium is turned back against the outer surface of the skin attacked and then these larvæ bore their way out and into the new host. This transfer is accordingly an active migration and not a passive inoculation. The further life history is probably merely growth to sexual maturity in the new host. The varying length of the larval and of the later life history in different species as well as other individual features will be considered under the separate headings.

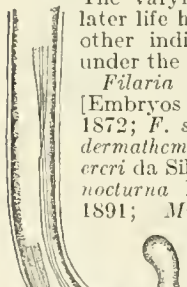

Fig. 4087.—Tail of Male *Filaria bancrofti*. Magnified. (After von Linstow.)

Filaria bancrofti Cobbold 1877.—(Syn.: [Embryos in blood] *F. sanguinis hominis* Lewis 1872; *F. sang.-hom. aegypt.* Sonsino 1874; *F. dermathemica* Da Silva Araujo 1875; *F. wuchereri* da Silva Lima 1877; *F. sanguinis hominis nocturna* Manson 1891; *F. nocturna* Manson 1891; *Microfilaria nocturna* Shipley and Fearnsides 1906.) Body elongated, white, or when preserved, brown like a horsehair, opaque, very delicate, showing tendency to coil; cuticula without transverse striation, anterior end slightly thickened, without lips or papillæ (Leiper finds two rows of oral papillæ) posterior end rounded. Male, 35 to 40 millimeters long; 0.1 to 0.12 millimeter broad, head 51μ, neck 43μ, in diameter; esophagus 0.13 millimeter long, posterior region coiled like a corkscrew, tip of tail (Fig. 4087) slightly bent, 1 millimeter long; three small postanal papillæ, and some preanal (eight perianal papillæ—Leiper); spicula 0.2 and 0.6 millimeter long. Female, 75 to 95 millimeters long, 0.21 to 0.28 millimeter broad, head 68μ, neck 51μ in diameter, vulva 0.72 to 1.27 millimeters from head, anus 0.282 from tail. Eggs 25 to 28μ or 35 (Lothrop and Pratt) by 15μ. Embryos 0.127 to 0.2 millimeter (or 0.2 to 0.33 millimeter) long by 8 to 10 (7 to 11)μ broad, with unstriated cuticula, but enveloped in a delicate sheath (Fig. 4088, *B*).

Although the embryos were first reported as early as 1863 by Demarquay, and the adults in 1876 by Bancroft, both have been very generally confused with other species of the group, especially *F. magalhæsi* for the adult stage and others for the embryos. Thanks to the careful researches of Fülleborn and others the embryos are now well known but even now only little can be given concerning the adult worms beyond the data contained in the general characteristics which are taken from Maitland and Manson's

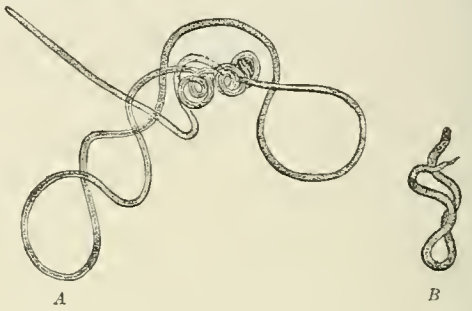

Fig. 4088.—*Filaria bancrofti*. *A*, Adult male × 7.5. *B*, Embryo from hydrocele fluid × 200. (After Lotbrop and Pratt.)

account, and from that of Lothrop and Pratt. The discrepant measurements given by different authors are due, in part at least, to the fact that different species were under consideration. Even yet there may be several closely related species only slightly different in structure and of similar habits included under the same name. More careful study of adults from various regions is necessary to clear up the confusion now existing.

The male (Fig. 4088, *A*) is much shorter than the female and the posterior end exhibits a strong tendency to twist like a tendril. Both sexes manifest a proclivity to curl into a knot, and various observers note the difficulty of disentangling the individual worms from such a mass. In the female the thick-walled vagina extends posteriad a short distance from its external orifice, and splits into two thin-walled uterine tubes, which occupy the entire cavity of the body, forcing the intestine against the muscular wall at one side. These tubes are filled with ova containing embryos in all stages of development. The smaller embryos are coiled within a thin struc-

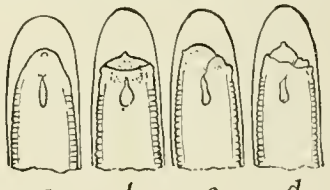

Fig. 4089.—Head of *Microfilaria nocturna*. (After Looss, 1914.)

tureless chorion which as already explained stretches to become the sheath. Preserved specimens may assume a brownish tint, owing to a change in the color of the uterine walls.

The embryonic filariæ in freshly drawn blood or in hydrocele fluid are rounded at the anterior end and pointed at the posterior. Though in constant motion, twisting and coiling, they never (?) exhibit a true progressive movement. They are covered by a delicate sheath, which is indistinguishable normally except as a flagellum following the tail at some distance, 0.3 to 0.4 millimeter (Fig. 4086);

rarely, when the movement of the body is reversed, this disappears from the tail and becomes evident at the head. The collapsed sheath in such specimens as have undergone endosmotic changes may appear like a distended sac enveloping the entire worm; such an appearance though frequently figured, is entirely unnatural. Attached to the tip of the head is a minute spine, which at times is protruded in rapid succession with a peculiar "pouting" movement (Fig. 4089). The further structure and differential diagnosis of this embryo are discussed elsewhere (p. 682, *et seq*).

Life History.—The female is viviparous, and the embryos, which are produced in enormous numbers, are evacuated into the lymph stream and ultimately pass from it into the blood current, where they are often found in extraordinary abundance. They measure 0.2 to 0.33 millimeter by 7 to 11μ (Lothrop and Pratt 0.26 to 0.3 millimeter by 6 to 8μ). Twelve hours after being taken into the stomach of a mosquito one finds side by side free embryos and empty sheaths. By the next day the embryos have traversed the wall of the stomach and are in the thoracic muscle (Fig. 4090). They become very much shorter and stouter with a short spine at the caudal end. At the end of eleven days they are 20 to 25μ broad and more than 580μ long. At seventeen to eighteen days they begin to leave the muscles and migrate into connective tissue in front of the prothorax. These larvæ are very active and having moulted lie in the old skin as within another embryonic sheath. At this time they have attained a length of 0.9 to 1.6 millimeters and have reached the stage for another transfer. These larvæ show an alimentary canal with esophagus well differentiated and a rudiment of the reproductive apparatus (Fig. 4090). While some remain in muscles even up to the fiftieth day, the most are gone. By even the twentieth day larvæ have penetrated the

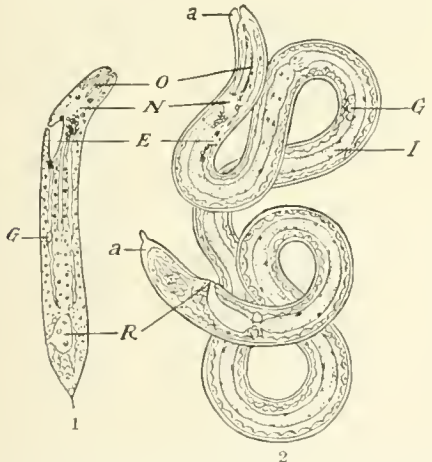

Fig. 4090.—Developmental Stages of *Filaria bancrofti* in *Culex fatigans*. 1, Young form from muscles; 2, nearly ripe stage from lacunæ of thorax. *a*, loosened larval skin; *O*, esophagus; *N*, nervous system; *E*, excretory system; *G*, genital anlage; *I*, intestine; *R*, rectal anlage. (After Looss, 1914.)

head and proboscis in sections of which they appear crowded into the cavity headed toward the point (Fig. 4091). Like the malarial organism they are inoculated directly. The last stage of development occurs in the skin; they become adult and copulate there; thus the variable position of lesions of elephantiasis are explained. In anopheles, James finds that the transformation requires only from twelve to fourteen days, and the activity of the embryos does not cease. According to the same author the broad inactive form measures 71 to 53μ long and the slender active form 151 to 132μ long and 2.6μ broad; in this latter stage the esophagus is two-fifths and the tail one-third of the entire length.

Bancroft and Manson suggested almost simultaneously that the mosquito might serve as a carrier of the embryonic filariæ in the blood. Manson, however, first observed the changes which these embryos undergo in the mosquito. He allowed the mosquitos to suck the blood of a filarial subject and found at first that the embryos are within a delicate sheath or membrane, apparently almost structureless; later, there becomes evident a marked transverse striation, and the sheath is ruptured by the worm forcing its cephalic end against it. Once free from the sheath, the embryo bores through the stomach wall of the insect and wanders into the thoracic muscles. The embryos which emigrate to the thoracic cavity do so as soon as they are withdrawn from the human host; those found some hours later in the mosquito's stomach are such as by immaturity or injury are not destined to metamorphose and changes in such are retrogressive.

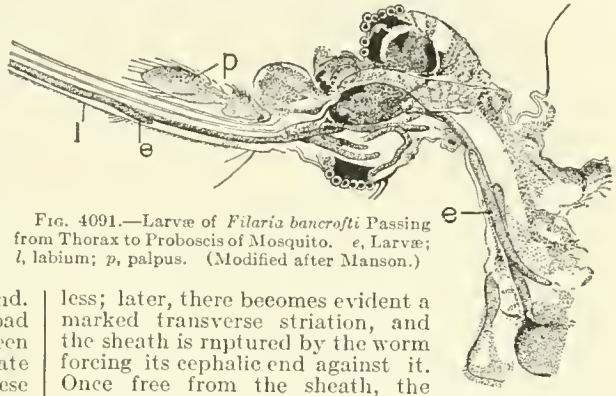

Fig. 4091.—Larvæ of *Filaria bancrofti* Passing from Thorax to Proboscis of Mosquito. *e*, Larvæ; *l*, labium; *p*, palpus. (Modified after Manson.)

The infection takes place when the mosquito containing the fully developed embryos is sucking blood, and Bancroft has proved the migration of such embryos from the thoracic muscles into the labium, from which he believes they escape at a definite point at the tip to penetrate the body of the new host. Grassi believes that the larvæ escape from the bent labium in the act of biting.

In the transmission of embryos certain species of mosquito only are culpable; among such are *Culex fatigans* in Australia, Trinidad, and Egypt; *Anopheles rossi* and *sinensis* in India, probably also *Anopheles costalis* in West Africa; this genus James regards as the proper intermediate host since in it the development is more rapid; *Stegomyia calopus* in British Central Africa and *S. pseudoscutellaris* in Fiji; certainly some other species may also function as intermediate hosts. In case the embryos are taken up by any unsuitable species of mosquito they are digested in the stomach; or if a few individuals succeed in wandering out, they are absorbed in the muscles.

Distribution.—Tropical Asia, Africa, America, and Australia are all infected. In Samoa and some other South Pacific Islands this parasite is particularly abundant, as much as eighty to ninety per cent. of the population being infected.

The supposed mention of this parasite in the United States by Salisbury in 1868, who found the ova in the urine refers really to the pin-worm. Some years later (1886) Guiteras called attention to the presence of the embryos in the South, reporting four cases from Key West and one from Charleston, S. C. Only a little later De Saussure published a clinical history of twenty-two cases, also from Charleston. Since then many cases have been reported in the Gulf and South Atlantic States, many of which have been undoubtedly imported, but indigenous cases are not wanting, and one concerns a woman who had always lived in Pennsylvania. The last account by Lothrop and Pratt gives a most extensive and valuable study of two cases in Boston

imported from the Barbadoes, and includes important new data on the characteristics of the adult worms.

Pathology.—The adult worm was first found in 1876, by the elder Bancroft, in a lymphatic abscess of the arm and subsequently in a hydrocele. The two sexes are found coiled together, and probably live for some time. Since then this discovery has been abundantly confirmed. Manson has shown that the species normally occurs in the lymphatic vessels, and that the embryos, as well as rarely also the adults, gain the circulation by way of the thoracic duct. The embryonic blood filariæ were first observed by Demarquay of Paris, in a man from Havana, who was suffering from chylocele. The name *F. sanguinis hominis*, first used for these embryos by Lewis in India, has been applied to several different embryos, which Manson has rightly distinguished by appropriate names since they belong to different species. Such embryos have been reported from urine, tears (?), and secretion of the Meibomian glands as well as from the blood, in cases of chyluria and elephantiasis, and also in apparently healthy individuals. In the Barbados nearly thirteen per cent. of the persons examined were infected, and yet two-thirds of the infected cases manifested no external sign of the disease.

The presence of embryos in the blood is evidence of the parasitism of the adult in some part of the lymph system. The duration of life of both adult and larvæ is entirely unknown; for the former, however, it is certainly several years. So far as known the embryos do not bring about pathological changes, though leucocytosis with an increase of eosinophiles is noted in early stages, to disappear later. According to one view the adults occlude large lymphatics and produce lymph stasis with resulting dilatation of the lymphatics. It seems more plausible to attribute the effects here as has been done elsewhere to the elimination of toxic materials by the parasites which evoke inflammatory changes, thickening of vascular walls, and circulatory disturbances. The clinical manifestations depend upon lymphatic obstructions which give rise to both general and local symptoms; the latter vary widely according to the part involved and to possible modification by infective processes. According to Manson, to whom above all others we are indebted for knowledge of filariasis, the results of *F. bancrofti* are found in lymphangitis, varicose inguinal and axillary glands, lymph scrotum, orchitis, chyluria, and various forms of elephantiasis (*q.v.*). Other investigators agree so far as the simpler types are concerned, but question strongly the case of elephantiasis. They point out its frequence in localities where *F. bancrofti* is unknown, and the failure of the two to agree in lands where both are found. Such hold to a bacterial infection often concurrent with filiariasis as the true cause. The discussion is still open; certainly the effects of filariasis favor the origin of elephantiasis, but it is equally clear that the relation is not an exclusive one.

An estimate has been made of from forty to fifty millions of embryos in the blood of a single man, and yet the individual suffered no apparent effect. It must be said, however, that the results of the parasite are brought about gradually.

Prevention.—The protection of drinking-water from contamination by mosquitos is strongly to be advised and the case of the Friendly Islands is cited as evidence of the value of this measure. These forty per cent. of the males are affected by filariæ, but the chiefs who have closed water-tanks rarely acquire the disease; it is evident that the chiefs are also least subject to mosquito bites. The protection of drinking-water and the destruction of useless pools will certainly reduce the number of mosquitos, and consequently the extent of the disease. Rational prophylaxis is evidently identical with that adopted against malaria.

It must be noted that the presence of an infected individual is a distinct menace to the health of a community since the widespread distribution of mosquitos like *Culex fatigans* capable of acting as the intermediate host insures the possibility and under some circumstances the certainty of wide transmission of the disease. There is little doubt that the cases recorded from the southern United States are primarily traceable to such introduction from the West Indies. The same explanation lies near at hand for those occasional cases which have been recorded in various localities both here and abroad.

Filaria loa Guyot 1778.—(Syn.: [Adult] *F. oculi* Gerv. et v. Ben. 1859 (nec v. Nordm. 1852); *Dracunculus oculi* Diesing 1860; *Dr. loa* Cobbold 1864; *F. loa* Stiles 1907 + [Embryo] — *F. sanguinis hominis* var. *major* Manson 1891; *F. diurna* Manson 1891; *F. bourgi* Brumpt 1903; *Microfilaria diurna* auct.) Male, 25 to 33 millimeters long, 0.3 to 0.45 millimeter thick. Cuticula not striated but, except on first and last fifth of body, covered with small bosses. Head conical, truncated; with six small papillæ each side near the base of the conical portion. Tail (Fig. 4092) tapering, rounded, slightly curved ventrad; three rounded stalked preanal papillæ and two smaller postanal on each side. Spicules two, unequal, 0.11 and 0.18 millimeter long.

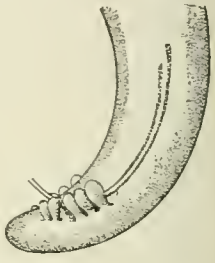

Fig. 4092.—Tail of Male *Filaria loa* with Spicules and Papillæ. (Author's specimen.)

Females, 50 to 65 millimeters long, 0.5 millimeter broad. Cuticula covered with minute bosses, irregularly distributed but extending to anterior tip (Fig. 4093) and though infrequent also nearly to posterior end. Anterior end conical, posterior end straight, tapering, rounded. Vulva 2 millimeters from anterior end. Eggs in uterus 30 to 35 by 20 to 25μ; embryos 250μ long, 5 to 6μ broad. For diagnostic differences (see table p. 683).

This parasite was first recorded in 1770 and the interpretation given an old print of 1598 that it represented an operation for the removal of a loa is certainly erroneous. For many years it was regarded as a very rare parasite; in 1905 Ward published a complete analysis of about 100 cases, all recorded up to that date. Since then many more have been recorded and the life cycle has been elucidated. Early authors considered it identical with the Guinea worm, but its non-striated embossed surface differentiate it at once on careful examination from the smooth striated cuticula of *Dracunculus medinensis*, even if the difference in size is passed over because the loa is interpreted as an immature form. The embryos are much alike but can be differentiated by careful examination (see table and Fig. 4086).

The embryos are found in the circulating blood and in serous fluids although they are absent at times when adult worms are found in the connective tissues. The simplest explanation of the latter case is that females if present and mature are not impregnated. Certainly the location of adults in the connective tissue and their migratory habits would readily explain the very variable period of the life cycle in different cases by the element of chance involved in fecundation, where only a few parasites are present in one host.

The embryos manifest a marked periodicity that is just the reverse of that shown by *Microfilaria bancrofti* and led Manson to give this form the name *M. diurna*. They are present during the hours of daylight and entirely or relatively wanting in the blood at night. A pure periodicity is not common being modified by the intensity of the infection, irregular habits or disease of the host, and to some extent under

apparently normal conditions. Of course, a mixed infection apparently eliminates the periodicity and careful microdiagnosis is necessary to identify the two species and to fix their relative frequence at various hours of the day. The location of the excretory cell, removed from the excretory pore, the size of the genital rudiment, and the extension of the nuclei into the extreme caudal tip, are features of the loa embryos that separate them from those of *F. bancrofti* which in size they resemble so closely.

The periodicity of these embryos led Manson to suspect as intermediate host some species of blood-sucking insect that plagued man during the day, such as the Mangrove flies. Leiper established the fact tracing the development of the larvæ in the salivary glands of various species of *Chrysops*. Experiments tried on *Stomoxys*, as well as on mosquitos, fleas, and ticks were negative. The growth of these larvæ is slow after they have been reintroduced into the human host. It is variously estimated that three or four years or more are required to reach the adult condition. Longer and shorter periods seem to agree with the relative abundance of the parasite and hence chance of fecundation.

Life History.—*Filaria loa* was regarded for many years as an eye parasite since all of the cases up to 1905 recorded its presence in or near that organ. Then Penel at an autopsy in Paris found it generally distributed through the subcutaneous connective

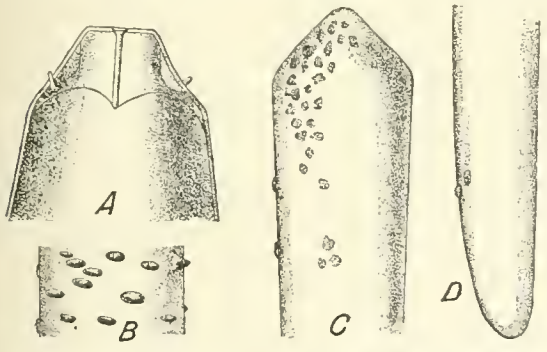

Fig. 4093.—*Filaria loa*. *A*, head of male; *B*, midbody of male with cuticular bosses; *C*, head of female with bosses; *D*, posterior end of female with two bosses. Magnified. (After Blanchard.)

tissue and in contrast with the one or a few specimens taken from a single host previously, collected thirty-four individuals from the one. This discovery has been amply verified since then and the life history established in its main features. Introduced by some insect bite the larvæ grow to maturity in the connective tissue, wandering freely from point to point through the loose subdermal layer. This brings them at times into the region of the eye where they are seen and removed. Such an occurrence is, however, purely incidental to the migratory period of the life cycle. Having attained sexual maturity the female is fecundated, settles down at some point in the connective tissue or lymph glands and produces a myriad of embryos that are deposited in the tissue or in serous cavities and ultimately reach the blood stream. The identity of *Microfilaria diurna*, described by Manson from the blood and conjectured to be the embryo of *F. loa*, has been fully established, by the admirable work of Fülleborn and others. These circulating embryos are acquired by biting mangrove flies (*Chrysops*) and develop in them to the infecting larval stage. The life history has thus no relation whatever to the water supply and the former generally accepted view that drinking-water was in some way responsible has been finally and totally rejected.

Distribution.—The loa is endemic in tropical western Africa from Angola to the Gold Coast and irregularly into the interior. It was carried to the western hemisphere by the slave trade and the first record of its occurrence came from the West Indies by Mongin who in 1770 found it in a slave recently imported. Though frequently introduced in this way into the tropical zone of both Americas including the islands, it never established itself at any point so far as known. A series of recent cases in North America reported by Ward concerns missionaries and travelers who had visited the region where the loa is endemic. The parasite was often carried to Europe in the same way without gaining a footing. In its endemic area the loa is very common and infests natives and Europeans indifferently.

Pathology.—The parasite was formerly thought to occur in the eye whereas in fact it only appeared at times in the connective tissue surrounding the eyeball. Its presence became conspicuous when it crossed the cornea in the subdermal layer between the conjunctiva and the bulbus oculi. In some cases, however, it was detected in the eyelid or was even seen to cross the bridge of the nose from one eye socket to the other. It would often disappear suddenly and then reappear after days, weeks, months, or even years. All these phenomena described in great detail in the earlier records and summarized by Ward (1905) are merely incidental as is now known to its general migrations through the connective tissue of the host. Relatively few worms ever reached the eyeball. Those which did differed greatly in size and maturity, thus furnishing in fact evidence of the casual character of this appearance at any time during the growth and wanderings of the parasite. The presence of a loa in the eye was accompanied by slight itching or transient pain which attracted attention to it and led to efforts for its removal. The rapidity of its movements is abundant proof of its natural migratory habits.

Generally speaking the presence of the loa in other parts of the body is unperceived, but there are periodic appearances that are now definitely referred to the parasite. These are the so-called Calabar swellings, recently well-named Loa-edema by Looss; they are localized dermal swellings frequent in hosts of this parasite. They occur both in whites and in negroes, in tropical and in other countries, and are probably related to temperature as was suggested by Robertson who first observed them in Scotland. They appear suddenly as colorless, painless tumefactions as large as the end of the thumb on any part of the body and move or disappear gradually. The association of these swellings with the approach of a loa to the surface is clearly shown by many observations; their precise cause is less certain. It may be due to the undue stimulation of certain nerve cells, to the discharge of embryos or of waste matter into the host tissue, or to the rubbing consequent upon the slight irritation induced by the movements of the worm. They are said to be most abundant in children. Generally the presence of the parasite is of little significance to its host, but in exceptional cases it may evoke dangerous swellings on esophagus, larynx, or urethra. Manson sees therein an explanation of the numerous cases of sudden death in West Africa. Külz regards the loa as the cause of tropical muscle abscesses.

Treatment.—Only in the eye cases is it possible to relieve the trouble by removing the parasite. The negroes drive it from the eye by dropping a grain of salt into the conjunctival sac or by extracting the worm with a thorn. Deftness in operating is necessary, and if after cocainizing the eye the worm be grasped with a pair of forceps, a cut in conjunctiva or lid gives an opening through which it usually starts to escape, or may be withdrawn by a second forceps.

Filaria demarquayi Manson 1897.—(Syn.: *F. ozzardi* Manson 1897; *F. juncea* Railliet 1908.) Male

known only from a fragment of the posterior end which is tightly coiled and has two spicules. It is 0.2 millimeter thick, tapers gradually and is rounded at the end. Female 60 to 80 millimeters long, 0.21 to 0.25 millimeter thick. Mouth terminal with small papillæ; anus 0.25 millimeter, vulva 0.75 millimeter from tip of body. Embryos without sheath, tail pointed without nuclei; 0.2 millimeter long, 0.005 millimeter thick (see table p. 683).

Manson found these embryos in 1895 in the blood of apparently healthy natives of St. Vincent. Later in 1897 Ozzard sent him blood smears from Carib Indians of British Guiana in which he detected two types, pointed and stumpy-tailed larvæ, which he described together as *Filaria ozzardi*. The stumpy-tailed variety was recognized later as *Microfilaria perstans* and the other type clearly agrees with *Microfilaria demarquayi*. The adult females were taken in 1899 by Galgey in St. Lucia and agree well with others obtained by Daniels in British Guiana. The females occur in the mesentery, omentum, and subperitoneal connective tissue and are present in about fifty per cent. of cases examined. Neither they nor the corresponding microfilaria appear to affect the health of the host.

Experimentally the embryos have been carried up to the cylindrical "sausage-shaped" stage in the thoracic muscles of both stegomyia and anopheles, so that the mosquito may properly be regarded as the intermediate host and inoculating agent of this species. Low has surmised that some tick may serve as vector since development is not complete in the experimental mosquitos.

The species occurred in the islands of the West Indies; St. Vincent, St. Lucia, Trinidad, St. Domingo, and in British Guiana where it overlaps the territory of *Acanthocheilonema perstans*. Although confused at first, both adults and embryos are distinguishable from that species in size and structure as indicated in the descriptions and tables given here.

Acanthocheilonema perstans Railliet, Henry et Langeron 1912.—(Syn.: *Filaria perstans* Manson 1891; *F. sanguinis hominis minor* Manson 1891; *F. ozzardi* var. *truncata* Manson 1897.) Body cylindrical, smooth, neither rings nor papillæ on surface; behind the rounded head a cervical construction. Male, 40 to 45 millimeters long, 0.06 to 0.08 millimeter thick. Tail coiled; anus 0.09 millimeter from tip. Two unequal spicules. Four pairs of preanal and one pair of postanal papillæ; all very small and obscure. Female, 70 to 80 millimeters long, 0.12 millimeter thick. Vulva 0.6 millimeter from cephalic tip. Posterior end bent with anus 0.14 millimeter from tip. Embryos in blood stream without sheath, with obtusely truncated tail and nuclei to the end. Extremely active and very changeable in form. Length 100 to 300μ (average 200μ; Manson), breadth 4 to 7μ. Manson found a minute spine at the apex of the head the existence of which has been denied by other observers.

Discovered in the embryonic stage by Manson in the blood of Congo negroes, the microfilaria was readily recognized as a new type. It was distinguished by its small size and by the absence of any periodicity in its appearance in the surface capillaries. Manson later found the same embryos in blood smears from British Guiana; Manson and later Brumpt repeated the discovery in the Congo.

For years the species was regarded as of little or no pathological significance, but recently Marshall has attributed to it a rôle in the production of an edema, like the Calabar swellings, with abscesses and even pulmonary fever. The adults occur in fat and connective tissue near the ascending aorta, the pancreas, pericardium, mesentery, and suprarenals.

Early stages of the larvæ have been raised by Low and Fülleborn in experimental mosquitos but not up to the infecting stage. Wellman reported its growth in a tick (*Ornithodoros moubata*) in twenty-one to twenty-three days, but later experiments have failed to confirm this.

The species occurs commonly in central Africa especially in the Lake region, and in British Guiana; isolated cases are reported from northern Africa and (?) from Fiji. Its frequence ranges from thirty per cent. of natives examined in Kamerun and fifty per cent. in the Congo territory, to eighty-five per cent. in the regions where sleeping sickness is rampant. It seems to favor territory covered with undergrowth and characterized by high temperature and extreme moisture. Its presence in such a large percentage of the natives affected by sleeping sickness led Manson to suggest that it was the cause of that malady. Külz maintains still that severe infections in which the absence of trypanosomes were established, suggest sleeping sickness and terminate fatally.

The apparent agreement in geographic distribution between *Microfilaria perstans* and banana culture led Bastian to maintain that this was a soil nematode (*Tylenchus*) which lived at times in the banana plant and reached its human host with that food. This weird and utterly unsupported idea has been widely quoted.

Onchocerca volvulus Railliet et Henry 1910.—(Syn.: *Filaria volvulus*, Leuckart, 1893.) Milk-white, filiform worms. Cuticula thick, further strengthened by conspicuous external hoop-like thickenings. Male, 30 to 35 millimeters long, tapering strongly to both ends where it is about 40μ thick; at center 140 to 200μ thick. Mouth small, no papillæ. Tail coiled; anus 0.07 from tip. Three adanal papillæ, of which the middle one is the most conspicuous; also two on each side of the caudal tip. Spicules two, unequal, 0.17 to 0.20 and 0.07 to 0.08 millimeter long. Female, tightly coiled, about 40 to 70 centimeters long, and 0.33 centimeter thick in the center; tapering toward both ends. Vulva only 0.06 to 0.7 from anterior tip. Viviparous. Eggs oval, thin shelled, with short polar filaments, embryos, 270μ long, 5 to 6μ thick, tail sharply pointed, without sheath.

The adults occur in simple or multiple tumors from the size of a pea to a hen's egg. They are usually subcutaneous, rarely deep seated, located chiefly on the trunk, less frequently on the head and extremities. These tumors are not painful and appear often long after the host has left the infested territory. It is possible to determine the origin of the tumors from engorged lymph vessels. Male and female worms are found so intricately coiled together with the tissue that the large, old females have not yet been successfully extricated from the mass. Abscess formation is frequent. The embryos are discharged into the abscess but do not attain the blood stream according to the observations of most investigators, although their presence in lymph-filled spaces would seem to favor their appearance later in the circulation.

Probably these embryos undergo further development in some intermediate blood-sucking host and are transferred by it again to the human host. No evidence has been obtained as to these changes or the insect which serves as vector.

The parasite occurs within a narrow territory in tropical West Africa between Sierra Leone and the northerly tributaries of the Congo. Both the tumors and the parasite are recorded from Dahomey, Sierra Leone, and the Congo basin even as far as the great African la es. The worm was originally described from specimens sent Leuckart that were taken from Gold Coast negroes.

In French equatorial Africa, *Filaria bancrofti* is said to be wanting and it has been conjectured that there this species is responsible for elephantiasis. It has been found in inguinal lymph glands and those afflicted with elephantiasis are often carriers also of volvulus tumors. But the hypothesis is still far from having been firmly established.

Dirofilaria magalhaesi Railliet et Henry 1911.—(Syn.: *Filaria bancrofti* Magalhaes 1892, nec Cobbold 1877; *F. magalhaesi* R. Blanchard 1895.) Body slender, elastic, resistant; cuticula heavy, cross-striated. Male, 83 millimeters long, 0.407 millimeter broad; tail with double spiral, on each side four preanal and four large postanal, papillæ of mulberry form (Fig. 4094); smaller (?) spicule 0.23 millimeter long, longer unknown. Mouth terminal without lips; anus 0.11 millimeter from posterior end. Female, 155 millimeters long, 0.33 millimeter broad at head, 0.285 millimeter at neck, 0.7 millimeter in maximum; vulva 2.56 millimeters from cephalic extremity. Eggs 38 by 14μ; embryos 0.3 to 0.35 millimeter long and 6μ broad with transversely striated cuticula.

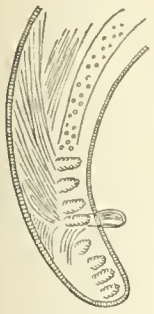

Fig. 4094.—Tail of *Male Filaria magalhaesi*. Magnified. (After von Linstow.)

Of this form Magalhaes discovered in Rio Janeiro two adults in the left cardiac ventricle of a boy at a necropsy. It was at first wrongly assigned to *F. bancrofti* from which it is easily distinguished by the above characteristics. It is now classed as a new genus with other like forms found in the blood system of dog, leopard, monkey, etc. Like all nematoda living in the heart the cuticula is tough to resist the powerful blood pressure, the body being like catgut, whereas *F. bancrofti* is delicate and easily torn. The proportions of embryos and adults also differ materially.

The life history is unknown and the presence of the embryos in the circulating blood during life was not established. The parasite is apparently only occasional in man and its discoverer made no statement of any symptoms of disease, or of any relation to the death of the host. While consequently the pathological significance of this species remains in doubt, one must not lose sight of the character of the closely related form from the heart of the dog.

This species, *Dirofilaria immitis*, which in fact was designated as the type of this genus, is a common parasite of the dog. It was originally discovered by Leidy in 1856 in the dog's heart and has been recorded since then from the same host in North and South America, eastern Asia, and western Europe. It was once erroneously reported as a human parasite but is now definitely stricken from the list. Both the adults and the embryos from the circulation are common objects for laboratory demonstration.

F. conjunctivæ Addario 1885.—(Syn.: *F. palpebralis* Pace 1867, nec. Wilson 1844; *F. peritonei hominis* Babesiu 1880; *F. inermis* Grassi 1887.) Female alone known. Length 10 to 18 centimeters; thickness 0.5 millimeter. Cuticula smooth, concentrically striated. Mouth terminal without lips or papillæ; anus close to rounder posterior end. Vulva near anterior end; uterus double, filled with eggs and embryos, the latter measuring 350μ long and 5.5μ broad.

A normal parasite of horse and ass, occasional only in man. In its usual hosts often confused with an associated species, *F. papillosa* Rud., and hence not well known. Life history unknown; according to Alessandri *Chrysops coccutiens* L. serves as intermediate host.

First found in conjunctival tumors by Dubini at Milan and later on the island of Sicily, it is now known to be present in Hungary and probably more widely in Europe, and to occur in other parts of the body as well as the eye. Very likely the species listed next is in part at least, the same form.

Filaria lentis Diesing 1851.—(Syn.: *Filaria oculi humani* von Nordmann 1832.) With the case of von Nordmann, in which immature nematode worms were found in the lens, have been associated various poorly known and often doubtful cases of later observers, in several of which it is probable that the object was a vestige of a vessel or filament and not a filaria. In three cases the parasite was in the lens, in three also in the vitreous humor, and in two in the aqueous humor. The most recent by Drake and Brockman, at Madras, has been assigned by Blanchard to *Filaria equina*, which is abundant in India. The character of other species is likely to remain permanently doubtful. Some of them are very likely young forms of the preceding species, *F. conjunctivæ*.

There is little doubt that cases which concern half-grown nematodes of moderate size in negro slaves coming from the Gold Coast are *F. loa* (*q.v.*), though queried by Braun. No evidence is available that the Guinea worm (*Dracunculus medinensis*) ever occurs in the eye.

Agamofilaria Stiles 1907. Collective group including agamic filarias, having attained the adult type but sexually immature and hence at present incapable of being more precisely classified.

Stiles would include here as *Agamofilaria oculi* (Siebold 1839) "*Filaria lentis*" which is the *Filaria oculi humani* of von Nordmann (1832) described above.

Several other species probably should be classified under this heading—at least until sufficient data have accumulated to enable one to form a satisfactory judgment as to their relationship to mature adults. Most of them are poorly described. The best known form from man is one found in the southern United States and described by Stiles as

Agamofilaria georgiana Stiles 1907.—Eighteen specimens of an immature filaria were taken from a sore on the leg of a negress at Darian, Georgia. They were 32 to 53 millimeters long and 0.56 to 0.64 millimeter broad. The mouth was terminal and surrounded by six papillæ, four prominent submedian and two smaller lateromedian (Fig. 4095). The cuticula is non-striated and the esophagus simple.

Nothing is known of the life history or mode of infection and no other case has yet been reported.

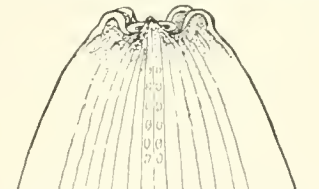

Fig. 4095.—*Agamofilaria georgiana*. (After Stiles, 1907.)

Microfilaria.—Collective group, including microscopic embryonic or early larval forms of characteristic filarial type found usually in the circulating blood or in serous fluids. First described from man, but occurring also in other hosts.

Many types of blood-inhabiting filarial embryos have been reported to which correspond no adults yet described. *F. diurna* thus recorded in the earlier edition of the Reference Handbook has been since shown positively to be the embryonic form of *F. loa*. This among other items refutes positively the contention of von Linstow that all these forms are merely varieties of one species. Some of them may indeed belong to species already named; but most are inadequately known and others are erroneously described. Further work is demanded before their designation can be made positive or their elimination justified.

Microfilaria philippinensis.—(Syn.: *Filaria philippinensis* Ashburn and Craig 1906.) Length 290 to 335μ, breadth 6 to 7μ. Sheath present, delicate, close fitting, visible only at ends as a fine thread in

living specimens; worm not seen to move to and fro within. In center of head small spine which is constantly exerted and retracted. Cuticula finely striated. Tail pointed, abruptly attenuated. Progressive motion common in fresh blood smears. Observed in blood of Visayan at Bilibid prison, Manila, and of four scouts, natives of Luzon, Philippine Islands.

It occurred in small but practically constant numbers in the blood at all hours of the day and night. No symptoms or pathologic lesions were observed that were clearly due to the parasite though one patient gave a history of chyluria. The development of the parasite was followed in *Culex fatigans*, Wied, up to its lodgment in the mosquito's labium ready to infect a new host. The mosquito secures at a meal forty to fifty times as many filariæ as occur in an equal volume of blood taken from a needle prick. Twenty-four hours after ingestion they have escaped from the sheath, pierced the stomach wall, and lie in the body cavity. By the third day they are in the thoracic muscles and there undergo radical changes in form and size. The twelfth day finds them in the labium ready for transfer. At this time they have a well-defined alimentary tract with esophagus, intestine, and anus; one sees also three postanal papillæ (*M. nocturna* has four such). The further development is unknown; the adult has not been discovered.

A microfilaria that exhibits no periodicity has also been observed on the Fiji, Tonga, and Samoan Islands. This is assigned by some authorities to *Filaria bancrofti*.

Fülleborn was unable to separate specimens of this type sent him from Manila from the well-known species. Furthermore, Phalen and Nichol report the typical *M. nocturna* from the Philippines. Yet one may not disregard the positive evidence of two skilled investigators concerning morphological as well as physiological features. There is nothing impossible in the presence of a new form side by side with the cosmopolitan *M. nocturna*. Further evidence is necessary before the case can be regarded as closed. More doubtful are the following types:

Microfilaria powelli Penel 1905.—The embryos were found at night in the blood of a native at Bombay and are provided with a sheath; this is probably only a small specimen of *Microfilaria bancrofti* as such have often been observed by others.

Microfilaria taniguchii Penel 1905.—Among smaller larvæ with a sheath that were certainly *M. nocturna* others reported from Japan were said to be large and without a sheath. The same author described differences in the adult which may reasonably be questioned; and pending further studies the entire report must be set aside.

At present it is impossible to place definitely the blood filaria reported by Cholodkowsky as present in the peasants of the province of Twer (Russia) and producing pustules on the fingers.

Among the so-called filariæ are some forms to which that name probably does not in right belong. These are too imperfectly described to justify an attempt to locate them more precisely, but in each case individual characters serve to eliminate them from the family of the filariidæ properly so called.

F. labialis Pane 1864.—Length 30 millimeters; pointed anteriorly; mouth with four papillæ, posterior end slightly inflated; vulva in posterior tenth; uterus double, but in posterior branch rudimentary.

A single specimen only from a pustule on the upper lip of a man in Naples, Italy. Not reported since 1864. The location of the vulva excludes this form unquestionably from the filariidæ.

F. lymphatica Treutler 1793.—(Syn.: *Hamularia lymph.* Treutler 1793; *Filaria hominis bronchialis* Rud. 1819; *F. hominis* Dies 1851; *F. lymph.* Moq.-Tandon 1860; *Strongylus bronchialis* Cobbold 1879.) Length about 26 millimeters; brownish spotted with white; transparent and pointed anteriorly; thickened and blunt posteriorly; two short spicules. First found in 1790 in the hypertrophied bronchial ganglia of a man of twenty-eight years of age; it has been reported since by Brera and by Zürn, who discovered another specimen at Geneva in 1879, under conditions like those of the first case. The view of Diesing and Weinland, that it was probably *Strongylus longevaginatus* (= *S. apri*), is improbable according to Railliet, who views it as a male of *F. conjunctivæ*. The view of Braun that it is *F. equina*, a common parasite of horse and ass in Europe, seems more probable.

It would be hazardous to maintain that the various accounts grouped together under this heading really concern only a single species; it is still more open to criticism to utilize the ancient name of Treutler as the designation of a subgenus of the older Filaria.

Filaria restiformis described by Leidy in 1880 is an immature nematode 66 millimeters long and 1.5 millimeters broad which was passed in the urine of a man in West Virginia, fifty years of age, who had suffered some days from hematuria. Stiles examined the original specimen and found it was an immature mermis and not a filaria. This makes it even more difficult to explain except as a fraud; the attending physician contended that the patient's statements were not open to question, and yet he was not present when the worm was extracted. Smith and Denney have recently described another case in a "poor white" of Wilmington, N. C., so closely like the first in all respects that they are justified in emphasizing the improbability of fraud. They acknowledge fully that reasonable speculation based on present knowledge of the mermithidæ which are typical insect parasites, can hardly explain the presence of such a worm in the human excretory system. These cases must await further observations for an adequate explanation.

Entirely different are certain larger forms that have no immediate relation to the blood-inhabiting embryos. These include two species worthy of note: *Filaria romonorum-orientalis* Sarcani 1888 is a species observed in the blood of a Roumanian woman. The parasite measured 1 millimeter long by 0.03 millimeter broad, and had an alimentary canal and well-developed sexual organs. The form described seems to have nothing in common with the filariidæ, and its correct interpretation is at least uncertain.

Filaria kilimaræ Kolb 1898 is a mess of half a dozen different forms or more collected in British East Africa from pools of water, feces of ape and hyena, flesh of fish and hippopotamus, liver of zebra and antelope, vomit of one negro and abdominal cavity of another. The name has at present absolutely no definite significance. Several species and probably also several genera are represented in the collection.

Even more undeserving the name is *Filaria gigas* Prout 1902, which probably represented plant or insect hairs or other débris by chance included in a blood smear. Similar errors are probably at the basis of the supposed filaria described by Rheindorf from spleen smears of a Berlin diabetic, and by Reichmann from the blood of a Jena laborer. The diagnosis of blood filariæ from a limited material is open to serious chances of error.

The "*Trichina cystica*" of Salisbury 1868, interpreted often as a filaria and classed in this genus is in all probability the common pin-worm (*Oxyuris vermicularis*).

When "eggs" have been assigned to "Filaria" by any writer evident doubt is thrown upon the observation. Normally a viviparous form does not produce such and in any event the thick-shelled ova attributed to filaria by some writers cannot possibly belong to this genus or family.

Dracunculus medinensis Linnaeus 1758.—(Syn.: *Gordius medinensis* L. 1758; *Filaria medinensis* Gmelin 1789; *F. dracunculus* Bremser 1819; *F.*

æthiopica Valenciennes 1856; *Dracunculus medinensis* Cobbold 1864.) Female, 30 to 100 centimeters long (ordinarily 60 to 90), 0.5 to 2 millimeters (commonly 1.5) broad; body uniform in diameter, white or yellowish brown; the anterior end smooth, rounded; mouth, small with two papillæ on cephalic shield which has near its margin six smaller papillæ; posterior end terminating in short spine curved ventrad. Alimentary canal atrophied in adult and with all other internal organs replaced by enormously developed uterus; vulva external to papillæ; vagina present (McConnel) or atrophied (most writers). Uterus filled with larval filariæ, 0.5 to 0.75 millimeter long and 15 to 25μ wide.

Male doubtfully observed, said to be much smaller than female, only 4 to 10 centimeters long, found fixed to the female by posterior extremity, about 14 centimeters from the anterior end of the latter. Probably this was in fact a female with prolapsed genitalia. An unripe male was bred experimentally; it measured 22 millimeters in length, and possessed five postanal papillæ. Undoubtedly, the male follows the female into the tissues and perishes there soon after copulation. The extreme growth of the female is consequent upon the enormous extension of the uterus laden with myriads of embryos.

Records of the "Guinea worm" as it is generally designated, go back far into antiquity. Probably this was the fiery serpent which plagued the children of Israel in their wanderings through the wilderness. The first positive reference to it is found in Plutarch who quotes a writer of the second century B.C. on its occurrence near the shore of the Red Sea. The writings of the Egyptians and those of classical times contain numerous references to it. The Arabian physicians knew it well, and Rufus of Ephesus not only gives a good description of the disease and its cause which he designates as a little snake, but recounts the commonly accepted opinion that "the Arabians suffer from it, and many strangers acquire the disease *if they drink the water*, for that is the chief cause."

The adult female is a common parasite of man; it occurs also in apes, monkeys, dog, jackal, leopard, horse, and cattle. It is found in superficial ulcers in the subdermal connective tissue. When the ulcer reaches the surface a minute orifice is formed which persists. Manson found that if cold water is dashed upon the skin near this area, the anterior end of the parasite is protruded like a white string 1 millimeter thick and 10 to 20 long and collapses exuding a drop of milky fluid. The worm then contracts within the ulcer and after an hour or two of rest can be made to repeat the process.

The milky exudation is a mass of active embryos at a much more advanced stage of development than those of other filariæ; each measures 0.5 to 0.75 millimeter long and 15 to 25μ wide. They have (Fig. 4084) a rounded anterior end, with a small three-lipped mouth, a large pointed tail, a striated cuticula, and near the center a small oval body which is the rudiment of the genital apparatus. The alimentary canal is complete; the esophagus measures one-fourth the length of the body. In a moist environment, either water or mud, these embryos live one to three weeks, swimming about actively at intervals, but undergoing no change and taking no food.

As Fedtschenko first proved they utilize small aquatic animals (*Cyclops*) for further development. Soon after the two are brought together they enter by the mouth and are found in the stomach of the cyclops while within forty-eight hours they have reached the body cavity (Fig. 4096). After a developmental period of four to six weeks they are ready for transfer. At that time they measure about 1 millimeter in length, have two lips and on the now truncated tail three small knob-like processes. When brought into 0.2 per cent. hydrochloric acid they become again actively motile and break through the body wall of the cyclops.

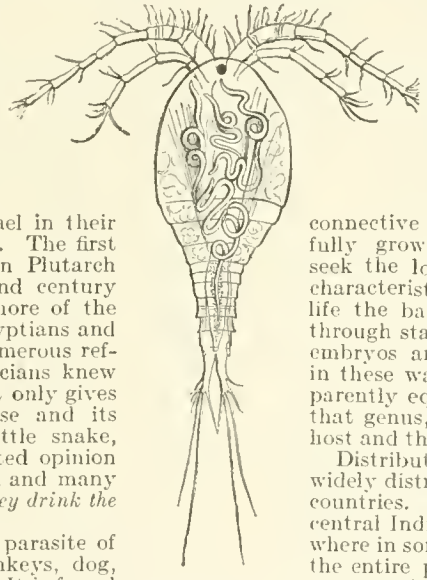

FIG. 4096.—Embryos of *Filaria medinensis* in body cavity of *Cyclops*. (After Fedtschenko.)

The early experiments on infection were unsuccessful since the cyclops employed contained too young, unripe larvæ; but Leiper succeeded in infecting a monkey with mature larvæ in cyclops. Six months after the experiment he found in the connective tissue three unimpregnated female worms 3 centimeters long and two males only 22 millimeters long. From other data one is led to infer that the entire life cycle covers probably a year, or a little more or less. Powell reports the unique case of a group of twenty-one persons who went from Bombay, for two days only, into an infected district and there were compelled to drink unfiltered water. In eight of them, adult worms appeared on the feet between 345 and 435 days thereafter.

These experiments make the life history reasonably clear in its main features. In the infected area surface water is everywhere utilized for drinking. These waters swarm with cyclops which therewith reach the human stomach and by gastric digestion the larvæ are set free to invade the connective tissue of the human host. When fully grown and impregnated the females seek the lower extremities and produce the characteristic sores. In the course of his daily life the barefooted native passes frequently through standing water and at that time the embryos are expelled. Cyclops is abundant in these waters and as the embryos are apparently equally well served by any species of that genus, they readily find an intermediate host and the life cycle is completed.

Distribution.—The Guinea worm is rather widely distributed in tropical and subtropical countries. Most abundant in southeastern and central India and on the west coast of Africa, where in some seasons from one-half to nearly the entire population is affected, it is found more or less from India westward through Persia, Turkestan, Arabia, many parts of tropical Africa, and in a limited area of Brazil, where its introduction may probably be attributed to the slave trade. In Curaçoa and Surinam, where it was formerly endemic, and where it was no doubt introduced with negroes, it has now entirely disappeared. Records of its occurrence in Europe and North America are mostly from natives of the infected area or visitors to it, and though frequently introduced it has never gained a footing in either place. Osler reports two cases from the United States.

Within these areas the parasite is often strikingly local being very abundant in places and rare or absent at other points. Seasonal variations in its frequence depend evidently upon the life history, but one finds also others related to the water supply rather than the season.

Pathology.—The adult female migrates through the subcutaneous connective tissue and comes to rest at some point likely to be freely exposed to water. It forms there a painful swelling much like a boil. These are formed on the lower extremities in eighty-five per cent. (or more) of all cases recorded. The foot and ankle are especially favored, but sores are recorded on the waist, arm, tongue, eyelid, scrotum, buttocks, and back. The latter is a common location in Indian

water-carriers, a unique adaptation to circumstances. As a rule, a single female is found in a sore, but as many as five or six boils are not uncommon on a single host. A St. Domingo negro described in 1770 by Poupée-Desportes harbored, at one time, fifty worms.

The sores which become very painful last two to three weeks and in the absence of complications heal spontaneously. Parts of the worm may be left in the host and become calcified there. It is a common error to suppose that the sore suppurates regularly. No such results follow the work of the worm itself and many times healing comes promptly and completely. But the conditions of existence in the tropics favor bacterial infection and among careless natives the suppuration may be excessive, even such as to produce gangrene and necessitate amputation of the part affected or, rarely, to cause death of the host. Among the native population the worm is ordinarily removed by what is known as the Soudanese method. The protruding tip of the female is grasped firmly between two bamboo splints on which it is gradually rolled up (Fig. 4097). Extreme care is exercised to avoid breaking the slender body since in case a portion of the worm is broken off and remains behind the pain is great and fatal gangrene often ensues. Consequently, the worm is coiled on the splints very slowly and the patient is represented as walking about with one or more coils hanging from the body stopping now and then to roll them a little tighter until the process is completed. This requires ten to twelve days.

Fig. 4097.—*Filaria medinensis*, Rolled on Split Stick. (After Fedtschenko.)

Missionary physicians in the infected territory find the removal of the worm by direct surgical interference a simple matter, not accompanied ordinarily by complications. Occasionally subsequent growth of fibrous tissue calls for further operative interference to remove it. The injection of a one per cent. solution of sublimate in the tissue near the worm when it first makes its appearance under the skin results in the death of the worm and its absorption. This method advocated by Emily appears to be much in vogue recently and to yield good results.

While the mortality from the disease is low, yet its importance is clearly recognized in infested areas. Often nearly every member of a village is incapacitated for work. Among companies of native laborers or soldiers it visits enough to interfere seriously with regular work and in the Indian army five per cent. are annually affected. More loss of time is due to this than to any other disease. Not infrequently it produces an arthritis that limits the later use of the joint.

Prevention.—The control of drinking-water affords a positive means for stamping out the disease in short order. But the practical difficulties involved in such control are by no means simple of solution. Rapidly running water (springs, brooks, etc.) does not shelter cyclops and hence is relatively free from danger when other better measures for protection cannot be enforced. Simply straining water through cotton is naturally effective in preventing infection and might be generally adopted even by primitive tribes if adequately explained to them.

The Mermithidæ possess an obliquely striated cuticula. In the adult form neither mouth nor anus are functional. The head carries six oral papillæ and the caudal end of the male three or four series of numerous circumanal papillæ. The male has two spicules.

These forms, which are free living in the adult stage, pass their early life as parasites in insects chiefly. Stiles established a collective group *Agamomermis* to contain the immature forms, several of which have been taken as parasites, or possibly pseudo-parasites of man.

The best known form is *Agamomermis restiformis* Stiles 1907 (Syn.: *Filaria restiformis* Leidy 1880) which is discussed *in extenso* on another page. Alongside of it should be recorded another peculiar type described by Leidy.

Agamomermis hominis-oris.—(Syn.: *Filaria hominis oris* Leidy 1850.) Length 14 centimeters, width at head 0.1 millimeter, at center 0.38 millimeter. Mouth terminal, posterior end provided with an epidermal spine, 0.05 millimeter long.

Leidy found the single specimen in the collection of the Philadelphia Academy labelled "Obtained from the mouth of a child," and queried if it might be the young or the male of *F. medinensis*. Leuckart shared the opinion which has, however, been questioned by some later investigators.

It seems much more likely now that this was an immature Mermis which was taken into the mouth with food (an apple?). Such an occurrence is not infrequent in this country. In 1881 Lockwood in discussing adventitious entozoa cites details of three cases in which a white thread-worm, subsequently diagnosed as a Mermis, was found in the core of an apple that someone was eating. In size these worms agree fairly well with Leidy's description. It is easy to see how these might equally well have been taken from the mouth if the person eating the apple had been careless. Similar occurrences are reported by other observers and all agree in believing the Mermis was parasitic in some insect which was on its part parasitizing the fruit.

The family of the Spiruridæ is represented in the human host by two species of a single genus.

Physaloptera Rudolphi 1819.—Mouth flattened dorsoventrally, with two equal lateral lips, each dentate and bearing three papillæ; behind the lips an annular, cuticular fold. Bursa with eight pedicellate papillæ, and caudal region within it with twelve others unstalked. Two unequal spicules present. Vulva in the anterior region of the body. Eggs with heavy shell.

Physaloptera caucasica von Linstow 1902.—Esophagus one-fifth the entire length; lateral lines strongly developed. Male, 14.2 millimeters long by 0.71 millimeter broad; bursa broad, rounded, tapering posteriad, with eight stalked conical papillæ in two longitudinal rows; spicules 1.76 and 0.65 millimeters long; sessile papillæ in front of cloacal orifice one pair, behind two pairs, on the tail three pairs more. Female, 27 millimeters long, 1.14 millimeters broad, vulva at one-sixth the length from the anterior end; eggs 57 by 39μ.

The single account of this species by O. von Linstow is based on specimens, two males and nine females, in the collection of the museum at St. Petersburg, Russia. They are said to have been taken from the human alimentary canal in the Caucasus.

Physaloptera mordens Leiper 1907.—In general appearance like young *Ascaris lumbricoides*. Esophagus one-sixth of body length; anus one-eleventh of length from posterior tip. Female, 40 to 55 millimeters long, 2 to 3 millimeters broad; vulva behind the first fifth of total length. Eggs 43 by 35μ. Male 30 to 50 millimeters long. Bursa oval in outline. Four stalked lateral papillæ not in a longitudinal series, first and fourth pairs being nearer the median line. Spicules 4.6 and 0.6 millimeters long.

Not rare in man in central Africa. First discovered at necropsy of a Uganda victim of sleeping sickness. Found in stomach also esophagus and intestine, adhering firmly to wall and in this respect distinguishable from ascaris for which it has probably been often mistaken.

The Dioctophymidæ, more generally but incorrectly designated the Eustrongylidæ, have a caudal bursa with thickened margins but without radiating ribs; a single spicule. The only known representative of the one genus which occurs in man is

Dictophyme renale Goeze 1782.—(Syn.: *Ascaris canis* et *martis* Schrank 1788; *A. visceralis* et *renalis* Gmelin 1789; *D. visceralis* Collet-Meygret 1802; *Eustrongylus gigas* Diesing 1851; *Strongylus renalis* Moq.-Tand 1860; *Eu. visceralis* Raill. 1885.) Generally blood red, slightly tapering at both ends, especially the anterior; mouth triangular, bordered by six small papillæ; lateral lines with about 150 papillæ; anus terminal. Male, 13 to 40 centimeters long, 4 to 6 millimeters broad. Caudal extremity obtuse, encircled by membranous pouch with papillæ on margin. One slender spicule, 5 to 6 millimeters long. Female, 20 centimeters to 1 meter long; 5 to 12 millimeters broad; tail obtuse and slightly curved; one ovary; female sexual opening 50 to 70 millimeters from anterior end; eggs ovoid, thick shelled, brown; shell deeply pitted 64 to 68μ by 40 to 43μ.

This is the giant of all the nematoda, and is a kidney parasite encountered in man, dog, cattle, horse, wolf, and many fish-eating animals. It is extremely rare. Ordinarily found in the pelvis of the kidney, it may also occur in the body cavity.

The development begins in the female worm, but is completed only after the egg has been expelled from the host. Five or six months in winter and a shorter time in summer are necessary for the remainder of the development of the embryo. It lives in the shell a long time in water or moist earth without hatching out, but cannot endure drying. The embryos will not develop if transferred directly to the dog, so that an intermediate host seems necessary. This has been conjectured to be a fish.

Pathology.—Of the numerous cases reported of the occurrence of this parasite in man, the majority are assignable to other parasites. Not more than ten are authentic. Trumbull's case (*Medical Record*, 1897) has been explained by Stiles as probably a filaria.

The family of the Trichotrachelidæ is characterized by a body extremely elongated with two distinct regions, the long anterior very slender and the short posterior more or less inflated, containing intestine and genital organs. Esophagus very long, anus terminal. Males usually with a single simple sheathed spicule, sometimes without one. Female with simple ovary; vulva at junction of two regions of body. Two important genera which include the commonest and the most feared of human parasites.

Trichuris Roederer et Wagler 1761.—(Syn.: *Trichocephalus* Goeze 1782.) Anterior region very long and filiform; posterior region short, sharply set off from anterior and markedly inflated. In the male it is rolled into a spiral; one spicule, with infundibuliform sheath. In the female the posterior region is lightly bent, but not in a spiral. Parasitic in the large intestine and cecum of mammals. Eggs club shaped with peculiar translucent plug in the shell at each pole. Development direct and without ecdysis.

Trichuris trichiura L. 1771.—(Syn.: *Ascaris trichiura* L. 1771; *Trichocephalus trichiura* Goeze 1782; *T. hominis* Schrank 1788; *T. dispar* Rud. 1801; *Mastioodes hominis* Zeder 1803.) Male, 40 to 45 millimeters long, with strongly attenuated anterior region comprising three-fifths of total length. Spicule single, 2.5 millimeters long, located in a spinous protractile sheath; posterior region in a flattened spiral. Female, 45 to 50 millimeters long with attenuated anterior region two-thirds of total length. Eggs, 51 to 53μ long by 21 to 23μ wide, brownish, thick shelled, with polar knobs; deposited before cleavage begins (Fig. 4098).

The striking appearance of this genus, a single species alone of which is parasitic in man, is due to the strongly contrasting regions of the body. The filiform region contains only the esophagus, an exceedingly delicate capillary chitinous tube passing through a series of conspicuous cells that fill the body cavity; these form the so-called "cell body" of older authors. In the greatly enlarged posterior region the transparency of the body wall permits one to recognize the various organs even in the living worm.

The eggs are produced in large numbers, 400,000 annually by a single female (Leuckart), and undergo no development until they have passed out of the human body. Cleavage takes place in water, but only at the end of some months or even more than a year. The eggs are well protected by the heavy shell from adverse circumstances, so that Davaine has kept embryos living within them for five years. The introduction of these embryos still within the shell is ordinarily brought about through drinking-water, though Blanchard suggests the evident possibility of their introduction on salads and uncooked vegetables. In the human stomach the shell is dissolved and the embryos are set at liberty to reach sexual maturity at the end of four weeks, as has been definitely established by the experiments of Grassi.

Distribution.—This is one of the commonest parasites of man, being distributed over practically the entire earth, though more abundant in the warmer regions. Local variations in its frequency are noteworthy. Braun cites, as records of autopsies, its presence at Dresden as 2.5 per cent., at Erlangen 11.1

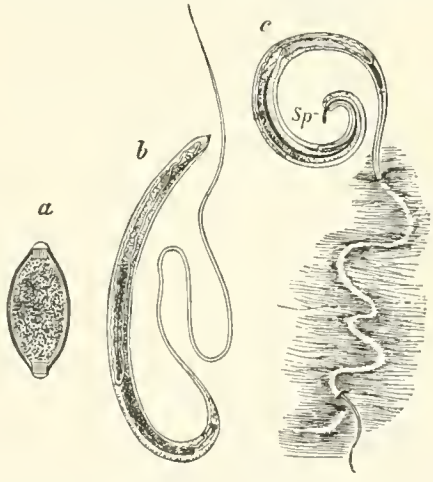

Fig. 4098.—*Trichuris trichiura*. *a*, Egg; *b*, female; *c*, male with anterior end embedded in mucosa; *sp*, spicules. (After Claus.)

per cent., at Kiel 31.8 per cent., at Munich 9.3 per cent., at St. Petersburg 0.18 per cent., at Göttingen 46.1 per cent., at Basel 23.7 per cent., at Greenwich 68 per cent., at Dublin 89 per cent., at Paris 50 per cent., and in southern Italy near 100 per cent. This species is growing rarer in Paris according to statistics available, and probably elsewhere also, owing to the disuse of surface water for drinking.

Pathology.—*Trichuris trichiura* inhabits the human cecum ordinarily, but rarely also the vermiform process and colon, and may be found in persons of all ages, even occurring in infants of a year old.

Usually only a few individuals are present in a single host, but in some cases as many as 1,000 parasites have been found at once. Normally they occur with the filiform anterior region embedded in the mucosa, and recent investigation tends to demonstrate that such as are found free in the canal have been driven out by postmortem changes.

This species has been regarded earlier as playing a pathogenic rôle in typhoid, cholera, and beriberi, and more recently all pathogenic significance has been

denied it. Though the presence of a few does not occasion pathogenic symptoms, yet since Askanazy has shown the occurrence of hemoglobin in the alimentary canal of these worms, the fact that they nourish themselves on the blood of the host cannot be doubted. In occasional severe cases noteworthy depression, suppression of the urine, with fever, cardiac weakness, and often nervous symptoms, have been noted.

Fig. 4099.—Intestinal Trichina. *A*, Female with embryos; *B*, male, × 80. (After Heller.)

More recently various writers have emphasized the pathogenic significance of the whipworm as an inoculating agent and thus in a new sense the cause of typhoid and other intestinal diseases. It is clear that the epithelial punctures produced by the normal position of the worm afford opportunity for bacterial invasion not given by the uninjured mucosa, but the extent of this injury is not yet clear. The worm has also been charged with being the cause of appendicitis in a certain group of cases and in fact specimens have been detected in the diseased appendix in many instances on record. The theory of bacterial inoculation by the whipworm has been powerfully championed but the evidence thus far collected establishes the clear possibility rather than the definite frequence of the occurrence.

Treatment is said to be difficult, and naphthalin, thymol, and pelletierine have been used with only moderate success. A later writer commends santonin as rapid and effective.

Prophylaxis.—Care in obtaining drinking-water and in selecting and cleansing uncooked vegetables will evidently limit the spread of the parasite.

Trichinella Railliet 1896.—(Syn.: *Trichina* Owen 1835.) Very small, slender, without marked distinction of regions in body. Male without spicule, but with lateral appendages at posterior end, as if a poorly developed bursa were present. Female ovoviviparous; vulva at anterior fifth of body. Only a single species.

Trichinella spiralis, Raill. 1896.—(Syn.: *Trichina spiralis* Owen 1835.) Male (Fig. 4099, *B*), 1.4 to 1.6 millimeters long, by 0.04 millimeter broad, without spicules, but with a short conical appendage on either side of the cloaca, behind which are two pairs of papillæ. Female (Fig. 4099, *A*), 3 to 4 millimeters long, 0.06 millimeter broad; vulva ventral near anterior fifth of body; anus terminal, viviparous. Fully developed larva, 0.8 to 1 millimeter long by 0.04 millimeter broad; cyst measures 0.4 by 0.25 millimeter.

The sexually mature parasite, sometimes called the intestinal trichina, inhabits the small intestine of man and various other mammals. The larval form, known as the muscle trichina, is found encysted in muscular tissue. Easily infected are man, pig, rat, mouse, guinea-pig, rabbit; less easily sheep, calf, horse; with difficulty cat, dog, badger. The intestinal form will develop also in birds, but the embryos

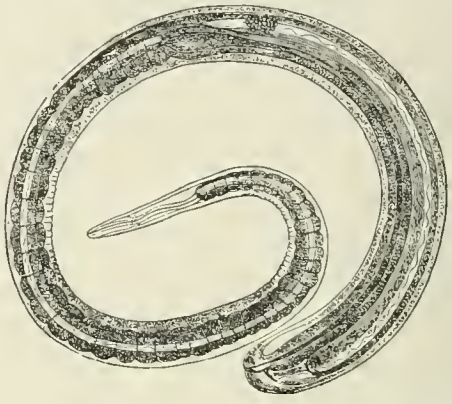

Fig. 4100.—Fully Developed Muscle Trichina with Alimentary Canal and Genital Primordium, Removed from Cyst. Magnified. (After Leuckart.)

are expelled with feces and do not reach the muscles.

History.—Encysted trichinæ were first noted by Peacock in London as early as 1828, but it was 1835 before their character as encapsulated entozoa was recognized by Paget and the parasite described by Richard Owen. The presence of encysted trichinæ in man was confirmed by a multitude of observations from various countries, and Joseph Leidy added a most important fact in the discovery of similar worms in pork. Feeding experiments by Leuckart, Virchow, and Küchenmeister, together with the observations of Zenker on a maid that had died of apparent typhoid, led to the elucidation of the life history and to proper estimation of the pathogenic character of the parasite which had heretofore been regarded as harmless or as the immature form of a *Trichocephalus* or *Strongylus*. Rapid accumulation of isolated cases and of epidemics of trichinosis, almost all from north Germany, placed beyond question the etiological significance and importance of the trichina.

Life History.—If a portion of flesh containing the larval worms is eaten by a suitable host, the larvæ are set free in the stomach and pass into the small intestine. They attain sexual maturity in about two and one-half days, copulate, and the male soon dies. Two opposed views as to the dispersal of the young have long been held. According to one the migration of the embryos is an active one in that they bore their own way out of the canal and through the connective tissues to their ultimate seat. The other view, however, of passive transport by the blood and lymph streams may be regarded as demonstrated by recent work, particularly that of Graham, whose account is followed in the main here. The gravid female bores into the intestinal wall as far as the lymph vessel. There the young are produced, being set free by the female into the lymph stream, which carries them ultimately into striated muscle tissue. At birth they measure 0.09 to 0.11 millimeter in length by 5 to 6μ in width, and at the close of this migration but little more, being then 0.12 to 0.16 millimeter long. In eight days these embryos are in the intramuscular con-

nective tissue and only a few days later in the muscle fibers themselves (Fig. 4102). The fibers lose their transverse striation and undergo granular and fatty degeneration. The embryo increases rapidly in size, and rolls into a loose spiral in an expansion of the completely degenerated fiber. By the action of the surrounding connective tissue, in which connective-tissue corpuscles and leucocytes are contained, a cyst of characteristic form is produced (Fig. 4101). It is thickened at the poles and measures about 0.4 millimeter by 0.25 millimeter in diameter. This process occupies several weeks, during which later broods of embryos are produced, since each female lives five to seven weeks and gives birth to from 800 to 2,000 young. Thus in the early stages of an infection one finds in the muscle embryos in various stages of development and encystment, side by side.

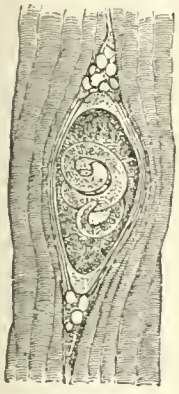

Fig. 4101.—Encapsulated Trichina. (After Leuckart.)

Once encysted the larvæ remain quiescent; it may be for long periods. Thus encysted trichinæ have been found living in human muscle, twenty-five and even thirty-one years after the presumed infection. Not infrequently, though perhaps not always, one finds evidences of further change in the formation of a delicate calcareous layer about the cyst (Fig. 4103). In some cases this encroaches upon the larva so as to produce ultimately a calcareous nodule in which a remnant alone of the worm is contained. It is held by some that calcification does not ensue until after the death of the larva from unknown causes. Fatty degeneration of the encysted trichinæ can also be observed, and is likewise held to be a pathogenic process. Such larvæ as rarely occur in connective tissue are without the characteristic cyst, but appear to be smothered in a mass of proliferating connective tissue.

While it has been determined experimentally that a considerable number of hosts furnish conditions favorable for the development of the trichinæ, the normal host is no doubt the rat, and evidence has been adduced to prove the introduction of this parasite into Europe from the East with the brown or Norway rat. The method of transmission in this species is clear when one recalls that rats are cannibals and universally make way with aged or infirm members of the tribe. The well-known avidity with which pigs catch and eat rats explains the infection of swine, and it is from this source that man is infected.

Fig. 4102.—Muscle Trichina Fifteen Days after Infection × 165. (After Leuckart.)

Nearly all of the epidemics of trichinosis on record are confined to north Germany. In Saxony from 1860–75 there were 39 epidemics affecting 1,267 persons, of whom 19 died; at Hedersleben (1865), a town of about 2,000 inhabitants only, a total of 337 were sick and 101 died; at Emmersleben (1883) fully one-third died among those who ate the infected meat. Stiles has given a statistical review of trichinosis in Germany during recent years, from which is taken the following: 1860–80—8,491 cases, 513 deaths, 6 per cent. mortality; 1881–98—6,329 cases, 318 deaths, 5 per cent. mortality.

From the table of separate years it appears that there has been a general decrease in trichinosis in Germany during recent years, due probably to general education of the public on the dangers of eating raw pork as well as to meat inspection. The latter, which removes from consumption 1,500 to 2,000 trichinous hogs annually, is carried out in a most scientific manner by an army of some 30,000 inspectors and microscopists, at an annual cost (estimated) for the German Empire of $3,000,000, while for the city of Berlin alone the cost is $80,000. In spite of this

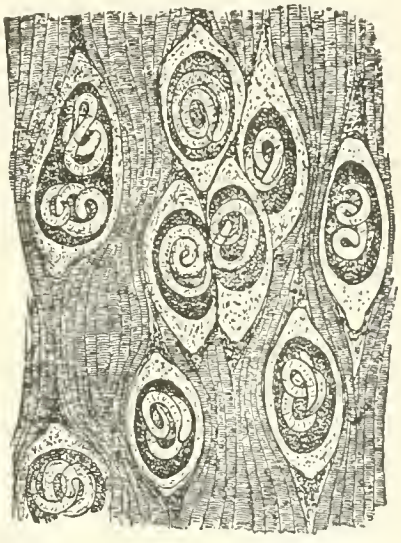

Fig. 4103.—Muscle with Encysted Trichinæ in Process of Calcification. (After Braun.)

system and expenditure security from trichinosis has not been attained *even for the meat examined*, as the following table shows, according to which more than half the cases of this disease are traceable to inspected meats.

Summary for the German Empire 1881–98 Inclusive.

	Cases.	Deaths.
Meat inspected and passed as free	2,042	112
Meat condemned but used	142	13
Due to defects in inspection system	1,204	7
Total results of errors	3,388	132
Inspection uncertain	63	0
No inspection of meat used	874	84
Data obscure or wanting	1,968	98
Said to be due to American meats	18	3
Due to uninspected Russian meat	18	1
	6,329	318

During double the period given there have been recorded in the United States approximately 900 cases.

Of the eighteen cases and three deaths alleged to have been due to American pork during 1881–83, neither Virchow nor others have accepted the evidence as tenable, and the careful examination made by Stiles renders it clear that the attacks upon American pork found in the German press are not supported by German health statistics. While the inspection doubtless diminishes chances of infection, it certainly gives rise to a false feeling of security.

For the years 1860–95 Stiles has collected records of about 900 cases from the United States. Undoubtedly during this time cases have been diagnosed as atypical typhoid or rheumatism which were in reality

attacks of trichinosis, but in the opinion of various authors there were also unrecorded cases in Germany. Nevertheless it is clear that there is a much less prevalence of the disease here, and it is interesting to note the nationality of these cases so far as recorded.

Table of Two Hundred and Seventy-four American Cases.

	Cases.	Per cent.		Cases.	Per cent.
German	208	76.0	American	4	1.5
"Foreign"	37	13.0	French Canadian	3	1.0
Negro	10	3.0	"French descent"	1	0.4
Italian	4	1.5	Dane	1	0.4
Irish	4	1.5	Swede	1	0.4

Statistics as to the prevalence of trichinosis are given by numerous European authorities from examinations made at autopsies. The results vary from nothing in France, according to Blanchard, to about two per cent. in Germany, according to various authors. These figures are based upon macroscopic examinations in large part at least, and Leuckart with others has remarked that greater success would follow more rigid search. In the United States Williams has subjected 505 cadavers to a careful microscopical study, with the result that twenty-seven cases were found to be infected, or five and a third per cent. One-third of them were classed as severe, and only two were evident on examination with the naked eye. The nationality of the cases is given in the following table, which is suggestive, though the number is too small to warrant the drawing of final conclusions:

	Positive.	Negative.	Total.	Per cent. of positive cases in each nationality.
United States, white	6	201	207	2.89
United States, colored	5	65	70	7.14
British and Irish	5	57	62	8.06
Canadian	2	10	12	16.66
German	6	43	49	12.24
Italian	2	10	12	16.66
Other nationalities	0	27	27	0.00
Unknown	1	65	66	1.51
	27	478	505	5.34

The infection of rats varies so widely in different localities that little dependence can be placed on figures heretofore given from the examination of small numbers of individuals. The examination of pigs shows in Boston 4 to 5.7 per cent. infected (Billings), in United States army 2.1 per cent. (Müller), in various German districts from 1.5 per cent. to 0.1 per cent. The records of Mark show distinctly that reasonable hygienic conditions reduce the percentage of infection among pigs enormously, even in a few years.

The trichinæ are found most abundantly in the muscle of the diaphragm, tongue, and neck, and are present at times in incredible numbers, estimated by Leuckart at from thirty to forty millions for a single host (man). Diagnosis of the disease may be positively confirmed by the discovery of embryos in bits of muscle removed from the patient by scalpel or special harpoon. After extended effort the embryo trichina has been detected in the blood by special proceedure. When blood taken from infected guinea-pigs is diluted with three per cent. acetic acid and centrifuged, it is always possible to find the young trichinæ before the twenty-eighth day after infection. Even when smaller quantities of blood have been taken in man from the vein of the ear, the young trichinæ have usually been found. This method of diagnosis will undoubtedly replace the older plan of excising a portion of muscle to test the supposed infection.

The occurrence of other nematodes of somewhat similar size and appearance, the so-called false trichinæ, in the muscles and other organs of hare, rat, mouse, bird, fish, and even man (*cf.* case of Cobbold above, under *Leptodera terricola*) make it imperative that the determination be made with care in suspected cases of trichinosis. Of definite diagnostic value is the so-called "cell body" of the esophagus, which is prominent in the anterior pointed region of the worm and which, though varying in length, is easily recognizable in all stages of growth and in both sexes (Fig. 4100).

Prophylaxis.—Man acquires the disease by the consumption of pork, in which are found living trichinæ. The chance of infection from all other animals is utterly inconsiderable, though a recent German author calls attention to the necessity of submitting dog meat to inspection on account of its rapidly increasing use as food. It has also been proved that salting, smoking, and other methods of curing ham do not afford a guarantee for the death of trichinæ which may be present. Two preventive methods have been suggested. The first is followed by Germany in her system of meat inspection; as already noted the system is expensive and does not afford absolute protection. Furthermore, unless the number of trichinæ present is enormous so that pathological changes have been induced in the flesh, the destruction of the meat constitutes an unnecessary loss of valuable food material. The second method of preventing the disease is the thorough cooking or curing of the meat so as to destroy the trichinæ. A temperature of 70° C. is sufficient to kill the encysted parasites, but in order that the center of a piece of meat may reach this temperature cooking must be prolonged. One may determine the sufficiency of the cooking by the uniform clear gray color of a cut surface and the absence of red juice under pressure of the knife. This individual prophylaxis is both most reasonable and most effective; for the consumption of well-cooked pork is free from danger.

The old-fashioned slaughterhouse, at which the refuse was thrown to pigs and fell in part also to the rats infesting the place, was a serious menace to the health of the community, and offered the most admirable conditions for the rapid multiplication of parasites, especially these. On the other hand, the great modern packing establishments, in which all scraps are utilized under methods that destroy the life of any parasites present, are important agents in the limitation of this disease and in the general improvement of public health. Proper methods of slaughtering, curing and preparing pork, and the abandonment of the unsanitary custom of eating the flesh of the pig uncooked are the true methods for the suppression of the disease.

In the family of the Strongylidæ the body is elongated, cylindrical, rarely filiform; alimentary canal complete; mouth provided with six papillæ sometimes in the axis of the body, sometimes turned toward the dorsal or ventral surface, and frequently armed by chitinous teeth; esophagus more or less enlarged at the posterior end, but not provided with a distinct bulb; sexes separate; male with caudal sac or bursa in shape like a saucer, or, if deeper, a bell encircling the end of the body. Two equal or inequal spicules project from it, and the ribs or rays which mark its surface have characteristic arrangements in different species. The margin of this sac may be notched or deeply cut, so that it appears to consist of two separate parts; near the male orifice a small number of papillæ are often found. Female with one or two ovaries; female sexual opening very variable in position. The eggs when laid have undergone at least part of their development.

Many of these forms have only relatively recently

come to the notice of the scientific world; they are highly specialized parasites and most dangerous enemies of man. Thanks to the investigations of Railliet and Henry the structure and relationships of these hitherto poorly known types are now fairly well understood. The family constitutes a large and very complex group and is subdivided into a number of subfamilies of which only three are noted here, the Metastrongylinæ, the Trichostrongylinæ, and the Strongylinæ.

The Metastrongylinæ are polymyariæ and have a small buccal capsule or none at all. A rhabditiform embryo is lacking. They are parasites of the respiratory or circulatory apparatus. Their development is unknown.

Metastrongylus Molin 1861.—Mouth with six lips, the two laterals being the largest. Vulva close in front of anus; two uteri, convergent; eggs with well-developed embryos when laid. Bursa with posterior ribs slender; two long filiform spicules.

Metastrongylus apri Gmelin 1789.—(Syn.: *Gordius pulmonalis apri* Ebel 1777; *Ascaris apri* Gmelin 1789; *Strongylus suis* Rud. 1809; *Str. paradoxus* Mehlis 1831; *Str. clongatus* Duj. 1845; *Str. longevaginatus* Dies 1851; *Metastrongylus paradoxus* Molin 1860.) Male, 12 to 25 millimeters, bursa bilobed, five ribs in each lobe, spicules very long and slender, measuring 2.5 to 4 millimeters in length. Female, 20 to 50 millimeters long, with short fish-hook tail at the base of which lies the anus and just in front of it the vulva on a rounded eminence. Eggs ellipsoid, 0.06 to 0.1 millimeter long by 0.04 to 0.07 millimeter broad; when laid they contain well-developed embryos which on hatching measure 0.22 to 0.35 millimeter long by 0.01 to 0.012 millimeter broad.

The parasite inhabits commonly the bronchi and bronchioles of pig, sheep, and occasionally also man. Diesing reported it first from a six-year-old boy in Klausenburg; Chatin found some individuals, probably by accident, in the alimentary canal of a patient in France.

The observation of Rainey and Bristowe on nematode embryos from the larynx, which they called *Filaria trachealis*, points to this species even if an exact determination is impossible. Its abundant occurrence in the pig in Europe and its extreme rarity in man indicate some feature in the unknown life history, which renders human infection improbable.

The Trichostrongylinæ are meromyariæ with an inconspicuous buccal capsule, if any. The eggs when laid are segmenting and a rhabditiform embryo is developed. They are parasites of the alimentary canal.

Trichostrongylus Looss 1905.—Mouth with three small lips and papillæ. Caudal bursa with lateral lobes. Spicules spatulate with boat-shaped accessory piece. Vulva in posterior region of body. Eggs thin shelled.

Trichostrongylus instabilis Railliet 1903.—(Syn.: *Strongylus instabilis* Railliet 1893; *Str. subtilis* Looss 1895.) Body very slender and delicate, cuticula finely striated, oral papillæ inconspicuous; buccal cavity infundibuliform; esophagus nearly one-sixth as long as the body. Male with inconspicuous alæ at anterior end, 4 to 5 millimeters long 9μ in diameter at anterior end, 80μ near bursa; two spicules 0.15 millimeter long, with accessory piece 0.05 millimeter long (Fig. 4104). Bursa bilobed, with asymmetrical ribs. Female, 5 to 6 to 7 millimeters long, 0.01 millimeter in diameter at head, and 0.09 millimeter in posterior third of body. Tail sharply pointed, anus near tip; vulva about one-fifth length from posterior end; uterus bilobed, with a few (three to six, or even eight to nine) eggs in each lobe; eggs oval, 63 to 80 by 41 to 36μ thin shelled, containing twenty to thirty cleavage cells when laid; development unknown. Infection by drinking-water.

This parasite was described by Looss from specimens found at postmortems in Egypt. The species is a normal parasite of the herbivora especially the sheep and man. It occurs in the duodenum close to the pylorus. The infection was regularly light, and Looss doubted its pathogenic character on account of this as well as its small size and unarmed buccal cavity. The eggs are much like those of the hook-worm in form and appearance, but larger and further developed when laid.

Trichostrongylus orientalis Jimbo 1914.—Males, 3.8 to 4.8 millimeters long; 0.072 to 0.079 millimeter in maximum width; bursa 0.23 millimeter broad, externo-dorsal rib bent slightly in sigmoid curve; spicules 0.12 to 0.13 millimeter long, accessory piece 0.065 to 0.085 millimeter long. Female, 4.9 to 6.7 millimeters long, 0.075 to 0.083 millimeter broad; eggs 0.075 to 0.091 by 0.039 to 0.047 millimeter.

In duodenum, more rarely stomach or jejunum, of man in Japan. Apparently widespread and common.

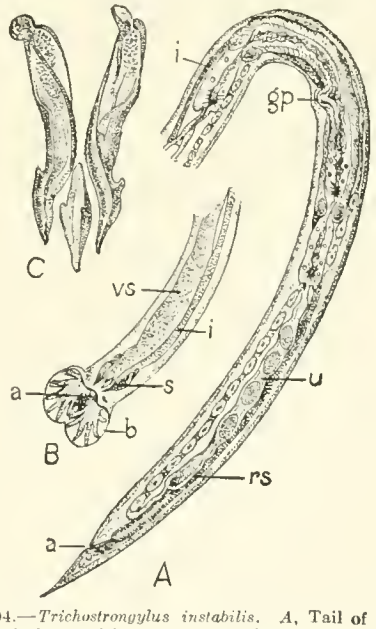

Fig. 4104.—*Trichostrongylus instabilis*. *A*, Tail of female; *a*, anus; *gp*, genital pore; *i*, intestine; *rs*, seminal receptacle; *u*, uterus; *B*, tail of male; *b*, bursa; *s*, spicules; *vs*, seminal vesicle; *C*, spicules and accessory piece. Highly magnified. (After Looss.)

The delicate body of this worm is easily overlooked, a fact doubtless responsible for its late discovery. In the opinion of Jimbo the eggs in feces have often been mistaken for those of the hook-worm from which they are, however, differentiated by size and structure. While common the parasites are apparently of no pathologic importance in the human host.

In 1895 Ijima reported under the name of the preceding species a form found by Ogata in 1889. These are probably the present species as are also others reported by various Japanese writers under the old name. The distinction between the species is clear on careful examination.

The most important previous case is that of Ogata who discovered as many as 200 small nematodes in fluid taken from the stomach of a woman who died in Japan during the "Miura plague" of 1889.

While these parasites were not regarded as the cause of the epidemic, it is clear that the presence of so large a number creates a presumption against their supposed harmlessness.

Two other species *Tr. probolurus* Railliet 1906 and *Tr. vitrinus* Looss, 1905 occur in Egypt frequently in the sheep, antelope, and camel; rarely in man. These species are possibly of some importance in this country as they are reported here from camel and

from native herbivora so that their occurrence in man is not unlikely.

Mecistocirrus Railliet et Henry 1912.—Cephalic end slightly inflated. Cuticula carries eighteen inconspicuous longitudinal ridges. Vulva just anterior to anus. Cervical papillæ distinct. Spicules thin, one-sixth length of body.

A single species, *M. fordi* Daniels 1908, from eastern Asia is common in pig and cattle and has been reported by Stephens for man also in Hongkong.

Hæmonchus Cobb 1898.—Oral papillæ absent; cervical papillæ two, lateral, directed posteriad. Spicules short with accessory piece. Vulva near pointed posterior end, beneath a linguiform process directed posteriad.

Hæmonchus contortus Rudolphi 1803.—(Syn.: *Strongylus contortus* Rud. 1803; *Str. filicollis* Molin 1861.) This cosmopolitan parasite of ruminants produces in cases of multiple infection a severe pernicious anemia well known to animal breeders. Magalhaes reported from Brazil that in a case of severe anemia a patient yielded this parasite after administration of an anthelminthic. The life history is unknown but infection is attributed to water polluted by the rhabditiform embryos. The parasite is so common in other countries and the chances for casual infection so good if it were at all possible that one may well question the identification in the case from Brazil which is the only one on record for this species.

The Strongylinæ are meromyariæ with well-developed buccal capsule. The group corresponds to the ancient sclerostomes and includes dangerous blood-sucking parasites of the alimentary canal; among these the hook-worms are probably best known. Many other genera belong here and of them several have been reported from the human host in various countries.

Oesophagostoma Molin 1861.—Buccal capsule much inflated, reduced to a chitinous ring and cut off from the body by a nuchal furrow. Vulva near anus. Two equal, slender spicules; two prebursal papillæ. Larval stages in cysts on intestinal wall; adults in intestinal lumen of same hosts.

Oesophagostoma apiostomum Willach 1891.—(Syn.: *Oes. brumpti* Railliet et Henry 1905.) Immature females 8.5 to 10.5 millimeters long, 0.3 to 0.33 millimeter thick, oral crown of twelve pointed lamellæ, directed anteriad and centrad. Eggs 0.03 by 0.027 millimeter. Found at the autopsy of negroes in East Africa and Guinea. Said to occur also in many monkeys from Africa and India.

Leiper found some parasites from a native of Nigeria which he identified as *Oes. apiostomum* Willach; this determination has been questioned by Brumpt and Railliet who believe the human form represents a new, unnamed species. These parasites live until sexual maturity is reached in nodules as large as a pea or bean, on the wall of the alimentary canal. The young worms resemble hook-worm larvæ at a certain period so closely that they can hardly be distinguished from them; later differences appear. When sexually mature they emerge from the cyst and inhabit the intestinal lumen. Heavy infections do great damage to the intestinal wall.

Oesophagostoma stephanostomum Stossich 1904, var. *thomasi* Railliet et Henry 1909. Immature females, 16 to 20 millimeters long, 0.9 millimeter thick and at center tapering to both ends. Oral crown of thirty-eight semicircular lamellæ with an adjoining circle of seventy-six short chitinized teeth. Males, 17 to 22 millimeters long, 0.75 millimeter broad. Spicules 1.38 to 1.48 millimeters long. At the necropsy of a native in Manaos, many tumors the size of a bean which contained this form were found on the intestinal wall. It is apparently only a variety of a parasite from the gorilla and closely related to another form from the chimpanzee.

Ternidens Railliet et Henry 1909.—Distinguished from the preceding chiefly by absence of an inflated buccal capsule. Three teeth project from the bottom of the capsule. The bursa has dentate margins and the vulva is near the posterior end.

Ternidens deminutus Railliet et Henry 1905.—(Syn.: *Triodontophorus dem.* Raill. et Henry 1905, *Globocephalus macaci* Smith, Fox, and White 1908.) Cuticula delicate, distinctly striated. Body tapering regularly to both ends. Mouth elliptical, chief axis dorsoventral. Oral ring with twenty-two to twenty-four lamellæ. Two large lateral and four small submedian papillæ on head. Male, 9.5 millimeters long, 0.56 millimeter broad. Bursa broader than long. Female, 12 to 16 millimeters long, 0.65 millimeter maximum breadth. Vulva 0.65 millimeter, anus 0.27 millimeter from posterior end. Eggs 0.064 to 0.07 by 0.038 to 0.04 millimeter.

The species first described from specimens in the Natural History Museum at Paris has been found at necropsies in Nyassa. Apes may be the normal host though the only record in this country comes from Asiatic monkeys in the Philadelphia Zoological Garden; the discovery was reported by A. J. Smith. Probably the species is not rare, but often confused with the hook-worm which it resembles in size though not in structure. Looss opines that the normal location is the large intestine and not the small intestine as reported.

Syngamus trachealis, the gap worm of chickens, has been reported once by Leiper as a parasite in the human respiratory tube. Since the worm is widespread and common in its normal host, this the only case of its occurrence in man needs confirmation.

The hook-worms or ankylostomes comprise several genera with many species. Two are known to occur commonly in man and others have been recorded from that host, although their frequence has not been determined. The species are all dangerous blood-sucking parasites and induce anemias of a profound character in many cases. The human parasites represent two genera, *Ancylostoma* and *Necator*, and are often called respectively the Old World and the New World hook-worm. The name of the genus to which the former, long well known, belongs, has been spelled in many different ways. The International Commission on Zoological Nomenclature has finally adopted the form used here.

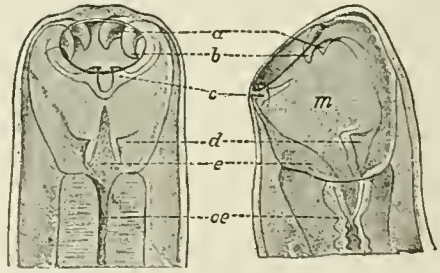

FIG. 4105.—Oral Capsule of *Ancylostoma duodenale* in (*A*) Dorsal and (*B*) Lateral Aspect. *a*, Inner; *b*, outer ventral tooth; *c*, dorsal tooth; *d*, stylet; *e*, dorsal rib; *m*, buccal cavity; *oe*, esophagus. (After Hertwig.)

In the hook-worms the anterior end is curved dorsad and the month opens obliquely from a large buccal capsule variously armed with teeth and cutting plates. The forms are oviparous and produce eggs with a thin transparent shell.

Ancylostoma Dubini 1843.—(Syn.: *Dochmius* Dujardin 1845.) On anterior ventral margin of buccal capsule two pairs of large uncinate teeth, turned inward. Within capsule one median dorsal and two short bilateral ventral cutting plates.

For the disease produced by this form the name ankylostomiasis has long been in use; and this should be adopted in preference to the term uncinariasis or uncinariosis which was formed from *Uncinaria*, the generic name formerly applied to the human parasite but now more properly used to include other hook-worms not found in man.

The disease is known also as brickmakers' and miners' anemia, Egyptian chlorosis, tunnel disease, etc. Its chief symptoms are anemia with the circulatory disturbances accompanying the pernicious type, colicky pains in the abdomen, great weakness, alternating constipation and diarrhea with brownish or bloody stools, nausea, and edema. Positive diagnosis is made by the discovery of the parasites and eggs in the feces. In such cases care should be exercised not to confuse this with other species.

As the effects due to the two species are not distinguishable, a general discussion may be given for both together. By means of the powerful armature of the

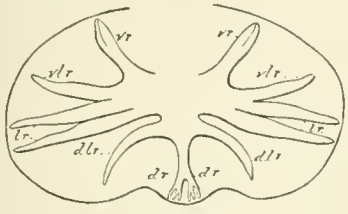

Fig. 4106.—Bursa of Male *Ancylostoma duodenale*. Magnified. (After Railliet.)

buccal capsule they pierce the intestinal mucosa and with the muscular esophagus pump out blood. The intestinal epithelium is lost from the area taken into the capsule, and in addition to this the parasites move from spot to spot so that the host loses not only the blood taken by the parasite directly, but that lost through many minute hemorrhages at previous points of attack. The functional vitality of the intestinal wall is evidently reduced, and some are inclined to believe that the parasite also produces a poison which acts upon the host unfavorably.

Thymol and male fern are most frequently used for driving out these parasites, and Stiles quotes the following directions for thymol treatment:

Two grams of thymol at 8 A.M., repeated at 10 A.M., and castor oil or magnesia at noon. Diet of milk and soup. As some cases are obstinate, a reexamination of the feces in a week is necessary, and the repetition of the treatment if eggs are still to be found. It should be noted that on the whole experiments are very unfavorable to the use of alcohol during the thymol treatment.

Rational prophylaxis must be based on better knowledge of the extent of the disease. When it is suspected microscopical examination of the feces and treatment of all infected individuals are necessary preliminaries to its eradication. The construction of water-tight latrines in tunnels, brickyards, and other corporation properties where the disease is prevalent, together with the periodic disinfection of their contents by quicklime or by cremation, will largely prevent the spread of the disease. If, in addition, defecation in other places is forbidden and the regulation enforced, while on the other hand fresh pure drinking-water is supplied and workmen are impressed with the necessity of personal cleanliness as a preventive for the disease, the difficulty will be reduced to a minimum. It must be kept in mind that Looss has demonstrated the probability of infection from water with larvæ coming on to the skin, so that the presence of such larvæ in standing water is a real menace, even if none of it ever reaches the mouth.

The Old-World species has been known for some time, and its effects are clearly traceable back of the historic study of Perroncito, which showed it to be the cause of the severe miners' anemia, which was associated with the construction of the Saint Gothard tunnel. It is only within the year 1902 that Stiles has called attention to the tremendous economic and hygienic importance of the New-World species in our Southern States, although the records of the presence of some species, probably this one, extend back for many years. In Central America uncinariasis has been for centuries the most important and dangerous general disease, involving twenty-three per cent. of the population; it appears in the old Indian traditions, and with the disease is associated "dirt-eating." The species has not been precisely determined. In Africa the infected negro does not seem to be subject to serious resulting anemia.

Ancylostoma duodenale (Dub. 1843).—(Syn.: *Agchylostoma duodenale* Dub. 1843; *Strongylus quadridentatus* v. Sieb. 1851; *Anchylostoma duod.* Dub. 1850; *Dochmius anchylostomum* Molin 1860; *Sclerostoma duodenale* Cobbold 1864; *Str. duodenalis* Schn. 1866; *Dochmius duodenalis* Leuck. 1876; *Ankylostoma* and *Ankylostomum duod.* auct.) Body cylindrical; buccal cavity with two pairs of uncinate ventral teeth, and one pair of dorsal teeth, directed forward; dorsal rib not projecting into capsule. Female, 10 to 18 millimeters long by 0.5 to 0.6 millimeter wide; vulva at or near posterior third of body; eggs 52 by 32μ, segmenting when deposited with direct development. Male, 8 to 11 millimeters long by 0.4 to 0.5 millimeter wide; caudal bursa (Fig. 4106) with dorsomedial lobe, dividing at two-thirds the distance from base, each branch being tridigitate, and with prominent lateral lobes united by a ventral lobe; spicules long, slender.

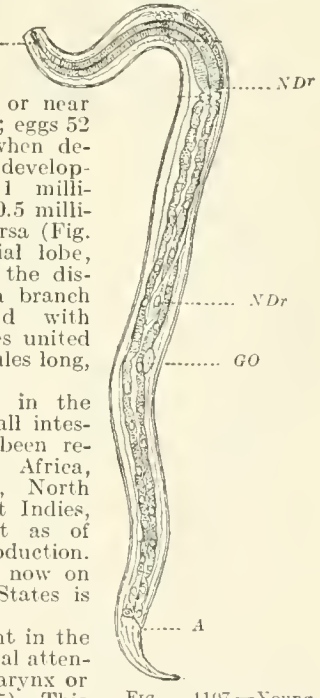

Fig. 4107.—Young *Ancylostoma duodenale*. Four Days after Infection. *A*, Anus; *GO*, genital cell; *NDr*, esophageal glands; *MH*, oral cavity. × 190. (After Looss.)

This species occurs in the upper region of the small intestine of man, and has been reported from Europe, Africa, Asia, the Philippines, North America and the West Indies, where some regard it as of relatively recent introduction. The number of cases now on record in the United States is large.

Structure.—One point in the structure deserves special attention—the so-called pharynx or buccal capsule (Fig. 4105). This is very nearly spherical, and is armed with four strong curved chitinous teeth. At the bottom of the capsule are two triangular lance-like organs, the function of which is the penetration of the tissue of the host. The body is curved dorsad at the anterior end on account of the shortness of the dorsal wall of the buccal capsule, so that the orifice actually points dorsad.

Life History.—The eggs are deposited in the alimentary canal of the host and must pass out of the body in order to undergo development, which will not take place in water, but proceeds rapidly in feces or in slime, so that the rhabditiform embryo is hatched in twenty-four hours at 27° C. As 1° C. kills the eggs in from twenty-four to forty-eight hours, the climate of a large part of this country is an evident barrier to the spread of the parasite. At hatching the embryo

measures 0.3 millimeter in length, but grows rapidly, and after moulting once it enters upon a resting stage within the cast-off skin of the second moult. In this, the infecting stage of the parasite, the worms may live for a month or more in water without food, but if subjected to desiccation they perish. This naturally points to water as the probable means of infection, although the presence of such larvæ on moist salads and other vegetables, eaten uncooked, may well be a subsidiary means.

Stiles and Miller found, as the result of extended experiments, that the longest period after which Necator eggs were alive in fecal material kept in water was seventy days, and that fermentation for three months in an LRS privy kills hook-worm eggs.

Looss succeeded in proving that these larvæ enter the human body by way of the skin, which stands in perfect agreement with his earlier observations, that the larvæ which were fed to various animals in water did not settle down but were discharged per anum unchanged; yet part of them bored into the mucosa of the larynx and esophagus and were active and growing two weeks later. When taken into the human body the worms undergo radical changes in structure.

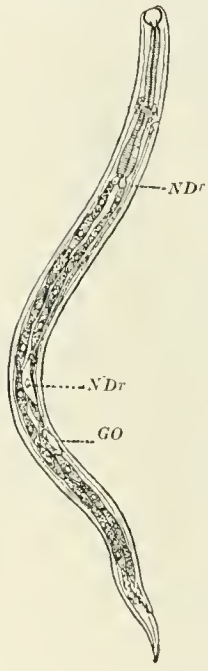

Fig. 4108.—*Ancylostoma duodenale* in Stage II. of Development. × 105. *GO*, genital cell; *NDr*, esophageal glands. (After Looss.)

One may distinguish with Looss a third stage without buccal capsule (Fig. 4107), a fourth with provisional buccal capsule (Fig. 4108), and a fifth in which this organ corresponds to the adult form. From four to six weeks from the time of infection are required for the parasites to mature.

The view of Looss, that infection takes place through the skin, has been confirmed by a number of observations and experiments. Most striking was the infection of a limb about to be amputated and the subsequent discovery of many larvæ, which had forced a way in between hair and follicle and appeared in sections to have penetrated as far as the subdermal tissue. This method of infection explains the susceptibility of Egyptian field laborers, and also epidemics among brick-makers as well as all cases in which the workmen are wont to work in moist earth with bare feet and hands. It explains the infection of children walking on damp ground, and gives, according to Bentley, the key to the "ground itch," or Pani-ghao, an affection of the skin of the lower extremities, endemic in Assam and in the West Indies. Its appearance is coincident with the advent of the rainy season, and is associated by this author with the presence of the larvæ of *Ancylostoma duodenale* in the soil of the infected areas. The typical lesion consists in a primary erythema followed by a vesicular eruption, which frequently becomes pustular, and in severe cases may result in obstinate ulceration or even in gangrene.

Another species, *Ancylostoma ceylanicum* Looss 1911, from the Civet cat, is said to be common in cats and dogs and also to occur in man in India; according to Leiper, this is identical with *A. braziliense* Faria 1910 which also was taken from cats and dogs. This form may very likely occur in man not only in the localities reported for it, but more widely. Accurate examination of human material is highly desirable to determine the precise species to which man is host.

Necator Stiles 1903.—Buccal capsule relatively small; in place of marginal teeth a dorsal and a ventral pair of semilunar plates. Also a dorsal and ventral pair of lancets deep in capsule.

Necator americanus Stiles 1902.—(Syn.: *Uncinaria americana* Stiles 1902.) Ventral recurved uncinate teeth absent from mouth, one pair prominent dorsal semilunar plates, and an inconspicuous ventral pair being present; dorsal median conical tooth projecting prominently into buccal capsule (Fig. 4111). Female, 9 to 11 millimeters long by 0.31 to 0.35 millimeter wide; vulva near middle of body but in front of it; eggs (Fig. 4110) 64 to 72μ by 36 to 40μ, segmenting or with well-developed embryos when deposited. Male, 7 to 9 millimeters long by 0.29 to 0.31 millimeter wide; dorsal ray of caudal bursa divided to the base, each branch bipartite to tip (Fig. 4109).

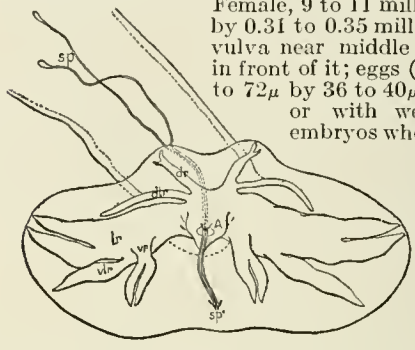

Fig. 4109.—Bursa of *Necator americanus*, Showing Ribs (*dr*, *lr*, etc.). *a*, Anus; *sp*, spicules. Magnified. (After Stiles.)

This form was differentiated in 1902 by Stiles from the long-known European *A. duodenale*, from which in fact it differs radically. It has been obtained from cases of hook-worm disease in man in Texas, Virginia, Florida, Porto Rico, and Cuba, and its wide occurrence goes to show that the parasite, though not recognized hitherto, is endemic in the Southern States, where it is the most common cause of disease on the farms and among the poor whites.

The life history of the parasite is unknown, though the early stages correspond to those of *A. duodenale*. The cases of the disease have been collected and abstracted by Stiles, who holds with evident right that it is not a recently imported disease, but has existed unrecognized for years. It has been traced from Virginia to Florida, and is most abundant in sandy areas. Guiteras has also published cases from Brazil.

Fig. 4110.—Eggs of *Necator americanus* from Feces. × 235. (After Stiles.)

Even yet this form is not distinguished from the older type in all cases and hence its distribution is only partly known. During recent years powerful influences have been at work in the United States to eliminate the disease from the Southern States and Porto Rico. The Rockefeller Hook-worm Commission and the U. S. Public Health Service have done splendid work in determining the area of distribution and in conducting an educational campaign in the infected territory. The infection ranges from seventeen per cent. of those examined in the Southern States, to thirty-one per cent. at Panama, seventy per cent. on the north coast of South America and ninety per cent. on Porto Rico. As leaders in this work Stiles in the South and on Porto Rico Ashford and King may be named.

Looss discovered this species in the pigmies of central Africa and it occurs widely through the tropical belt there; these facts, with its abundance in the American territory to which slaves were brought, serve to point out its African origin. Yet it is also abundant in Asiatic territory with suitable climatic conditions. The species occurs naturally in the Gor-

illa and has been transferred experimentally to monkeys and to rabbits and guinea-pigs; in the last two it is transient.

Family of the Asearidæ.—Body relatively thiek; mouth surrounded by three lips, one of which is dorsal, the others ventrolateral; esophagus long, muscular, inflated at the end and often accompanied by an esophageal bulb; male with one or two spieules; female with double ovary, oviparous; development direct. All are intestinal parasites.

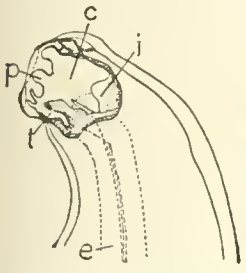

Fig. 4111.—Lateral View of Head of *Necator americanus*. *c*, Oral capsule; *e*, esophagus; *i*, stylet; *p*, papilla; *t*, dorsal median tooth. (After Stiles.)

Ascaris, L. 1758.—Polymyaria, with very prominent lips; males with two equal spieules and many preanal and postanal papillæ; vulva in advance of center of body. More than 200 species are recorded; three have been reported from man.

Ascaris lumbricoides, L. 1758.—Body reddish or grayish yellow when living; spindle shaped; lips (Fig. 4112) almost similar, approximately semicircular, with fine teeth on the edges, the dorsal possesses two papillæ, and eaeh of the ventral ones only a single papilla. Male, 15 to 17 or even 25 centimeters long and 3 millimeters thiek, with the posterior end curved toward the ventral face; spieules two, short, 2 millimeters long; papillæ fifty-five to sixty preanal and seven pairs postanal. The female, 20 to 25 or even 40 centimeters long and 5 to 5.5 millimeters thiek, with straight conical posterior end. The female sexual opening at the limit of the anterior third of the body, and situated in a ring-shaped depression. Fertilized eggs (Fig. 4113) elliptical, shell with transparent mammillated covering, 50 to 75μ long by 40 to 58μ wide, laid before cleavage begins. Unfertilized eggs, irregular, with scanty albumen covering, coarser granules, and thinner shell, measuring 81 by 45μ.

This, the common round worm of children, is one of the most abundant and widely distributed of human parasites. It is distributed over the entire world, and though more abundant in the warmer regions, is recorded from Finland and Greenland. It is also

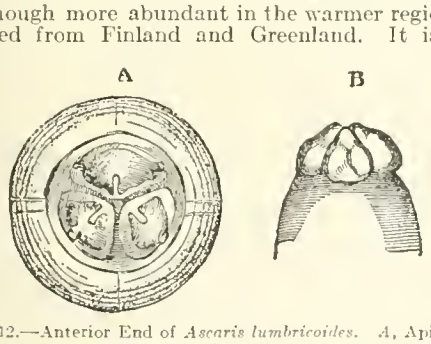

Fig. 4112.—Anterior End of *Ascaris lumbricoides*. *A*, Apical and *B*, dorsal aspect.

more common in the country than in cities, which may be due to the presence of the same species in the pig and sheep. This parasite was well known to the ancients, both the Greeks and the Romans, although the ἄσκαρις of Greek authors is the form now known as *Oxyuris*.

Life History.—The development of the eggs does not begin until long after they have been expelled from the human intestine, and is dependent upon both moisture and warmth. Under mean temperature the embryo is completed in from thirty to forty days, and then lies in a spiral within a thin shell, which it does not seem to leave so long as the egg remains free, though it undergoes a moult here. The embryo may live long within the shell, even up to five years. The further development was believed by Leuckart to require the intervention of another host in which a larval stage is passed, but Davaine was successful in hatching the embryos in the intestine of the rat, and believes that the intervention of a second host is unnecessary. Subsequent experiments by various authors have strongly confirmed this view by raising experimentally adults in the human alimentary canal two months after the ingestion of eggs containing embryos. Accordingly the eggs are probably introduced into the human system with the embryo within by accident or by means of the drinking-water. The embryo is then set at liberty in the alimentary canal, and further development is merely growth. Of course the infection may be brought about by the means of contaminated vegetables, especially salads, which have been imperfectly cleaned.

Pathology.—It has already been mentioned that the worms are most frequently found in children of medium growth, but this is due to the ease of infection rather than to conditions for development, since the

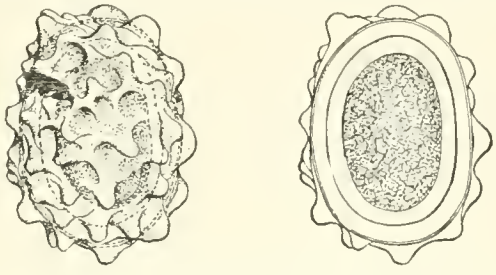

Fig. 4113.—Egg of *Ascaris lumbricoides* from Feces. *A*, In surface view and *B* in optical section. (After Stiles.)

worm has been obtained from persons of all ages. Ordinarily one finds only a few specimens at once, but in some cases from 500 to 1,000 have been obtained from a single individual. It is noteworthy that hemoglobin has been detected in the alimentary canal of the parasite, showing that its food consists in part of human blood. Their normal location is the small intestine, but specimens not infrequently wander into the stomach and are vomited. Rarely they have been known to make their way into the pharynx and choanæ, with the result of causing fatal suffocation both in children and in adults; also into the Eustachian tube or ductus choledochus, and they have even been found in abscesses of the liver.

Recently a number of unimpeachable cases have been brought forward in which the worm has bored its way through the uninjured wall of the intestine and has been found in the peritoneal cavity. Their presence here after having pierced abscesses of the wall is also known, and in some cases even, in which adhesion of the intestinal to the abdominal wall was present, the worm emerged from the body through an abscess at this point. In fevers the asearidæ will spontaneously desert the intestine.

It is evident that these wanderings are associated with greater danger to the host. The presence also even of a few individuals in the intestine gives rise at times to marked nervous disturbances, hysteria, epileptic attacks, congestion of the brain, aphonia, etc., which are most easily explained on the basis of a poison excreted by the worms. In fact, recent investigators have been able to obtain such a toxic substance from the body of this species, and students in the laboratory handling specimens of *A. megalocephala* from the horse have been distinctly affected by poisonous emanations. The symptoms disappear with the removal of the worms. Moniez, however, is inclined to attribute the troubles in large part to the use of santonin for the expulsion of the worms, as this substance has an unfavorable effect upon the human

organism. Guiart has called attention to the important fact that the parasites by their movements produce lesions of the wall so as to afford a point of attack for intestinal fevers, and thus become a source of great danger for the host. Knotted masses of this parasite have also been the cause of fatal intestinal obstruction.

Treatment.—In general opinion santonin is the specific against *Ascaris*, and no one of the many other substances tried has achieved the same results. Moniez advises the use of centigrams equal to the number of years in a child's age, and for an adult twenty to twenty-five centigrams. The drug kills the parasites, and the administration at the same time of a purgative is advantageous in bringing about their immediate expulsion. Careful watch should be kept for the violent symptoms which sometimes accompany the use of santonin and means taken at once to counteract them.

The ascarids of the dog and cat are frequently introduced by chance into the human host and thrive there. Until recently these were all regarded as a single species. Leiper called attention to the fact that different forms had been confused and described two as new genera; a third genus has since been added.

Belascaris Leiper 1907.—Anterior end bent, with lateral alæ that broaden to form an arrow-shaped head. Species in cat, dog, and fennec. *Belascaris mystax* Zeder 1800 is the common round worm of the domestic cat in which host it occurs in great abundance everywhere. While it is difficult to interpret older records without error it seems probable that the numerous cases reported as "*Ascaris mystax*" in man should be assigned to this species. Such cases are on record from Denmark, Germany, England, Austria, Italy, Roumania, and the United States.

The egg of this species has a shell that is very thin and yet so thoroughly impervious that segmentation continues after the egg has been put into alcohol, turpentine, etc. In water or moist earth there is developed within the shell a coiled embryo which probably does not hatch out until the egg is subjected to gastric digestion. Experiments to produce infection by feeding such eggs with ripe embryos has proved unsuccessful and Grassi doubts the direct development theory generally held by other investigators.

There is no certain case of human infection with the large canine species, *Belascaris marginata* Rudolphi 1802. But its presence in man may be recorded at any time and some of the uncertain past records may concern this species.

Toxascaris Leiper 1907.—Anterior end bent with long slender alæ broadest at their middle point and tapering at both ends.

Toxascaris limbata Railliet et Henry 1901 is the smaller round worm of dogs; it has been recorded once definitely from the human host, in Egypt by Leiper. Like the previous species it may occur more frequently.

Lagocheilascaris Leiper 1909.—No alæ at anterior end, but a lateral ridge on each side nearly the entire length.

Lagocheilascaris minor Leiper 1909 was described from material taken from subcutaneous abscesses in natives in Trinidad.

Braun rightly holds that such an abnormal position in a typical intestinal parasite makes the cases suspicious.

Ascaris maritima Leuckart 1876.—Known only from a single immature female, which was vomited by a child in north Greenland in 1865. The specimen was 43 millimeters long and 1 millimeter broad, and is regarded by some authors not as a normal parasite, but as one accidentally ingested with the viscera of some food animal. According to Leuckart it is very near *A. transfuga* of the bears.

Ascaris texana Smith and Goeth 1904.—An immature female evacuated by a white patient in Texas. Length 58 to 60 millimeters. Uterine eggs 60 by 40μ. Certainly not an ascaris; its significance can only be determined by study of further material.

Oxyuris Rudolphi 1803.—Three lips poorly developed or wanting; esophagus long and provided with a distinct bulb. Male with only one spicule and with two pairs of preanal papillæ. Female with greatly elongated, pointed posterior end, two ovaries and vulva in anterior part of the body.

Oxyuris vermicularis Bremser 1819.—(Syn.: *Ascaris vermicularis* L. 1767; *Fusaria vermicularis* Zeder 1803.) Esophagus long and followed by a distinct bulb with teeth; body white, cuticula striated, forming wing-like projections from the dorsal and ventral surfaces near the head and also a low crest along the lateral lines of the body; three small retractile labial papillæ. Male, 3 to 5 millimeters long, with spirally rolled tail; a single spicule and six pairs of papillæ. Female, 9 to 12 millimeters long, 1 millimeter broad, tail awl-shaped; vulva a little in front of the limit of the anterior fourth of the body; eggs elliptical, thin-shelled, 50 to 54μ long by 20 to 27μ wide, containing an embryo when deposited (Fig. 4114).

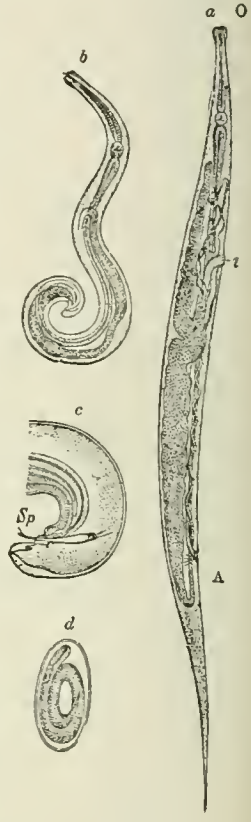

Fig. 4114.—*Oxyuris vermicularis*. *a*, Female; *b*, male; *c*, posterior end of latter; *d*, egg with embryo; *i*, vulva; *sp*, spicule. Magnified. (After Leuckart.)

This species, known from remote antiquity, is a cosmopolitan parasite of the human intestine. It has not been definitely recognized as a parasite of other animals, but Leidey's *O. compar* from the cat is very likely the same form. It is more abundant in cities than in the country, and occurs equally in cold and warm regions. These parasites are most abundant in infants, a fact which accords with the ease of autoinfection as shown by the development.

Life History.—The embryo develops with the egg shell while still contained in the uterus, and it was long thought that the further development could take place in the canal. In fact, however, the female at the time of oviposition lives in the lower part of the rectum and even attains the vicinity of the anus, although the earlier portion of the adult life history is passed in the small intestine, where the worms acquire sexual maturity and copulate. Evacuated from the body, the embryo undergoes transformation to the second embryonic stage while still within the egg shell, and now awaits ingestion by a new host. The primary infection is by drinking-water or contaminated fruit or vegetables, which are eaten uncooked; but self-infection and transference to other individuals are brought about by scratching and rubbing with the fingers to allay the intense itching caused by the daily migration of the females out from the anus on to the perineum and the surrounding parts. Perhaps in the distribution of *Oxyuris* eggs the flies play a part such as Grassi has demonstrated for *Trichocephalus* and eggs of *Tenia*. The direct development is very rapid, as Leuckart obtained experimentally *Oxyurides*

6 to 7 millimeters long within fourteen days after ingestion of the eggs; Grassi and others have confirmed this by further experiments.

Pathology.—The females are far more numerous than the males, and by their migrations determine unbearable pruritis, which recurs periodically on retiring. In a number of cases among young girls the worms have migrated into the vagina and have produced onanism, and even the inception of nymphomania. In many cases large numbers in the rectum have excited no untoward symptoms, but in others they have produced reflex nervous activities of all grades up to epileptic attacks, such as have been noted under *Ascaris*. Recent investigations in Egypt have demonstrated the responsibility of this parasite for nodules on the rectal wall, previously attributed to *Schistosoma*, which contain eggs of *Oxyuris vermicularis* in a calculus. *Oxyuris* has also been recorded in tuberculous nodules in the cavum Douglasii of a female, and Vuillemin has recently discovered them in a tumor near the anus of a boy. The latter case shows definitely the wandering of the worms through 2 centimeters or more of solid tissue. This habit exhibits a new and evidently dangerous feature in the parasitism of this species through the disturbance of the tissues and the introduction into them of bacteria from the rectum.

It is further charged with playing a causative rôle in appendicitis of the verminous type and in cases that were studied carefully both adults and eggs have been found in the appendix while the ulceration was judged to be of verminous origin.

Treatment.—It is difficult to remove these worms entirely. Vermifuges and purgatives with enemata, etc., are successful to a degree, but the ease of autoinfection is an obstacle to a complete cure. Local application of mercurial ointment will alleviate the pruritus, and manual extraction, if prolonged, will reduce their numbers rapidly. But in any event treatment is prolonged.

The subclass of the Gordiacea includes forms familiarly known as "hair snakes" or "hair worms." They are greatly elongated, slender worms, somewhat filaria-like in external appearance, but of radically different internal structure. Lateral fields are wanting, and the body musculation is of a different histological type from that of the eunematoda. The mouth is occluded and the alimentary canal persists in the adult only as a functionless vestigial strand. In both sexes the reproductive organs open to the exterior with the alimentary canal at a terminal or subterminal cloaca. The reproductive system is constructed on a different plan, and the lateral canal system is wanting. The male has no spicules, but the posterior end of the body is forked and functions as grasping organ.

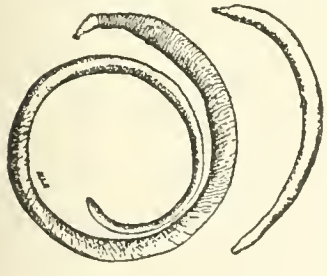

Fig. 4115.—*Gigantorhynchus gigas*. Male at right, female at left. Half natural size. (Original.)

The adult lives free in ponds, swamps, and other bodies of water, and the eggs are deposited on the stems of water plants. The larvæ possess a proboscis armed with hooks and bore into the body cavity of aquicolous insect larvæ, or rarely mollusks, where they encyst. According to Villot the second stage is passed in the intestine and body cavity of fishes. More commonly apparently the worms develop to maturity in the body cavity of insects, from which they emerge into the water for the adult free existence.

Several species have been reported from the human alimentary canal. They are pseudo-parasites, having been swallowed, according to one view, in the adult condition with drinking-water; but their occurrence in fruit, especially apples, makes this even a more likely source of infection. Lockwood noted in 1876 the frequent presence, in fruit, of *Mermis*, another genus of Eunematoda, and suggested the probable occurrence of this form as a pseudo-parasite of man under conditions; this has not been actually recorded so far as I find. But of Gordius as a pseudo-parasite Parona has recently listed eleven cases, the first as early as 1638; of these Kirtland's (Ohio) is the oldest from the United States. Two other unpublished cases have recently been communicated to me from Michigan and Maryland. In all, six cases are recorded for the United States and in four of these the worm was identified as *Paragordius varius*.

The Gordiacea are, however, emphasized by Cobbold as important for the medical practitioner, since they have been passed off as the Guinea worm and as having been evacuated with fecal matter by neurasthenic persons under treatment.

The Acanthocephala may best be discussed as an appendix to the class Nematoda, although they are regarded by many as a cognate class and by others are separated even more widely. The forms included here, though parasites of the most complete type, are not common in man. The group may be characterized as follows: Elongated, cylindrical body, often deeply corrugated, bearing at anterior end a retractile proboscis provided with many minute hooks in rows. No trace of alimentary canal. Reproductive organs open at posterior end; sexes separate. Male with campanulate bursa about the orifice. Mostly small forms, parasitic as adults in vertebrates only. The structure is uniform, and can be learned from the brief account which follows of the largest and commonest species.

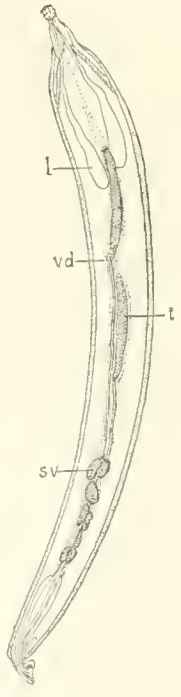

Fig. 4116.—*Gigantorhynchus gigas*. Opened to Show Internal Anatomy. *l*, Lemniscus; *sv*, seminal vesicle; *t*, testis; *vd*, vas deferens. Modified. (Original.)

Gigantorhynchus gigas Hamann 1892.—(Syn.: *Tænia hirudinacea* Pallas 1781; *Echinorhynchus gigas* Goeze 1782.) Body milk white, sometimes slightly tinted, with transverse irregular ridges. Posterior end somewhat smaller; proboscis spherical, armed with five or six rows of hooks. The proboscis can be retracted into a neck-like region, which is much slimmer than the following portion of the body. Male, 60 to 90 millimeters long by 3 to 5 millimeters broad, with bell-shaped caudal pouch. Female, 230 to 350 millimeters long by 4 to 9 millimeters broad; tail blunt; eggs almost cylindrical, 0.087 to 0.1 millimeter long with three embryonic envelopes.

The adult worm is found in the small intestine of the pig, ordinarily fixed to the wall by the proboscis, and is widely distributed.

Structure.—The elongated body (Fig. 4115) is largest near the head and tapers gradually toward the posterior end. At the anterior end a sharp constriction separates the body from the short neck portion, which is not more than one-fourth or one-fifth the diameter of the body close to it. From the apex of this region may be projected the proboscis which is contained within it, like the reversed finger of a glove. As the proboscis rolls out the hooks also turn outward, and when the proboscis is completely extruded the

shape of the organ is nearly that of a sphere on which are from five to six irregular rows of hooks. Behind these the proboscis is slightly smaller.

If the internal structure be examined, it will be seen that the proboscis is provided with retractor muscles, by means of which it may be withdrawn into the body. At the base of the proboscis is the small mass of nervous matter which represents the brain.

There is no trace of an alimentary canal, hence these forms, like the tapeworm, take nourishment by absorption. Two elongated sac-like organs hang down into the body cavity along the sides of the proboscis. These are the lemnisci (*l*, Fig. 4116); their function is uncertain.

The mass of the body is made of up the organs of the reproductive system. All these worms are dicious. The male organs (Fig. 4116) consist of two large testes, together with the ducts and accessory glands connected with them. The tail of the male has a hemispherical expansion, something like the caudal bursa of other nematoda; the male sexual opening in the center of this sac at the tip of the body is provided with a small copulatory organ. The internal sexual organs of the female are much similar in general appearance; the ovaries lie toward the front of the body cavity, which is largely filled with eggs in various stages of development. These are discharged by the oviduct, which opens at the posterior end of the body.

Life History.—The eggs of *Gigantorhynchus* are discharged from the alimentary canal of the host and distributed with feces. When eaten by some insect they are hatched in its intestine. The embryo, which has a conical form armed at one end with four hooks like tapeworm hooks, and a number of smaller ones, penetrates into the abdominal cavity of the insect and encysts there. In this condition the embryos may even live through the metamorphoses of the insect until the host is eaten by some pig. In the alimentary canal of the pig the embryo is set free, attaches itself, and acquires maturity. There is some dispute as to what insect is the intermediate host; the white worm-like larva of the May bug and the larva of the common rose chafer have been found to contain these worms in Europe, and Stiles has experimentally infected the larvæ of the June bug in this country. It is also maintained that various species of snail may function as the larval host. In all probability the larva is not confined to a single host, but may develop in many.

Leuckart accepts some reports of the occurrence of this species in man as trustworthy, and Lindemann says that it is not rare as a human parasite in southern Russia. Schneider notes the consumption, as food, of the larvæ and adults of *Melalontha*, the May beetle, which acts as the intermediate host, so that infection is evidently possible.

Gigantorhynchus moniliformis Bremser 1819.—Body attenuated anteriorly. Proboscis, 0.425 to 0.450 millimeter long, 0.175 to 0.19 millimeter broad, with hooks in fifteen transverse and twelve longitudinal rows. Male, 4 to 4.5 centimeters long. Female, 7 to 8 centimeters long, or even up to 27 centimeters, according to Westrumb. Eggs ellipsoidal, 85μ long, 45μ broad.

The normal hosts of this species are field mice, rats, etc., and the intermediate host in Italy has been determined as *Blaps mucronata*. Calandruccio in experimenting on the life history succeeded in infecting himself with the adult. The severe symptoms which manifested themselves were dispelled by the evacuation of the worms. In other cases of the occurrence of this species as a human parasite its identity was less definitely established.

Echinorhynchus hominis Lambl 1859.—Length, 5.6 millimeters; width, 0.6 millimeter; proboscis almost spherical with twelve transverse rows of eight hooks each. Large hooks, 103μ long, small hooks, 77μ.

An uncertain species of which Lambl found a single specimen at Prague in the small intestine of a boy who had died of leucemia.

Echinorhynchus sp. Welch 1872.—In 1872 Welch described as *Echinorhynchus* a body which he found encysted in the mucosa of the jejunum of a soldier. According to Railliet it was evidently a Linguatulid (see *Arachnida*).

Echinorhynchus sp. Moniez 1896.—Kunstler and Pitres found certain peculiar bodies in the pleural cavity of a patient who had suffered two years from pleurisy, but without fever. They interpreted these structures as coccidia, but Moniez holds with greater probability to their likeness to eggs of *Echinorhynchus*. The case is entirely isolated under either explanation.

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PRINCIPAL ARTICLES CONSULTED.

Bancroft, T. L.: Metamorphosis of *Filaria Bancrofti*. Proc. R. Soc. N. S. Wales, xxxiii., 48.

Blanchard, R.: Nouveau cas de *Filaria loa*. Arch. Parasitol., ii., 504.

Braun, M.: Die thierischen Parasiten des Menschen, Würzburg, 1915.

Fülleborn, F.: Beiträge zur Morphologie und Differentialdiagnose der Mikrofilarien. Arch. Schiffs- u. Tropen-Hyg., Beiheft 1, 1913.

Gedoelst, L.: Synopsis de parasitologie, Bruxelles, 1911.

Graham, J. Y.: Naturgeschiete der *Trichina spirolis*. Arch. mikr. Anat., l., 219.

Huber, J. C.: Bibliographie der klin. Helminthologie, Jena, 1893–98.

Leuckart, R.: Die Parasiten des Menschen, vol. ii., Leipzig, 1876.

Looss, A.: *Strongylus subtilis*, n. sp., Centralb. f. Bakt. und Par., xviii., 161; Anatomy and Life History of *Ancylostoma duodenale*. Dub. Rec. Egypt. Govt. School Med., 1905, 1911.

Lothrop and Pratt, J. H.: Two Cases of Filariasis. Am. Jour Med. Sci., cxx., 525.

Manson, P.: Tropical Diseases, London, 1898.

Neveu-Lemaire, M.: Précis de parasitologie humaine.

Nuttall, G. H. F.: On the Rôle of Insects, Arachnids and Myriapods as Carriers in the Spread of Bacterial and Parasitic Diseases of Man and Animals. Johns Hopkins Hospital Reports, viii., l.

Parona, C.: Pseudo-parassitismo di Gordio nell'uomo. Clinica Med., 1901, No. 10.

Railliet, A.: Traité de zoologie médicale et agricole, second edition, Paris, 1893–95.

Stiles, C. W.: Trichinosis in Germany, Bull. 30, Bureau Animal Industry, 1901; Report of the Prevalence and Geographic Distribution of Hook-worm Disease in the United States, Hyg. Lab., Washington, Bull. 10. *Agamofilaria georgiana* n. sp.—Zoological Characters of Round-worm Germs Filaria. Hyg. Lab., Washington, Bull. 34.

Thayer, W. S.: Occurrence of *Strongyloides intestinalis* in the United States. Jour. Exp. Med., vi., 75.

Ward, H. B.: Parasitic Worms of Man and the Domestic Animals. Nebr. Agl. Rept., 1895. Studies on Human Parasites in North America, I. Filaria loa. Jour. Infec. Dis., iii., 37–90.

Williams, H. F.: Frequency of Trichinosis in the United States. Jour. Med. Research, vi., 64, 1901.

Also numerous shorter papers by the same authors, Askanazy, Cobbold, Grassi, Hassall, Küchenmeister, Leichtenstern, Leidy, Ludwig, Magalhaes, Mark, Penel, Rodenwaldt, C. A. Smith, A. J. Smith, Stossich, Strong, and others.

Neoplasms.—DEFINITION.—Our knowledge regarding the etiology and nature of tumors is still so meager that it is impossible to offer an adequate definition of these processes. It can be said only that a neoplasm is a tissue overgrowth which is independent of the laws governing the remainder of the body; further than this it is impossible to go. It cannot be definitely asserted, as was at one time the custom, that this lawlessly proliferating tissue subserves no useful purpose in the organism, since there is reason to believe that the cells of a tumor involving a gland of internal secretion may continue to elaborate the material characteristic of that organ, and thus save the body from being deprived of the secretion as it would be were the gland in question to undergo destruction by some disease, for example, tuberculosis.

Such a situation is rare, it is true, yet the fact that it can exist at all is sufficient ground for excluding uselessness from the characteristics properly to be embraced in a formal definition of the term neoplasm. Neither can it be said that a new growth is always characterized by the atypical arrangement of its cells, since an occasional example differs in histology little or not at all from the normal structure in which it originates, betraying a neoplastic nature solely by its clinical behavior. Such tumors are found particularly in the thyroid gland and the liver.

Continuous growth, also, must be eliminated from the definition, since, although the great majority of tumors do proliferate indefinitely, even a malignant neoplasm may, under very exceptional circumstances, undergo partial or complete regression. This unusual outcome is most often encountered among the chorioepitheliomata. Furthermore, the successful cultivation of normal tissue *in vitro* for a period longer than two years suggests that this material, also, may be capable of unlimited proliferation under suitable conditions. If the inference be sound, then the faculty of endless growth is to be regarded as characteristic not only of neoplasms but of tissues in general, when the proper environment is furnished.

Terminology.—It is customary to terminate the name of a neoplasm with the suffix "oma," preceded, in the majority of instances, by the name of the tissue in which the tumor has its inception—as, myoma, a tumor originating in muscle; glioma, one developing from the glia, etc. The nomenclature, however, is badly in need of revision; thus, a cylindroma is a growth characterized in its fresh condition by the presence of hyaline cylinders, while a psammoma contains lime, the impression being given upon gross examination that the tumor has been sprinkled through with sand. Moreover, while hematomata and granulomata are really tumors in the sense in which the ancients employed this word, *i.e.* to denote any swelling, they are not true tumors as the term is understood at the present day.

Neoplasms containing more than one kind of tissue are described by such compound terms as myofibroma, osteochondroma, etc., in which the latter half indicates the preponderating element. Designations like these are to be employed, however, only when both tissues are actually involved in the production of the tumor.

General Characteristics.—How does a tumor differ from other proliferative processes? With the qualification introduced above, it may be said with Borst that a tumor is egoistic or independent, and opposed to the best interests of the body, while such proliferative processes as inflammation, regeneration, and hyperplasia are altruistic—are adapted, that is, to the ultimate benefit of the organism. Hence, the chief attribute of a tumor is autonomy, or independence, a characteristic very clearly shown in the observation that the size of a lipoma does not diminish when a condition of general emaciation sets in; indeed, the dimensions of the tumor may even continue to increase.

Another feature emphasized by Borst is the lower plane usually occupied by the tissues of a new growth. Though a tumor generally imitates the appearance of the organ in which it originates, it nearly always falls short of the corresponding normal structure in both architecture and function; its cells, in other words, are immature, being generally less highly differentiated or specialized, and are said for this reason to resemble those of the embryo, which have not yet attained the stage of completion. The departure from type may be but slight, in which case the neoplasm is called homoiotypical, homologous, or mature; if, on the other hand, it be considerable the growth is described as heterotypical, heterologous, or immature. Tumors of the former class are generally benign while those of the latter variety are usually malignant, and it may be said, though only in a general way, that the less closely any given tumor resembles its corresponding normal tissue, the more malignant is it likely to be.

Every new growth contains a characteristic active portion (the parenchyma), and a non-specific and comparatively inert connective-tissue constituent (the stroma) which holds the parenchyma together and carries the blood-vessels for its nutrition. Hence, a neoplasm may be regarded as a sort of organ and, in fact, this very feature was for Albrecht the most important of all those characteristics which separate the tumors from other morbid processes. The clearer the distinction between parenchyma and stroma the more does the new growth resemble an organ, and the more does it merit the term organoid tumor. Conversely, the less abundant is the stroma the more does the neoplasm appear to be made up of but one tissue (histioid tumor). In the carcinomata, at least, the stroma appears to be formed in obedience to some stimulation exerted by the tumor cells and its type to be determined by them. The cells of certain carcinomata (medullary), for instance, excite the production of but a scanty connective-tissue scaffolding, while those of a scirrhous carcinoma provide an amount which may be so great as to constitute the bulk of the tumor; again, the cells of another type, after they have metastasized in the osseous system, possess the power of stimulating the growth of bone. As for the sarcomata, their stroma is usually minimal in amount and composed chiefly of blood-vessels.

Neoplasms often undergo degeneration from failure on the part of their blood supply to keep pace with the rapidly increasing demands imposed upon it, or by themselves shutting off mechanically, as they increase in size, a supply which otherwise would be sufficient; circulation may be restricted in a pedunculated tumor, furthermore, by torsion of its pedicle. The results of this deprivation, howsoever it be brought about, soon become evident in the form of fatty or other degeneration, to which calcification is not infrequently superadded, while tumors situated near the surface of the body often ulcerate in consequence of the softening and suffer the effects of secondary infection.

Benignancy and Malignancy.—A benign tumor proliferates slowly by central growth, expanding like a child's toy balloon; a malignant neoplasm, on the contrary, attacks and replaces the surrounding tissues, spreading by infiltrative or peripheral growth. Benign tumors do not metastasize, as a rule, nor do they recur after removal.

A benign growth sometimes becomes malignant, though the manner in which this occurs is a debated question. Since such a neoplasm consists of mature, or differentiated tissue, the problem is quite as difficult to solve as the origin of a tumor from normal tissue. Borst rejects the possibility that so radical a change can take place in a benign neoplasm, and substitutes the hypothesis that the tumor possessed from its very inception a potential ability for malignant growth which finally became evident upon the falling away of certain local or general inhibitory influences.

Malignant neoplasms grow more rapidly than the benign, though in this respect they vary among themselves; even in the same tumor the growth rate is subject to fluctuations, not only throughout the neoplasm as a whole, but probably also in different areas of it. This observation helps to explain the improvement so often described after various non-operative therapeutic measures, a temporary lull in the activity of the tumor, which would otherwise have passed unnoticed, being ascribed to the treatment. Mere rapidity of growth, however, is not an essential characteristic of malignancy, since the cells of the embryo proliferate more rapidly than those of the malignant neoplasms.

The three main attributes ordinarily ascribed to malignancy are: Infiltration of the surrounding tissue,

metastasis, and recurrence after removal. Still, infiltrative growth is not entirely typical of the malignant tumors, since the cells of the normal placenta possess this property to some degree at least, invading the uterine wall and even its blood-vessels, and sometimes actually reaching the lungs in the form of emboli. Developing glands in the embryo also have the power to invade subjacent tissues though here, as with normal placentation, the process finally comes to a standstill; in the malignant growths, on the contrary, it continues with but very few exceptions until the death of the individual has been brought about.

Metastasis, or the development of secondary nodules in either proximate or remote portions of the body, is a consequence of the transportation of tumor cells through the blood-vessels and lymphatics and their growth at the point where they come to rest; the emigrating cells generally travel with the current, but in the lymphatics they are occasionally able to make their way against it (retrograde metastasis). Metastasis may occur, also, by contact, as when a tumor on the lower lip gives rise to one on the upper. The manner in which metastatic nodules develop forms a cogent argument against the parasitic hypothesis of tumor genesis. In every infectious disease with which we are acquainted, the local manifestations are produced by a tissue reaction directed against the invading microorganism; thus, the cells of a pulmonary tubercle are derived from the lung itself, those of a hepatic tubercle from cells of the liver, etc. The case is entirely different, however, with secondary tumors, the parenchyma of which is produced entirely by the proliferation of cells transported from the primary growth. Hence, a metastasis in the lung from a mammary carcinoma, say, is composed, not of pulmonary elements, but of cells from the mammary gland, the only portion contributed by the lung being the stroma. But not only are daughter tumors made up of cells from the parent growth; they reproduce the architecture of the primary neoplasm, so that metastases from an adenocarcinoma of the stomach become themselves adenocarcinomata, while those from an epithelioma reflect the structure of the skin. Nay, more, even the physiological task of the parent organ is undertaken, as when cerebral metastases from a hepatic growth discolor the surrounding brain with the bile which they secrete.

As a general rule, sarcomata metastasize by way of the blood stream and carcinomata through the lymphatic system, although exceptions to these rules are not unknown; accordingly, carcinomata generally spread first to the adjoining lymph nodes, and sarcomata to the lungs. The investigations of M. B. Schmidt have shown that not all the tumor cells attaining the circulation survive to produce secondary tumors.

The organs to be involved in metastasis depend in some measure upon the situation of the primary growth; carcinomata of the stomach and intestine, for example, are apt to metastasize in the liver, those of the prostate in the bones, etc. The fact that any given region offers a site of predilection for secondary nodules from neoplasms in a certain locality can often be explained by the anatomical relationship of the two parts; in other words, it is sometimes largely a matter of simple mechanics, as in the case of the vulnerability of the liver to invasion by secondary growths from gastric carcinomata. Again, the spleen, which is commonly described as a soil practically immune to metastasis, proves to be not an unfavorable location, in animals at least, for tumor grafts which have been inoculated into it; whence it would appear that its reputed freedom from secondary growths is due more to the failure of tumor cell emboli to lodge there than to any inherent unsuitability for their proliferation, and it is interesting to note, in this connection, that v. Hansemann has but recently denied that this organ in man does resist metastasis. In many instances, however, the explantation is not so simple; no perfectly definite reason can be advanced to explain why the cells of a prostatic carcinoma should prefer the osseous system, and it is most probable that factors still unknown are in operation, one of which may prove, after all, to be the nature of the soil in which the cells have been sown.

Like infiltrative growth, metastasis is not absolutely characteristic of malignancy, since even benign tumors occasionally form secondary nodules.

The third feature of malignancy, recurrence after removal, appears only when extirpation has been incomplete. There is no knowing exactly how long tumor cells may persist in the tissues outside the line of incision before giving rise to a visible metastasis, but it is certain that periods as long as ten years may elapse before the recurrence is noticed; still, this may be regarded as somewhat out of the ordinary, and the best surgical judgment inclines to accept five years as the shortest interval which must elapse before cure can be regarded as reasonably assured.

Even recurrence after removal is not typical of malignancy, since such a benign tissue as adenoid vegetations will return unless the operation has been thoroughly performed.

Cachexia is sometimes added as a fourth sign, but it is extremely doubtful whether malignant growths, as such, are able to induce malnutrition; certainly no definite deleterious product has ever been demonstrated in their cells. It is much more probable, on the whole, that cachexia is due to infection with an ulcerated tumor as its starting-point, to interference with the function of an indispensable organ like the stomach or intestine, or to some influence exerted upon the nutrition of the patient by his depressed mental condition.

The microscopic evidences of malignancy, while generally unmistakable, are occasionally difficult of interpretation, and even the most expert diagnostician may at times be deceived. This being so, it is necessary for the pathologist to have fragments from different portions of the growth at his disposal, and in particular should he be enabled to examine the margin, where, of course, any invasive tendency will be most clearly shown. But even under optimum conditions a decision is reached in some instances only with the greatest difficulty, and this because no exact criterion of malignancy is yet known. None of the cell inclusions so often described is characteristic of malignancy, and while it is true that the cells and their nuclei are often larger in a malignant neoplasm than they are in the corresponding normal tissue, that there is a greater diversity in the shape and size of the cells and in the amount of nuclear chromatin, that the number of mitoses is increased, and that the karyokinetic figures often differ widely from the normal type, it is equally true that these anomalies may exist to some extent in conditions other than malignancy. The individual cells offering thus no certain diagnostic criteria, there remains only the general structure of the growth upon which to base an opinion. A tumor of the breast, for example, composed of gland tubules similar in size, furnished with a single layer of epithelium, and each surrounded by a basement membrane, would be declared benign because it varied but slightly from the normal structure of the organ. Another, made up largely of irregular tubules containing more than one layer of cells, the epithelium exhibiting in addition to its atypical arrangement a distinct power to invade the surrounding tissues, even though in a few areas only, would be regarded as malignant because of its wide departure from the normal architecture of the breast. Such frank examples as those just cited may be accurately diagnosed in the great majority of cases, although every pathologist encounters from time to time a tumor which, in spite of its typical structure, ultimately destroys the patient, and conversely, a neoplasm of

atypical appearance which, nevertheless, proves to be clinically benign.

There is but little doubt that the natural tendency of a malignant tumor to metastasize is often enhanced by injudicious examination, since rough or repeated palpation may readily propel cell emboli along tissue spaces or vessels. The event may be hastened, also, by removing from the growth a fragment for microscopic examination, as blood-vessels and lymphatics are opened in the process; it is therefore better, wherever possible, to extirpate the entire tumor for diagnosis. That this danger is not entirely imaginary is shown by the relative frequency with which malignant neoplasms recur in the scar or the suture holes from cells set free at operation.

Classification.—No one of the elaborate classifications thus far offered can be accepted as perfect, for too little is known of the derivation and function of the normal tissues; furthermore, the nature of certain tumors leads to serious inconsistencies. Thus, as Borst has indicated, malignant growths of the muscles and nerves are included among the sarcomata as myoblastic and glioblastic sarcomata, though the term sarcoma should be reserved for growths of connective-tissue origin. Now muscles and nerves are not connective tissue; considered from the standpoint of embryology, they are of mesodermal or ectodermal origin, and although tumors developing in these tissues possess a morphological resemblance to the sarcomata, there are to be found among them epithelial neoplasms (neuroepithelium) to which it is hardly suitable to apply the term. These and other difficulties pointed out by Borst may be referred, however, to the attention of the special student, while, in the meantime, the scheme employed by this author is adopted as adequate for the present purpose. In pursuance of this plan, neoplasms may be divided into: I. *Connective-tissue Tumors;* II. *Epithelial Tumors;* III. *Embryonoid and Mixed Tumors.* Groups I and II are subdivided into (*a*) *mature* and (*b*) *immature growths.*

Mature Connective-tissue Tumors.—The mature, or benign connective-tissue new growths include such tumors as fibromata, lipomata, angiomata, osteomata, and chondromata. In them it may be said that the task of the tissues has been practically accomplished, though in a somewhat irregular manner, to be sure. The two classes of fibrils characteristic of ordinary connective tissue can be recognized in a fibroma by means of Mallory's stain, the adipose tissue of a lipoma closely resembles normal fat, the angioma consists of proliferating blood-vessels, and the cells of osteomata and chondromata prepare bone and cartilage respectively. In no case, however, is the corresponding normal structure exactly duplicated. A fibroma, for example, is apt to be more cellular than connective tissue, while in the fat composing a lipoma both cells and lobules somewhat exceed the normal dimensions. The atypical condition of the tissues making up a tumor is demonstrated again in the incomplete state of the blood-vessels, the fibromyoma being, according to Adami, the sole example in which they possess muscular coats. All other neoplasms are characterized by the absence of proper arteries and veins with communicating capillaries, and receive their blood supply through simple thin-walled channels. The lymph vessels, too, are abortive, and nerves are not ordinarily present as actual components of the growth.

Immature Connective-tissue Tumors.—The malignant connective-tissue group contains the sarcomata. Though the members are composed of unfinished tissue, it is possible to divide them into two classes—one in which the material is totally immature, and a second in which a certain amount of differentiation has occurred. Those of the former are purely cellular tumors in which the elements make no effort to produce collagen or other intercellular material characteristic of the site at which the growth originates, and appear to expend all their energy in mere proliferation. Such growths, the round and spindle-cell sarcomata, are among the most malignant of all neoplasms. They have practically no stroma save for an abundant meshwork of blood-vessels, and as the walls of these channels consist of a single layer of cells, hemorrhages occur in such tumors with great irregularity. For this reason and because, moreover, some of the vessels appear to have no walls, consisting merely of channels in the parenchyma, tumor cells readily attain the blood stream; hence the sarcomata metastasize early and extensively by way of the circulation.

The second group is made up of sarcomata showing some effort toward differentiation—toward a production, that is, of an adult tissue like bone or cartilage. Here belong such neoplasms as the osteoblastic and chondroblastic sarcomata. The attempt is less successful, however, than that which characterizes the benign connective-tissue tumors arising in similar locations, and, it is hardly necessary to state, falls still further short of what is achieved by the corresponding normal tissue itself.

A sarcoma is distinguished from a benign connective-tissue tumor by the absence or irregularity of the intercellular material, by variation in the shape and size of the cells, by the presence of an increased number of mitotic figures, and by its invasive growth. From an infectious granuloma it can often be separated by the fact that its elements are all of one variety, whereas infectious lesions contain such dissimilar types as fibroblasts, polymorphonuclear leucocytes, plasma cells, etc. Yet it must be confessed that the distinction between a sarcoma and a benign connective-tissue neoplasm, and particularly that between a sarcoma and an infectious granuloma, occasionally proves to be one of the most difficult which the pathologist is called upon to draw.

Mature Epithelial Tumors.—The benign epithelial series embraces the adenomata. The papillomata, often included in this group, are placed by Ribbert in a separate category (fibroepithelial tumors) for the reason that fibrous tissue and epithelium bear an equal part in their production. An adenoma is a tumor developing from glandular structures and imitating the parent organ in the arrangement of its epithelium into tubules bounded by a connective-tissue wall, the limits of which its cells have no power to transgress. As the epithelial elements are arranged in one layer about the lumina of these tubules, the resemblance to the normal structure is distinct, though not by any means complete. For example, there is a larger amount of epithelium than there should be in proportion to the stroma, and this glandular moiety of the tumor is not connected with the excretory ducts of the organ in which the growth is situated.

Immature Epithelial Tumors.—The malignant epithelial tumors comprise the various types of carcinoma, characterized by the immature condition and arrangement of their epithelium.

In these neoplasms, the orderly correlation between epithelium and connective tissue seen under normal conditions and present, though to a smaller extent, in the fibroepithelial tumors and the adenomata, is disturbed. The epithelium becomes totally emancipated from all restraint and, breaking through the restrictions normally imposed upon it, attacks and invades the neighboring structures. Carcinomata may be classified in accordance with the morphology of the elements composing their parenchyma as cylindrical-cell carcinoma, round-cell carcinoma, etc., though their division from a histogenetic standpoint into superficial and glandular carcinoma is, perhaps, more to be recommended.

Their architecture varies according to the structure in which they have their inception. The more highly

differentiated members of the class mimic the normal pattern to some degree, while at the other end of the scale there may be found carcinomata in which the epithelium is utterly undifferentiated, their polymorphous cells being arranged in solid columns or nests. Where there is but a minimal amount of stroma the growth is termed a medullary carcinoma; one in which parenchyma and connective tissue are about equal in amount is known as a carcinoma simplex, while that type in which the stroma greatly preponderates is called scirrhous. The character to be assumed by the stroma seems to be determined by some behest originating in the parenchyma, as has already been pointed out.

The connective tissues at the edge of a carcinoma are not infrequently the seat of an infiltration with small round cells, a condition which is regarded by many observers as a reaction on the part of the organism against further advance by the tumor, and the stroma itself may be more or less cellular in consequence of infection. In a few rare instances, the parenchyma appears to possess the power of converting the stroma into sarcoma; in such cases the carcinoma, as has been said, digs its own grave, for it is nearly always eventually overgrown and replaced by the sarcomatous portion.

To the epithelial tumors Borst adds a subgroup which cannot definitely be included under either the adenomata, the carcinomata, or the sarcomata, and includes therein hypernephromata, chorioepitheliomata, and adamantinomata.

Embryonoid and Mixed Tumors.—The members of Group III are referable to developmental anomalies. In the opinion of Marchand and Bonnet, cystic embryomata and embryonoid tumors of the ovary and testis originate in unused blastomeres at a very early period in the life history of these elements, the period of cleavage, a view with which Wilms wholly agrees; hence these growths contain derivatives of all three germ layers, and approach more nearly than any other to the normal architecture of the adult organism. Elsewhere in the body there occur neoplasms containing products of the three layers and known as fetal inclusions or teratomata, regarding which Wilms partially subscribes to Marchand's belief that they are analogous with the embryomata of the testis and ovary just mentioned. A subdivision of Group III comprehends the mixed tumors, simpler than those of the preceding class though still very complex in their structure. Under this heading Wilms includes the mixed neoplasms of the kidney, cervix, vagina, bladder, vas deferens, palate, and the parotid, submaxillary, and mammary glands. These also have their inception in unused blastomeres, differing from the embryoid tumors only in developing at a somewhat later stage in the life history of these elements—that of the three germinal layers.

Although Wilms, in accounting for the origin of these growths, accepts in part Cohnheim's hypothesis of tumor genesis, he does not agree that misplacement of embryonal remnants is the sole etiological factor; if it were, he points out, an accessory spleen would develop into a tumor.

The malignancy of the mixed tumors varies. Those of the kidney, according to this author, are extraordinarily malignant, whereas those of the parotid are relatively benign; the former, accordingly, often metastasize at an early period, while the latter produce secondary nodules but rarely.

For the term "mixed" tumor Ribbert would substitute "complex" or "composite" tumor, since this more definitely indicates the fact that several tissues take part in the formation of such a growth, and because, furthermore, a true mixture of the various components does not ordinarily occur. Neoplasms made up of two or more modifications of a tissue are not compound, according to this author. A chondro-osteosarcoma is not, for example, since cartilage, bone, and sarcoma are all variants of connective tissue; the constituents must be independent varieties.

By reason of their frequent occurrence, cystic embryomata of the ovary deserve a more extended description than can be given to other tumors of this group. Ordinarily about the size of an orange and filled with fatty débris, these are also known as dermoid cysts because their walls contain epidermis. To recapitulate Ribbert's description: From the smooth inner surface of the fibrous wall there projects at one point or another a nodule covered with hair, and frequently containing bone in which fully developed teeth may be set; section of such a mass will often clearly demonstrate the presence of salivary glands and even thyroid or brain, and since these cystic embryomata contain derivatives of all three germ layers, microscopic examination shows their contents to be even more varied than gross examination would suggest. Solid embryomata are much less often encountered in the ovary than are the tumors just described.

Etiology.—It has been repeatedly pointed out that any adequate hypothesis of etiology should take into account all varieties of neoplasm including the benign, a rule which, as will soon be seen, has been more honored in the breach than in the observance. The development of tumors has been referred, among other causes, to the misplacement and subsequent development of cell areas during embryonal life, to a release with advancing age of the physiological restraint said to be normally exerted upon all the tissues of the organism, and to parasites; these are the suggestions which have been most fruitful in provoking discussion and investigation. Among the secondary hypotheses may be mentioned those that ascribe neoplasia to the occurrence of a specific degeneration and the subsequent emergence of a new cell race, to a loss of function with a concomitant gain in the power of proliferation, to fertilization of the inculpated cells by other elements, to the awakening of "slumbering cells," to the presence of heterotypical mitoses, to a reproduction of the asexual phase of development (the chorion in mammals and its homologue elsewhere), and to a disturbance of chromosome equilibrium (Boveri).

The most famous of all these hypotheses is the first, usually ascribed to Cohnheim, although he was not by any means the first to suggest the association of neoplasms with embryonic rests. In the description of a congenital myosarcoma of the kidney, he suggested that the tumor might have originated from primitive muscle cells snared off from the myotome while the foundations of the urinary organs were being laid down, since more cells than are actually necessary may well be produced during early embryonal life; the unutilized elements, it was inferred, underwent isolation at a very early period in their history, and at a time when all their inherent power of proliferation remained intact. In the undifferentiated embryonal character of tumor cells, as well as in the congenital or early postnatal occurrence of neoplasms, Cohnheim sought support for an hypothesis which, he believed, accounted satisfactorily for the variety of tissues so often found in tumors, while at the same time it explained the clinical observation that epithelial growths are most common at the various orifices of the body, or the very regions where the embryonal structure is most complicated. Cohnheim made no effort to establish the circumstances which initiate malignant growth in an area of cells separated from the remainder of the embryo in the manner described, though offering the suggestion that one of them might be hyperemia.

This hypothesis has been adopted and developed by Ribbert, who believes that many carcinomata originate in embryonal remnants. It is evident, however, that all these are not able to assume the malignant

type of growth, since many of them lie indefinitely quiescent. Hence, although embryonal rests possess in common with other epithelial cell groups a normal tendency to penetrate underlying connective tissues, these latter structures must, under ordinary conditions, oppose some sort of inhibitory influence preventing attack on the part of the epithelium. A release of the normal invasive power may be accomplished by the presence of inflammation or simple hyperemia in the connective tissue, though it is at once apparent that such lesions must be distinguished by some special characteristic, since inflammation and hyperemia in adult connective tissues are not always followed by the development of carcinoma. In Ribbert's opinion, the process can be best explained on the assumption that those changes which precede the inauguration of carcinoma are the product of certain agents elaborated by the epithelium itself or, in other words, that the epithelial cells prepare the soil into which they eventually penetrate. But as this chain of events would terminate merely in the simple displacement of normal epithelium, it is necessary to enlist the subsidiary assumption that cells which become malignant undergo first a loss in differentiation that enables them to proliferate more luxuriantly. Malignant growths can be initiated more readily from embryonal rests than from adult epithelium because the cells of the former are still in a condition of incomplete differentiation.

In criticism of Cohnheim's hypothesis it has been asked how it is possible for embryonal remnants to develop after having lain dormant for years, an objection which loses its validity with the recollection that the sexual glands remain quiescent in the body for fourteen or fifteen years, as do the hair follicles of the face in males. Much more damaging to the hypothesis is Bashford's objection that neoplasms originate where the body is exposed to chronic irritation, and that if they develop from embryonal rests these must be distributed throughout the entire body; hence, that this explanation becomes, in fact, no explanation at all.

As for the hypothesis of Thiersch and Waldeyer, that carcinoma develops in consequence of a disturbance in the restrictions normally imposed by the tissues upon one another, v. Hansemann suggests that if tumors are the outcome of a diminution in physiological restraint during later life they would occur more commonly than they do, and would never arise in young individuals.

In direct opposition to Ribbert's view stands the hypothesis of Hauser and his followers. Hauser believes that carcinoma can originate only through a fundamental change in the biological properties of the cells implicated, an assumption which he supports by the occurrence of such changes as loss of physiological function, increase in the size of the cell and its nucleus, the higher chromatin content of the latter, the presence of abnormal mitotic figures, and finally, the enormous capacity for multiplication. All these characteristics indicate, in his opinion, the appearance of an entirely different type of cell—the emergence of a new cell race—the process, being, in short, a specific cancerous degeneration. In a transformation like this, a weakening of the defenses said to be erected by connective tissue against epithelium can play but a subordinate rôle. While Ribbert and many other authorities hold that a neoplasm can increase only by the multiplication of its own cells ("*aus sich heraus*"), Hauser and his associates maintain that it spreads by a wave of malignant degeneration which attacks successively the normal structures at its margin.

v. Hansemann, who has exhaustively investigated the types of mitosis found in tumor cells, describes three varieties, distinguished according to their chromatin content as hypochromatic, normal, and hyperchromatic. He explains the increased growth energy of the tumor cell by postulating a gain in the power of independent proliferation and a coincident loss of differentiation; this condition he calls anaplasia. He does not regard it, however, as the prime cause of malignant proliferation, since a growth stimulus is required in addition. When a stimulus of this order acts upon a normal cell, the outcome is hyperplasia; upon an anaplastic cell, malignant growth. One of the criteria of anaplasia is an unequal division of the chromosomes during mitosis, which, followed by an asymmetrical division of the cell, results in the production of elements biologically different from their ancestors. Those mitoses are asymmetrical in which the allotment of chromosomes to the daughter stars is unequal, but as the actual number of chromosomes going to each diaster can seldom be accurately enumerated, it is necessary to be content with an approximate estimate. Though v. Hansemann has suggested that irregular mitoses are fairly characteristic of malignant epithelial tumors, they have been found in sarcomata, in benign tumors, and even in regenerating normal tissue.

None of the hypotheses has fared so badly at the hands of its critics as has that which refers neoplasia to the intervention of a parasite. The attitude of the majority of pathologists was well expressed by that brilliant investigator, the late Eugen Albrecht, who declared that there is no more reason to attribute neoplasia to a parasite than there is to refer to such a cause the development of the nose. No definite proof has ever been offered in support of this hypothesis, the parasites occasionally associated with neoplasia (as in the cancer of the rectum and bladder which sometimes accompanies bilharziosis) being regarded merely as the cause of a chronic irritation which, in its turn, gives rise to the new growth. The existence of "cancer villages," "cancer streets," and "cancer houses," together with much of the other evidence so frequently advanced in support of the parasitic hypothesis, must be viewed with absolute scepticism until more cogent proofs have been adduced to sustain the contention. It can often be shown, for instance, that a "cancer village" is one in which the population is composed largely of individuals in the cancer age, most of the younger ones having migrated to the cities, while those authors who describe "cancer houses" take no account of the law of chance. As Adami has so well said, in discussing this question: ". . . . by the law of chance, just as one individual in a thousand may be of gigantic proportions, so one house in a thousand may show a great excess of cases of cancer—or of twin births—over the ordinary run of houses." Few of the reports describing the transfer of a neoplasm from one person to another (*cancer à deux*) are in any way convincing. If large numbers of individuals could be experimentally engrafted with a neoplasm, as mice are engrafted, a certain proportion might develop tumors; at any rate, a tumor sometimes becomes implanted upon an adjacent area of the patient's body, and there is no reason to suppose that the cells of a malignant growth would not proliferate in other individuals also, if they could be introduced under suitable conditions. But the ordinary contact of a physician or nurse with a patient, or between two persons residing in the same house, is hardly close enough for transfer from one to the other. And yet it would be a bold investigator indeed who would declare categorically that neoplasia is not an infectious process; it can be asserted only that it does not resemble any of those with which we are at present acquainted.

In regard to diet it is possible to be more definite, and it may be safely maintained that no relation can be discerned between diet and neoplasia, since tumors are discovered with equal frequency in vegetarian races and those living on a mixed diet; nor is there any convincing evidence of a connection between the occurrence of neoplasms and the character of the soil, the climate, or other surroundings.

It is evident that the suggestions so far advanced have contributed but little toward a solution of the

problem, and it is not even known whether tumors, as a group, have one cause in common or whether each member of the series has its own determining factor. The only definite information so far acquired in regard to etiology is that neoplasia seems to be in some way associated with chronic irritation, a connection that has been substantiated far too often, both in man and the lower animals, to be dismissed as a mere coincidence. Carcinoma about the mouth in smokers or in individuals with rough carious teeth, sarcoma of the finger in needlewomen, and fibroma occurring in horses at the points of pressure by collars or girths are a few of the most suggestive among almost innumerable examples. A discussion of the relations of age and heredity to etiology will be found in the articles on *Cancer* and *Carcinoma* in vol. ii. of this Handbook.

Attempts to Produce Neoplasms.—The possibility of inciting a new growth in tissues previously normal has attracted and maintained the interest of a large number of investigators. The recorded attempts are numerous, and if, as is possible, there have been still others which have never been published because of their negative outcome, the number of times that the experiment has been made must be very large. The greatest number have been moulded to fit one or the other of the two most widely known hypotheses of tumor genesis—the hypothesis of cell irritation and that of cell displacement, following which investigators have irritated cells or misplaced them in every conceivable way; but, save for Clunet's experiments, where sarcomata appeared in rats that had been exposed to *x*-rays, the outcome has always been negative. The power of these rays to incite malignant growth is sadly evident, moreover, in the number of operators who have developed carcinomata on the hands in consequence of the freedom with which they exposed themselves before the necessity for a protecting screen had been recognized. The recent work of Fibiger may prove to be a second exception; at present, however, it is still so recent as to lack confirmation. Fibiger has reported carcinoma of the stomach in rats fed for sixty-six days or more on cockroaches infected with a nematode which he has named *Spiroptera neoplastica*, and for which the cockroaches *Periplaneta americana*, *P. orientalis*, *Blatta Germanica*, and the meal-worm (*Tenebrio molitor*) are the intermediate hosts. In two instances the tumor had metastasized in the lungs, and in one there was a secondary nodule in a retroperitoneal lymph node.

The Biological Investigation of Neoplasms.—More information regarding the nature of tumors has been gathered in the past fifteen years than accumulated during all the preceding centuries, since neoplasms can now be studied in the lower animals. The earlier experiments of Hanau, v. Eiselsberg, and others who succeeded in transplanting tumors of the rat, supplemented by the investigations of spontaneous and transplantable carcinomata, sarcomata, and chondromata of the mouse by Jensen, Loeb, Borrel, Bashford, Murray, Russell, Haaland, Gaylord, Clowes, Baeslack, Sticker, Ehrlich, Apolant, Tyzzer, Rous, and Murphy, have already cleared up a number of questions, and it is to be hoped that this method of attack will eventually prove capable of solving the arch-problem itself.

Transplantable neoplasms have been discovered also in the dog, the rabbit, and the guinea-pig, while lesions resembling the true tumors in many respects are being investigated in the trout (Gaylord) and the domestic fowl (Rous). The nature of the latter two growths, and that of the so-called lymphosarcoma of the dog (Sticker) has not yet been definitely ascertained.

The mouse has been chosen for investigation principally because of the facility with which it can be obtained and handled, and the fact that our more recent knowledge of neoplasia depends almost entirely upon observations in this animal must not be taken to imply that the findings might not hold good for malignant growths in other species, were it convenient to investigate them in the same way. In the mouse, the usual site of origin for carcinoma is the female mammary gland, for sarcomata the subcutaneous tissues, and the clinical course of the disease follows closely that in man. Metastasis is common in both varieties of neoplasm, though it usually takes place by way of the blood stream and but rarely through the lymphatics, while true infiltrative growth is easily demonstrable.

Neoplasms of the lower animals have furnished a material excellently adapted to investigation of the parasitic hypothesis. The descriptions of "tumor cages" which have appeared from time to time in the literature have been regarded by a few observers as evidence of such an etiology, but the animals in which the disease appeared have been generally old female mice, and in most instances the neoplasms occurred in the mamma; that old animals should have been affected at the site where cancer ordinarily develops suggests that these alleged epidemics were due merely to the sudden outcropping of a number of spontaneous new growths, and makes it unnecessary to invoke an infectious etiology. The spontaneous tumors of the mouse are transplantable into other mice, it is true, but this fact affords no support to the hypothesis now under consideration, since the transfer is not in any way an infection but, on the contrary, a real transplantation. Within the first few days after the insertion of the graft, fibroblasts and blood-vessels from the host penetrate it in large numbers, replacing the old stroma, which gradually dies. The parenchyma, on the contrary, survives to give rise to the new tumor solely by the multiplication of its own cells; there is no evidence that neighboring elements in the host's tissues are converted into cancer cells.

Transplanted neoplasms are to be sharply distinguished from the spontaneous, for in the former case one is dealing with the cells of a certain animal introduced into the organism of another and consequently living under somewhat adverse conditions, while in the case of a spontaneous growth the cells of the tumor are the cells of the very animal itself, and their environment is consequently much more favorable. One indication of this distinction may be found in the fact that transplanted tumors frequently retrogress, although among spontaneous neoplasms of the mouse such an event occurs in less than one per cent. of cases; the difference is further shown by the readiness with which a spontaneous tumor can be transplanted into the mouse in which it arose, as contrasted with all other mice.

Mice may be immunized against the transplantation of either carcinoma or sarcoma by unsuccessful engrafting with a mouse tumor or by the inoculation of normal and intact cells of their own species, but the tissues of an animal itself, when reintroduced into its organism, have not the power to confer resistance, nor can a mouse bearing a spontaneous tumor be immunized with the tissues of other mice against the inoculation of its own growth into another part of the body. This fact is of extreme importance, bearing as it does upon attempts to circumvent metastasis or recurrence. When a graft is implanted into an animal which has been rendered immune, the ingrowth of fibroblasts and blood-vessels described in a preceding paragraph does not occur, and the fragment gradually dies from mere inanition; there is nothing to suggest that it is destroyed by any immune forces similar to those with which we are at present acquainted.

Since the cells of a sarcoma can hardly be distinguished from those of normal proliferating fibrous connective tissue, it has been impossible, so far, to

extend these histological investigations to include the sarcomata. This type of neoplasm will not grow in immunized animals; so much is certain; but whether the defeat is due to an absence of the stroma reaction, as it is with the carcinomata, cannot be ascertained by any method yet at our command.

Returning now to resistance against transplantable carcinoma, this is active only against a graft which is in process of establishing itself in a new host, having no inimical effect upon a transplanted tumor that has already gained a foothold, and it would certainly be even less efficacious against a spontaneous neoplasm; hence, the treatment of malignant new growths in man by means of tissue emulsions, filtrates, and so forth, has no support from the experimental work so far accomplished in the laboratory.

Treatment.—The problem of treatment is to find some substance which will exert a destructive action upon the malignant cell while at the same time the other cells of the body remain uninjured; but the difficulty of discovering such an agent becomes more and more evident as we constantly fail to detect any distinct difference between malignant and normal elements, with the one exception so far known, that the cancer cell usually possesses the power of continuous growth within the body. It has not been demonstrated beyond discussion that radium exerts a selective action upon the cancer cell, though its general cauterizing power is recognized, nor has chemotherapy yet offered anything of value; immunity, also, has proved to be but a barren field, since the existence of anything in the nature of an antibody has never been clearly shown.

Surgery, therefore, offers at present the only rational means of combating the disease. The hope of substituting some specific means of treatment for this crude and only too often inefficient procedure is based on the observation that transplanted tumors, and in a few instances even spontaneous growths, have been known to recede, although there is still no indication of the manner in which this occurs. Accordingly, although many of the results of ten years' investigation have been negative in so far as immediate applicability is concerned, they have at least fully demonstrated the utter hopelessness of temporizing with malignant disease, and the imperative necessity of early and thorough removal.

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Bibliography.

Borst: Echte Geschwülste. Aschoff's Pathologische Anatomie, vol. i. Die Lehre von den Geschwülsten, Wiesbaden, 1902.

Albrecht: Frankfurter Zeitschrift f. Path., 1907, i., 221.

Schmidt: Die Verbreitungswege des Carcinoms, etc., Jena, 1903.

v. Hausemann: Münch. med. Wchnschr., 1915, lxii., 339. Studien über die Spezificität, den Altruismus und die Anaplasie der Zellen, Berlin, 1893.

Adami: Principles of Pathology, Philadelphia and New York, 1910, vol. i.

Wilms: Die Mischgeschwulste, Leipzig, 1899.

Ribbert: Das Karzinom des Menschen, Bonn, 1911. Geschwülstlehre, Bonn, 1904.

Boveri: Zur Frage der Entstehung maligner Tumoren, Jena, 1914.

Cohnheim: Arch. f. path. Anat., etc. (Virchow), 1875, lxv., 61. Vorlesungen über allg. Path., vol. i., Berlin, 1877.

Bashford, Murray, Cramer, Haaland, Russell: Sci. Reports, Imperial Cancer Research Fund, London.

Thiersch: Der Epithelialkrebs, namentlich der Haut, Leipzig, 1865.

Waldeyer: Arch. f. path. Anat., etc. (Virchow), 1867, xli., 470.

Hauser: Das Cylinderepithel-carcinom des Magens, etc., Jena, 1890

Clunet: Recherches expérimentales sur les tumeurs malignes, Paris, 1910.

Fibiger: Zeitschrift f. Krebsforsch., 1914, xiv., 295.

Jensen: Centralbl. f. Bakt., etc., erste Abt., Orig., 1903, xxxiv., 28, 122.

Loeb: Jour. Med. Research, 1901, N. S., i., 28.

Borrel: Ann. de l'Inst. Pasteur, 1903, xvii., 112.

Gaylord, Clowes, Baeslack: Annual Reports, New York State Cancer Laboratory Carcinoma of the Thyroid in the Salmonoid Fishes; Bull. Bureau of Fisheries, 1912, xxxii.

Sticker: Zeitschrift f. Krebsforsch., 1903–04, i., 413, and 1906, iv., 227, Arch. f. klin. Chir. (v. Langenbeck), 1906, lxxxiii., 773.

Ehrlich, Apolant: Arbeiten a. d. Königl. Inst. f. exp. Therap., Heft i., 1906.

Tyzzer: Reports of the Cancer Commission of Harvard University.

Rous and Murphy: Jour. Exp. Med., 1910, xii., 696, and 1912, xv., 119, 270.

Williams: The Natural History of Cancer, New York, 1908.

Woglom: The Study of Experimental Cancer: A Review, New York, 1913.

Bainbridge: The Cancer Problem, New York, 1914.

Neosporidia.—Sporozoans in which spores are formed during the growth of the trophozoite. Many important parasites are included in this group but few of them occur in man. *Sareocystis* and *Rhinosporidium* are two genera of medical interest. See *Protozoa*.

A. S. P.

Nephrectomy.—By nephrectomy is meant the removal of a kidney. The entire kidney may be removed—*total nephrectomy*, or merely a portion of a kidney, as one pole—*partial nephrectomy*. A nephrectomy is called *primary* when a kidney is removed the first time it is cut down upon; *secondary* when following a previous nephropexy, nephrotomy, nephrostomy, or partial nephrectomy. The first nephrectomy was done in 1869 by Gustav Simon, of Heidelberg, who successfully removed a healthy kidney in order to cure a persistent abdominoureteral fistula.

Indications.—The most common conditions affecting the kidney whereby its removal may be required are: (1) tuberculosis; (2) hydro- and pyonephrosis; (3) malignant tumors; (4) injuries and wounds; (5) acute septic infarction; (6) renal calculi; (7) hydatid or other cystic disease; (8) certain cases of dystopic kidney; and, occasionally, (9) because of ureteral disease or injury, or its invasion by new growths. Among other rare indications for nephrectomy may be mentioned unilateral chronic hemorrhagic nephritis, "essential" hematuria, "idiopathic" nephralgia, and aneurysm of the renal artery. Nephrectomy for movable kidney, formerly occasionally practised, is absolutely indefensible. It is, of course, understood that nephrectomy is not indicated in *all* cases where a kidney is affected by one of the above-mentioned conditions, but only when less radical measures are found to be inadequate. For example, renal calculi are usually removed by nephrotomy or pyelotomy and nephrectomy is seldom indicated unless (*a*) marked destruction of parenchyma has occurred, usually with such an accompanying degree of infection and sclerosis that the value of any remaining secreting structure is problematical, or (*b*) when calculous disease is unusually widespread, or (*c*) when the calculus is very large and with so many branching processes that its complete removal would be difficult or impossible without too serious risk of secondary hemorrhage. In the writer's opinion, early total nephrectomy offers the only hope for cure of renal tuberculosis; yet many questions come up for consideration before removing the kidney in the individual case, notably the condition of the other kidney and the presence of marked tuberculous lesions elsewhere; hence for more accurate information as to the indications for nephrectomy in these cases the reader is referred to the article on tuberculosis of the kidney where operative treatment under varying conditions has been considered somewhat in detail. Likewise, in early stages of hydro- and pyonephrosis the cause of the obstruction may often be removed and a cure effected with or without the institution of temporary

drainage of the kidney. Also, in acute septic infarction of the kidney it is only the more severe types of the lesion which call for nephrectomy, the milder types progressing favorably after nephrotomy or decapsulation, while the mildest types do well even with non-operative measures. Finally, wounds and injuries of the kidney must be very severe to require total nephrectomy, for it has repeatedly been shown that unless too extensive morcellation has occurred it is usually possible to reunite the fissured parenchyma and to control the hemorrhage by suture, by packing, or by a combination of the two. Nephrectomy in these cases is indicated when the kidney is injured beyond hope of repair, when the blood supply seems likely to be inadequate, when the pelvis or ureter are irreparably injured, and when the condition of the patient will not allow time for the practice of conservative surgery.

To avoid repetition of matter relating to the diagnosis of conditions requiring nephrectomy to be found elsewhere in this Handbook under the respective topical headings, it is assumed that through a consideration of the clinical history, the *x*-ray findings, the evidence furnished by cystoscopy, with or without ureteral catheterization, and any other diagnostic aids, it has been determined (1) that nephrectomy will probably be required; (2) that the other kidney is present and functionally competent; and (3) that the general condition of the patient is such as to warrant a major operation. In this latter connection, one of Gerster's[1] rules is well worth notation. This is that when the hemoglobin test indicates less than thirty per cent. no operation is undertaken if the anemia is due to neoplasm or to a chronic form of suppuration; but if on the other hand it is the result of recent copious hemorrhage, nephrectomy as a hemostatic life-saving measure is unhesitatingly done.

Technique.—The kidney and its vessels may be reached retroperitoneally (1) by the lumbar route, or (2) by the lateral abdominal, or paraperitoneal, route; transperitoneally, by anterior abdominal incision. The lumbar route is the one usually chosen; the lateral, or paraperitoneal, route has a few adherents; while the transperitoneal operation is generally reserved for occasional cases of large solid tumors and, rarely, when adhesions are found to be so dense that enucleation presents unusual difficulties and the danger of provoking uncontrollable hemorrhage. Here the combined lumbar and abdominal routes are occasionally employed.

Lumbar Nephrectomy.—The patient lies upon the sound side with knees and hips semiflexed. Unless the operating-table is equipped with a special device for that purpose, the tissues between the last rib and crest of the ilium are raised by sand bags or, better, by an air cushion (see Fig. 3598, vol. v., p. 750). The operator usually stands behind the patient and makes his incision from above downward on the right side and from below upward on the left. Landmarks are the outer border of the erector spinæ muscle, the twelfth rib, and the crest of the ilium. Various types of incision have been employed. Vertical incisions do not give sufficient room if the kidney is at all large. König's angular incision gives a beautiful exposure but is apt to be followed by hernia. The Mayo[2] curved incision is very satisfactory; but the incision most commonly used at the present time is an oblique one starting just below the point where the outer edge of the erector spinæ muscle crosses the twelfth rib, thence obliquely downward and forward, passing about an inch above the crest of the ilium and as far anteriorly as seems necessary in the individual case, commonly to a point nearly opposite the anterior-superior spine. This incision may be prolonged forward parallel to and about an inch above Poupart's ligament until its midpoint is reached. If more room is required above, as occasionally happens, particularly with tumors involving the upper pole of the kidney, the incision may be prolonged vertically upward and the lower portion of the thorax mobilized by subperiosteal division of the twelfth and, occasionally, of the eleventh ribs. The length and obliquity of this incision will depend upon the obesity of the patient, the space between the last rib and crest of the ilium, and the size of the affected kidney. It is a serious mistake to attempt nephrectomy through too short an incision.

Skin, superficial and deep fascia, muscles, and lumbar aponeurosis are divided down to the transversalis fascia avoiding, if possible, injury of the last dorsal and iliohypogastric nerves. Any bleeding points in the superficial portions of the wound are left temporarily in the grasp of forceps, prolonged pressure without ligation usually being sufficient to check hemorrhage from vessels in this situation. Bleeding points in the deeper portions of the wound are ligated before dividing the transversalis fascia in order to have a clear field unobstructed by artery clamps or obscured by blood. The transversalis fascia is now incised in the upper part of the wound and the incision cautiously prolonged downward the full length of the wound. The fatty capsule of the kidney now comes into view and is incised far back under the outer border of the quadratus lumborum muscle in order to avoid opening the peritoneum. Two fingers are then inserted through this incision, the kidney is recognized, and by blunt dissection a portion of the fatty capsule is separated, the mass is drawn forward and a portion of the kidney exposed. Gerster lays great stress upon immediately identifying the peritoneal reflection after incision of the transversalis fascia, stating "that the primary exposure and identification of the peritoneal reflection is advisable in all cases; it is necessary when we are dealing with a suppurating kidney, and is of the utmost use where the great size of a renal new growth demands circumspection in gauging adhesions to adjacent tissues and organs, and the preliminary securing of the renal vessels indispensable." Having exposed the kidney, the manner of its removal will vary with the conditions found. If the fatty capsule is normal it is readily stripped from the kidney by the gloved fingers, the peritoneal reflection is easily seen and the peritoneum pushed away from the anterior surface of the kidney, allowing easy access to the ureter and vessels of the hilum. The fingers are then passed under the lower pole of the kidney, lifting it upward and toward the operator, thus putting the ureter on the stretch and rendering it easy of identification. The finger is then passed under the ureter and it is cleared from its bed for a space of an inch or more, two clamps are applied an inch apart, the ureter divided between them, both ends are carbolized and a ligature applied to the lower portion which is allowed to drop back to its bed, the ligature being left long for ease in identification later if resection at a lower level is contemplated. The finger then follows the upper segment of the ureter to the pelvis, clearing it of fat, the excess of loose areolar and fatty tissue is cleared from the vessels at the hilum and the pedicle is isolated. The kidney is then grasped in the left hand and drawn out of the wound as far as possible, the pedicle exposed, and a clamp applied close to the kidney. A blunt aneurysm needle threaded with No. 3 plain or chromic catgut is passed through the pedicle on the proximal side of the clamp and between artery and vein if they can be differentiated. The loop of catgut is then caught and divided and the needle withdrawn, thus leaving a ligature for each half of the pedicle. We have long been taught that the artery should be tied first, but Gerster's experience led him to suggest that when securing a pedicle containing large vessels it is best to tie and divide the vein first, then the artery, since otherwise too much tension may be put on the delicate walls of the vein which becomes unduly stretched and may be easily

cut or torn by the ligature. This advice is concurred in by W. J. Mayo.[3] When there is a long pedicle the kidney may often be brought entirely out of the wound and the preliminary application of a clamp before passing the ligatures may be unnecessary. In any event no tension should be made on the pedicle while the ligatures are being drawn taut. The pedicle is then cut close to the kidney and the kidney removed while the pedicle is controlled between the middle and index-fingers of the left hand. The cut ends of the renal artery and vein may then often be seen and may be picked up by forceps and separately ligated once more as well as any other small bleeding points, or a lock-stitch suture of No. 2 plain catgut may be taken distal to the original pedicle ligatures. Since even with a normal sized kidney a considerable cavity will be left after nephrectomy, it is practically always well to drain even a clean wound for forty-eight to seventy-two hours by rubber tube or cigarette drains or both, allowing them to emerge at the dependent portion of the wound. The wound is then closed by layers down to the drainage point, No. 2 or 3 chromic catgut being used for the deep structures, plain catgut or silk for the skin. If the patient is in poor condition or the wound infected, through-and-through silkworm-gut sutures may be used. In closing the skin it is well to place the sutures relatively far apart to allow for the considerable oozing that usually takes place.

When the tumor is large and the fatty capsule is sclerosed or contains septic foci, or when it is invaded by new growth, nephrectomy is far from being the relatively simple procedure described above. Here adhesions are carefully separated, the tumor mass freed and the pedicle then developed in a manner analogous to that described above, though with far more difficulty. In these cases Gerster's warning to identify the peritoneum at once should certainly be observed; since the work is not only made far more easy, but the danger of rupturing the peritoneum and allowing septic material to gain entrance to the peritoneal cavity without being aware of it, is removed. With the peritoneum in sight when torn or cut through, the wound in the peritoneum is sutured at once or the opening is packed with gauze and soiling prevented until such time as the accident can be conveniently attended to. Then, too, occasionally a section of peritoneum may be so intimately adherent to the infected mass that its separation may be practically impossible and its excision *en bloc* may be required. This can be done safely only when incision can be made under the guidance of the eye through a free portion of the peritoneum and the attached portion thus circumcised, the hiatus in the peritoneum then being closed by suture. In most cases adhesions are most dense around the upper pole; and it is in these cases, as well as when the tumor is merely large, that extension of the incision upward and mobilization of the lower portion of the thorax by division of the last one or two ribs may often be necessary. With inflammatory processes elsewhere in the fatty capsule the tissues of the pedicle are often infiltrated and friable. Before ligature, its size is reduced by careful dissection as much as is consistent with safety and still it may remain too large for simple double ligature as described above. In such a contingency the pedicle must be ligated in several sections. After the tumor is removed an opportunity is presented for revision of the pedicle and it is well to find, if possible, and separately ligate the main renal vessels distal to the original ligature, or whip over this portion of the pedicle by suture. Particular care to avoid unnecessarily strong traction upon an infiltrated pedicle is absolutely essential, as otherwise the renal vein may be torn. Should this accident occur, hemorrhage should be controlled by the fingers until the field can be mopped dry and the kidney dislocated sufficiently to allow accurate application of the forceps, for indiscriminate attempts to catch the vessel obscured by a pool of blood are apt to inflict irreparable damage, while the chances of accurately grasping the severed vessel are but slight. Drainage in infected cases should be liberally provided for by rubber tube and cigarette drains and occasionally by gauze arranged by Mikuliez's method, or the cavity is lined with thin sheet rubber dam having numerous perforations and the gauze packed in this.

Subcapsular Nephrectomy.—When the fatty capsule contains septic foci or is invaded by tuberculosis or new growth it is, of course, entirely removed if possible. When, however, the capsule is not so affected but is densely adherent to surrounding structures, as is apt to be the case with long-standing pyonephroses and after previous operative attack upon that kidney, subcapsular nephrectomy may be done. As Gerster says, "Whenever it becomes evident that the division of the adhesions at the upper and lower poles of the kidney would involve tedious and risky dissection, rupture of a pus sac, and simultaneous injury due to the soiling of adjoining large cavities, the subcapsular method should be adopted." The position of the patient and exposure of fatty capsule is as in ordinary lumbar nephrectomy. An incision is then made over the full length of the convex border of the kidney through the fatty and true fibrous capsules exposing the parenchyma. The kidney is now shelled out of its capsule, usually by blunt dissection aided by an occasional snip of the scissors, until the pelvis is reached. Upon this a portion of the capsule is reflected so that the entire pedicle is often somewhat massive and contains, in addition to the renal vessels and their normal supporting structures, the pelvis of the kidney and sometimes the ureter. There are several methods of delimiting and securing the pedicle. As adhesions to surrounding structures have not been separated, the kidney cannot be brought far forward into the wound, hence the pedicle clamp must often be applied by touch rather than by sight. With an assistant steadying, *but not making traction on*, the kidney, the tissues forming the pedicle are held between the index- and middle fingers of the left hand and a large curved clamp passed so as to compress the pedicle at a point between the fingers and the kidney. The blades of the clamp should extend well beyond the edge of the pedicle. When it is certain that the forceps embrace what is wanted *and no more*, they are tightly closed and the kidney is cut away with scissors, the incision running through a little kidney tissue if necessary rather than being placed too close to the clamp. With the kidney out of the way the pedicle is now inspected and the renal vessels identified if possible and ligated individually; otherwise the mass is ligatured in sections. Albarran's extracapsular method of tying the pedicle is quoted by Taylor[4] as follows: "While the divided pedicle is still held by the clamp an incision is made through the reflected capsule all around the pedicle, one centimeter internal to the instrument; then by careful blunt dissection the tissues investing the vessels and ureter are stripped backward. The ureter is ligatured as low as possible and divided. The vessels are then tied by a double ligature in two portions and in addition a mass ligature is applied for greater security. The portion of the pedicle on the distal side of the last ligature is cut away together with the clamp."

When ligation of the pedicle presents unusual difficulties Gerster uses a solid elastic ligature. It is composed of pure gum, one-sixth of an inch in diameter, and should be carefully tested before use. When this is not available pure black rubber tubing may be used. His description of the technique is as follows: "A piece of about twelve inches in length is passed around the pedicle as high up as possible and in such a manner that the middle of the cord will be in contact with the pedicle. Thus each half of the cord will be held by one hand of the surgeon. While

an assistant supports the kidney, the surgeon should steadily and firmly stretch the two segments of the cord and, maintaining the tension, should cross the two 'legs' of the band, the crossing point being in close proximity to the pedicle. At this point another assistant will pass a short piece of stout silk ligature under the point of crossing of the two halves of the rubber cord. Now the surgeon, still maintaining tension, will increase the angle at which the two ends of the cord were held to about 120 degrees, whereupon the silk ligature is firmly tied and the tension of the cord released. The result will be that the parts of the cord thus released will shorten, thicken, and will crowd up against the silk ligature, while the segment confined within the silk ligature and embracing the pedicle will remain at utmost tension. It cannot slip, it will remain tense to the end, while slowly cutting through the pedicle, and is the simplest and most dependable form of ligature known. It is far superior to silk or catgut, both of which soon become loose if applied to a stout and edematous pedicle." The method of securing the rubber band with a silk ligature was tested by him hundreds of times without accident and he considers it much better than a knot tied in the rubber cord itself. The ends of the rubber and silk ligatures are brought out through the drainage wound. The length of time required for the coming away of the rubber ligature varied between twelve and thirty-six days.

Occasionally in any type of lumbar nephrectomy when the pedicle is very short and an elastic ligature is not at hand, or the tissues are especially friable, or the patient is in poor condition, it may be advisable to leave clamps in place rather than attempt ligation. Murphy[5] uses two special right-angled jaw clamps with detachable handles for this purpose. When clamps are left in place the wound is packed with gauze, partly for drainage but more especially to steady the clamps, and the entire wound is left open or partially closed at each end, while several provisional through-and-through silkworm-gut sutures may be passed, to be tied later as the gauze is removed. Clamps are removed in three to five days.

Management of the Ureter.—When the ureter is found to be practically normal at the point elected for initial section, the mucous membrane is touched with ninety-five per cent. carbolic, the ureter is ligated and usually simply dropped back to its bed; though before this is done some infold the mucous membrane by purse-string suture. If the ureter is inflamed and the walls infiltrated it is freed and removed as far down as possible and few drops of ninety-five per cent. carbolic injected into the distal segment before ligation. In tuberculous cases some follow the method of carbolic injection just described, but it is unquestionably better surgery, as Lilienthal[6] suggested some years ago, to remove the ureter at its entrance to the bladder—*nephroureterectomy*. The technique is as follows: After removing the kidney, a urethral bougie is passed down the ureter and tied in. After the ureter is freed through the nephrectomy wound as far down as possible, the lumbar wound is closed to the drainage opening and dressings applied. The patient is then placed on the back and a short incision is made over Poupart's ligament, the inner extremity of the incision being at the edge of the rectus. Through this incision the peritoneum is stripped away from the pelvic wall until the ureter with the contained bougie is easily recognized, freed down to the bladder and brought out of the wound. The bougie is now removed, the ureter resected near the entrance to the bladder, the stump ligated and its mucous membrane cauterized by ninety-five per cent. carbolic or the actual cautery.

Accidents Occurring During and Following Lumbar Nephrectomy.—Among these the following require special mention.

Injuries to the Vena Cava.—Injuries of this structure during removal of the right kidney are not rare when infiltration has rendered the tissues of the pedicle friable and when the pedicle is unusually short. Under these circumstances the renal vein is occasionally torn, or cut through during the application of a ligature, and in efforts to clamp it the renal vein may be torn away from the vena cava, or the latter may itself be torn by the forceps. In operations upon the left kidney, the vena cava is not endangered.

Duodenal Injuries.—Another, but much more rare accident during removal of the right kidney consists in injury to the duodenum. W. J. Mayo[3] has reported three such cases, all ending fatally.

Accessory Renal Vessels.—These have been shown to be very common and since sudden copious hemorrhage from this source may occur, one must be on the watch for them when separating adhesions along the inner aspect of both poles of the kidney.

Opening of the Pleura.—When more room is required above, if division of the ribs is made subperiosteally there will be no danger of opening the pleura unless the assistant later retracts it too strenuously against the sharp, fixed, vertebral portions of the ribs. If this accident happens, or if the pleura is opened in the process of separating dense adhesions, it is signalized by a slight hissing sound with each respiration. The rent in the pleura should be immediately closed by suture or by temporary gauze packing, and suture later if the situation does not allow its immediate closure. It is remarkable how seldom serious consequences result from this accident.

Opening of the Peritoneum.—This accident and the means for its prevention have already been discussed.

Opening of the Pelvis of the Kidney.—This may be avoided by identifying the ureter early and clearing it up to the pelvis.

Secondary Hemorrhage.—This may occur when there is much infiltrated fat in the pedicle so that the ligature is not properly settled down upon the vessels, or from the slipping of a carelessly applied ligature; otherwise it is seldom seen except in the presence of sepsis. If hemorrhage is severe the wound should be immediately reopened and an attempt made to locate and clamp the bleeding vessel. Failing in this, the wound is tightly packed with gauze.

Anuria.—Transient anuria is not at all uncommon. If it is persistent after saline infusion and a fair trial of medical measures the other kidney should be decapsulated.

Shock.—A certain amount of shock is to be expected, particularly in difficult cases, if there has been much tugging on the pedicle, or much loss of blood.

Lateral Abdominal, or Paraperitoneal Nephrectomy.—This route is rarely used but is recommended by some when the kidney is large and its size could not be reduced by aspiration after the usual lumbar exposure, and particularly when the kidney is affected by malignant growths. The patient lies on the back or slightly turned toward the sound side, with an air cushion under the loin. The incision starts immediately in front of the tip of the eleventh rib and goes vertically downward nearly to the spine of the ilium. If more room is needed accessory incisions are made from the upper and lower extremities of this incision —forward along the costal margin above, or parallel to Poupart's ligament below. After the incision has been carried through the transversalis fascia the peritoneum is stripped from the lateral and posterior abdominal wall, exposing the perirenal fascia. This is incised and the lower pole of the kidney worked out, any large vessels that are encountered being divided between ligatures at once, since the vessel walls in cases of new growth are thin and likely to be torn by forceps left in place during further manipulations. The lower pole of the kidney is now tilted up and the ureter identified, doubly ligated and divided. The

upper pole is worked out, pedicle defined and ligated and the kidney then cut away as in lumbar nephrectomy. If enlarged glands are present they are now dissected out if possible. Before closing the wound a counteropening should always be made in the loin for purposes of drainage and additional drains brought out through the lateral abdominal incision when necessary.

Transperitoneal Nephrectomy.—This route is sometimes used when the mass is very large, especially from malignant growths, and when it is suspected that injury to the kidney is accompanied by injury to other abdominal organs. The patient lies upon the back and a vertical incision about four inches long is made at the outer border of the rectus or at any other point desired nearer the median line, the center of the incision being at the level of the umbilicus. This incision is extended in either direction if it is found that more room is required after the tumor has been explored. The small intestines are pushed toward the median line and held out of the way by gauze pads having tapes to which a clamp is attached outside of the wound to avoid overlooking and leaving a pad inside the abdomen when the operation is concluded. A short incision is then made in the peritoneum over the kidney to the *outer* side of the colon, thus avoiding the vessels supplying that viscus. The finger is introduced and the peritoneum stripped from the surface of the kidney, the incision in the peritoneum being enlarged from time to time as it is seen that it can be done safely. After the tumor has been enucleated, pedicle ligated, tumor removed and ureter resected at the desired level, the edges of the peritoneum over the tumor bed are sutured with plain catgut and the abdominal wound closed in the usual manner. If drainage is necessary (and it practically always is) either because of the size of the raw space left or because septic material has contaminated the tumor bed, drainage may be obtained by counteropening through the loin or the rent in the anterenal peritoneum may be partially closed at each end and the central portion sutured to part of the peritoneum at the abdominal incision, thus shutting off the pocket from the general abdominal cavity and leaving a sufficient opening for packing or other form of drainage. The abdominal wound is then closed down to the drainage opening. One advantage of this route is that the renal vessels may be ligated early and with comparative ease. The great disadvantage lies in the danger of contamination of the peritoneum, leading to fatal peritonitis; while when the tumor bed is drained anteriorly hernia is a frequent sequel.

Partial Nephrectomy.—This is occasionally applicable (1) in injuries of the kidney; (2) when nonmalignant tumors are strictly limited to one portion of the kidney; or (3) when one or the other pole is the site of a simple cyst or sharply circumscribed small abscess. Rarely, partial nephrectomy has been practised under other conditions, as the excision of infarcts as reported by Hotchkiss[7] and for tuberculosis *apparently* limited to one pole of the kidney. This latter is mentioned only to be absolutely condemned.

Exposure of the kidney is by short oblique lumbar incision which may be lengthened later if necessary. After the kidney is exposed and brought into the wound the pedicle is compressed by an assistant or by a rubber-sheathed clamp while the desired portion of the kidney is resected. The excised portion should be wedge shaped and the incisions should run transversely (parallel to the course of the vessels) and should not enter the pelvic cavity if this can be avoided, since this may be followed by troublesome urinary fistula. The wound in the kidney should be closed by two sets of plain catgut sutures—one set passing deeply and the other superficially—securing good apposition of the cut surfaces throughout the extent of the wound. The compression of the pedicle is then removed and if no further suture for the control of hemorrhage is necessary the kidney is replaced and the lumbar wound closed for primary union or drained as indicated.

Mortality of Nephrectomy.—The mortality percentage depends not only upon the type and severity of the lesion, the inherent difficulty of the operation, the functional value of the other kidney and the general condition of the patient, but also, and to a very considerable degree, upon the skill and cool, surgical judgment of the operator. Since a kidney is seldom sacrificed except as a last resort, we often have to deal with a patient whose vitality has been more or less sapped by a long period of suffering, by hemorrhage or by septic absorption; hence most nephrectomies are undertaken under unfavorable conditions, while in some the patient's condition is desperately bad. For these reasons a high operative mortality is to be expected. Tuffier (quoted by Ball[8]) some years ago reported 200 lumbar nephrectomies with a mortality of 28 per cent., and 161 transperitoneal nephrectomies with a mortality of 44 per cent. Gerster, in a series of 112 cases of lumbar nephrectomy for various lesions of the kidney, had 24 deaths, a total mortality of 21.43 per cent. This series included operations for pyo- and hydronephrosis, tuberculosis, neoplasms, echinococcus, and polycystic disease, and the mortality in the various tables ranged from zero in the last two classifications to 44.44 per cent. where the kidney was affected by malignant growths. It is evident, therefore, that the mortality of nephrectomy *per se* cannot be intelligently estimated.

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References.

1. Gerster, Arpad G.: The President's Address, American Surgical Association, 1912. Annals of Surgery, July and August, 1912.
2. Mayo, W. J.: Annals of Surgery, January, 1912.
3. Mayo, W. J.: Journal of the American Medical Association, January 31, 1914.
4. Taylor, Edward H.: Operative Surgery, William Wood & Company, 1914.
5. Murphy, John B.: The Clinics of John B. Murphy, April, 1914.
6. Lilienthal, H.: Annals of Surgery, April, 1911.
7. Hotchkiss, L. W.: Transactions of the American Surgical Association, 1913.
8. Ball, C. Arthur: The Practitioner, December, 1913.

Nephritis.—This is the name usually applied to inflammation of the kidneys of a non-suppurative nature, whether acute or chronic. Bright's disease is a much used synonym and is derived from the fact that Richard Bright first adequately described the condition in 1827. He recognized the dependence of dropsy and albuminuria upon kidney disease; he recognized the fact that, while in most instances dropsy and albuminuria were well-marked symptoms of the disease, in some cases dropsy might be slight or absent altogether and that albumin might be very scant. He described uremia, the cardiovascular changes, and many of the complications, such as apoplexy, blindness, etc.

Before the time of Bright, Actius, Avicenna, and Van Helmont associated certain cases of dropsy with kidney disease and in 1770 Cotunnius discovered that the urine of certain cases of dropsy was coagulated by boiling. Wells in 1806, Blackall in 1813, and Alison in 1820 all made observations along the same line as Bright's, but they were only fragmentary and there were many errors in their reasoning. Bright's observations were soon confirmed from various sources. The most noteworthy writers of the time are Christison, 1829, Gregory, 1831, Osborne, 1834, Rayer, 1839, and Rokitansky. The amyloid kidney was first described by the latter in 1842. Henle in 1847 was the first to investigate the minute anatomical changes in the kidney in nephritis and later observations were

made by Frerichs in 1851; Wilks, Johnson, Virchow, and Vogel in 1852; Traube in 1856, Rosenstein in 1860, and Grainger Stewart in 1868. Johnson especially studied the blood-vessels and in 1872 Gull and Sutton described their arteriocapillary fibrosis and brought out the importance of the blood-vessel changes in producing cirrhosis and atrophy of the kidneys. Other important contributors were Kelsh in 1874, Bartels in 1876, and Bamberger, Mahomed, Aufrecht, and Weigert in 1879. Since then the contributions have become too numerous to mention.

As the study of disease of the kidney is so largely based upon its normal and pathological physiology it seems best first to give a résumé of these subjects so far as they are understood and then to take up the different varieties in detail as to their morbid anatomy, symptomatology, and therapeutics.

Physiology of the Kidney.—There are several theories of the secretion or excretion of the urine, none of which has been completely proven. Bowman in 1842 based a theory of secretion on the anatomical structure of the kidney as discovered by himself and others. This was afterward elaborated and given experimental support by Heidenhain. They maintained that the water and salts were secreted by the physiological activity of the epithelial cells of Bowman's capsule, while the other solids of the urine were secreted in the same manner by the epithelial cells of the convoluted tubes and Henle's loop. The greater concentration of the urea, uric acid, etc., in the urine than in the blood was explained by a relatively greater activity in the cells secreting the solids than in those handling the water. The whole process was explained as being dependent upon the chemical composition of the blood coming to the cells and the quantity of blood flowing through the kidney.

Ludwig's theory brought out in 1844 is strictly mechanical. He believed Bowman's capsule and the glomerulus to be a filtering apparatus where all the constituents of the urine were driven through the epithelial lining of the capsule by the increased pressure of the blood in the glomerular capillaries. He explained the greater concentration of the urine, when passed, by a process of resorption of water taking place in the convoluted tubes as the very dilute urine from the capsule passed down through them. Ludwig originally considered that the resorption was due to osmosis because of the greater salt concentration in the blood, but more recent adherents of this theory consider it to be due to an active cellular resorption or secretion.

In support of Bowman's theory Heidenhain found that the injection of a saturated solution of indigo carmine into the blood-vessels of an animal produced a staining of the kidney cortex due to the deposit of pigment in the lumen of the convoluted tubes and in the contiguous border of the tubule cells. The blood pressure was first reduced below the secreting point for urine by dividing the spinal cord in the neck. This he took to mean that the tubule cells had the power of secreting this material even when the blood pressure was below the secreting point. The cells of Bowman's capsule and the glomerulus did not take up any pigment.

The frog's kidney has a double blood supply; the renal artery supplies the glomerulus, while the renal portal vein supplies the tubule cells.

Nussbaum found that ligation of the renal artery stopped the flow of urine from that kidney, but that injections of urea caused it to secrete. The injection of peptones, sugar, carmine, etc., did not cause their secretion as in the normal kidney. This was taken to mean that there are two distinct secreting systems, the glomerular and tubular, the first secreting water, salts, sugar, peptones, etc., and the latter urea, uric acid, and others of this group. Further proof that the function of the tubule cells is secretion and not resorption was given by ligating the renal portal vein which would cut out the function of these cells. If Ludwig's theory were correct this would increase the flow of urine because resorption of water could not occur, but in reality it decreased the flow.

In favor of the filtration theory is the construction of the glomerulus with its afferent vessel showing a greater caliber than the efferent, thus causing high pressure in the tuft. Also anything that increases the blood pressure in the kidney increases the flow of urine and the converse is also true. When the pressure falls below forty millimeters of mercury the flow ceases entirely. It must be remembered, however, that the various methods of increasing the blood pressure in the kidney also increase the flow of blood through it, so that the increase in urine may be due to this instead of the increased pressure. In favor of this is the fact that partial occlusion of the renal vein will increase blood pressure but sharply diminish the flow of urine and if it is completely occluded the flow of urine not only stops but will not return immediately when the vessel is released.

Martin Fischer has recently advanced what he calls the colloidal theory of secretion. He divides the secretion of water into two parts; the absorption of water from the blood by the colloids of the kidney cells, and then the giving up or secretion of this water to the tubule. He explains this as follows: for secretion, the cells must be supplied with abundant oxygen; this in their activity is consumed and converted into carbonic acid, thus rendering the cell colloids acid and causing them to absorb water. As the carbon dioxide is replaced by oxygen, this water is given off to the tubule. He explains the secretion of solids as a leeching out of the dissolved substances in the kidney cells by the water flowing in the tubules. When the oxygen supply is cut off by any means, the tissue acids cannot be oxidized and the secretion of urine stops because the cells cannot give up their water when in the acid state. They continue to absorb water and become greatly swollen. This will be taken up later in connection with the production of nephritis. The theory readily accounts for the fact that occluding the renal vein causes suppression of urine and that no matter how free the blood flow is if it does not carry oxygen the urine will not flow. Fischer supports this theory by many experiments, detailed in his work on nephritis.

Composition of the Urine.—The normal human urine is clear, amber in color, of a specific gravity of about 1,020, and an acid reaction, but is subject to wide variations in health. It is composed of water and inorganic salts and in addition urea and other organic compounds. Most of the nitrogen of the body is excreted in the form of urea (87.5 per cent. according to Folin), the balance being found in ammonia, creatinine, purin, and other unknown nitrogen compounds. The total excretion of nitrogen varies, being in the average man from fourteen to eighteen grams daily. Practically all the nitrogen is excreted in this way, as that lost in the sweat and feces is negligible.

Urea is probably formed to a large extent in the liver from ammonium salts in the blood, most likely the carbonate or carbamate. These come from the splitting of the protein molecule in digestion. Between thirty and thirty-four grams of urea are excreted daily and this comes mostly from the food as it varies with the food intake. Creatinine is next to urea and the ammonia compounds as a nitrogen carrier in the urine and varies in amount from one to two grams daily. It does not vary to any extent with the diet and probably comes directly from tissue metabolism. In fevers where tissue metabolism is increased there is a corresponding increase in creatinine. The purin bodies, uric acid, xanthine, hypoxanthine, adenine, and guanine also come mostly from tissue metabolism.

Of the inorganic salts of the urine the chlorides, phosphates, and sulphates are the most important. They come from the food and also from tissue metabolism. Sodium chloride is the most important and averages ten to fifteen grams daily.

Pathological Physiology.—The cardinal symptoms of nephritis in general are disturbance of water secretion, albuminuria and casts, edema, increased blood pressure, heart hypertrophy, and uremia.

Disturbances of water secretion occur in all cases of nephritis, the amount being cut down even to complete suppression at times in the parenchymatous forms, especially the acute cases, while in the chronic interstitial form the amount may be normal or even excessive. The suppression is partly accounted for by the great swelling of the kidney cells with the very resistant kidney capsule, cutting off the blood supply to a greater or lesser extent. In addition to this the kidney cells seem to be impervious to water. This is well explained by Fischer's theory already referred to, that increased acid production or accumulation of acid in the kidney cells causes them to swell and prevents them from giving up the water absorbed. This theory to which we shall frequently refer is given here in Fischer's own words: "All the changes that characterize nephritis are due to a common cause—the abnormal production or accumulation of acid in the cells of the kidney. To the action of this acid on the colloidal structures that make up the kidney are due the albuminuria, the specific morphological changes noted in the kidneys, the associated production of casts, the quantitative variations in the amount of urine secreted, the quantitative variations in the amounts of dissolved substances secreted," etc.

The effect of increased acid in the kidney can be readily shown by injecting acid solutions into the veins of animals or by interfering with the proper oxygenation of the kidney cells, by interfering with respiration, or locally by clamping the renal artery or vein. (Various poisons act in the same way by interference with the ability of the cells to use the oxygen which is supplied to them.)

In chronic interstitial nephritis the amount of urine is not always decreased and sometimes is in excess. This may be accounted for by the fact that the whole of the organ is not affected at once, but that small portions are progressively damaged as the disease advances and we have conditions comparable only with the parenchymatous forms only when the disease has spread to a marked extent.

Albuminuria is found in all patients with nephritis with the exception of a few cases of the chronic interstitial form. It can be shown in very slight traces in normal urine by delicate tests, but with the ordinary tests employed clinically, its presence can always be taken as evidence of pathological change. This may be of a very transient nature, as for instance after violent exercise.

The cause of albumin appearing in the urine is still unsettled. Heidenhain has claimed that the reason albumin does not normally enter the urine from the blood, while urea, salts, etc., do, is that crystalloids to which the latter belong can readily diffuse through animal membranes, but that colloids like albumin cannot. While this is true of serum albumin, egg albumin which is also colloid is rapidly eliminated when injected into the blood, and dextrose which is a crystalloid does not pass until it is present in the blood to excess.

Fischer claims that the albumin found in the urine comes not from the blood directly but from the kidney cells themselves, that "albuminuria results wherever conditions are offered in the body which permit the solid colloidal membrane that separates the blood from the urine to go into solution in the urine." These conditions are brought about whenever acid accumulates in the kidney cells rendering the colloids soluble. He has shown that evidence of excessive acid in the kidney or conditions predisposing to this condition exist in every albuminuria and on the other hand that any condition leading to this excess of acidity produces albuminuria. He has also shown that any means by which the solubility of colloids in an acid medium can be reduced will decrease albuminuria. This will be referred to later.

Casts are washed out from the tubules by the pressure of the urine from behind, but their method of formation is still in dispute. An albuminous material, the nature of which is not definitely known, probably enters the lumen of the tube in a fluid or a semi-fluid state and then hardens to form the cast. This has been thought to be an exudate from the blood or from the epithelial cells or to be due to epithelial degeneration. When the cast is washed out it carries with it other materials loose in the tube or loosely attached to its walls, thus giving rise to the purely hyaline cast, to the fine or coarse granular cast, or the fatty or epithelial cast, depending upon whether the cells are desquamated entirely or as granular or fatty débris. The coarser granular casts, fatty casts, and waxy casts are probably due to various degenerations in the epithelial cells desquamated. The cast then is an evidence of the condition of the kidney tubules from which it comes and not necessarily of the kidney as a whole.

Fischer has shown that by acidulating the kidney in various ways casts can be formed at will and also that by increasing the acid concentration epithelial casts can be converted into granular and even into hyaline casts. In connection with his theory of nephritis and the method of production of albuminuria, above referred to, he suggests that the colloids of the cement substances are more easily soluble in the acid solutions than the cells themselves and thus give rise to the desquamation of the cells in masses and at the same time the solution of the colloids produces the albuminuria. He warns against placing too much reliance on the variety of casts present, because autopsies have shown that different parts of the kidneys may be very differently affected at the same time and the urine is a mixed product from both kidneys. Also the character of the urine as to reaction, etc., may change the character of the casts in their passage through the ureter and bladder, no matter what was their nature when they left the kidney.

Edema.—This may not be due to the nephritis. In some hemorrhagic cases it may be due to the marked anemia or in cases where the cardiovascular changes are great it may be due to this condition. In acute nephritis and chronic parenchymatous nephritis, however, we have the true nephritic edema, so-called. There are numerous theories as to the cause of this form of edema, none of which has been conclusively proven. Different observers have placed the blame upon water retention, chloride retention, changes in the blood, and the injury of blood-vessels.

Schlayer and Hedinger have shown by various experiments that the edema in uranium nephritis is caused apparently by three factors: lessened permeability of the renal vessels, increased intake of fluids, and increased permeability of the peripheral vessels. In the vascular types of experimental nephritis induced by arsenic and cantharides, they found that both vasodilatation and vasoconstriction were impaired, and that caffeine and sodium chloride failed to cause diuresis. In the tubular type of nephritis, caused by chromium and sublimate, little disturbance was caused in the vasomotor control, but in neither of these did edema develop. With uranium in the animals that developed edema there was found to be no disturbance of vasomotor control, but sodium chloride and caffeine, while they still produced marked vasodilatation, failed to produce diuresis. This water retention they reasoned must

be due to trouble in the glomerulus as it failed to occur in the other forms of tubular nephritis. For the development of edema the experimental animals must receive abundant water.

The third factor was shown to be necessary by the failure of edema to develop in an animal with impermeable kidneys even when large quantities of water and salts were given. If, however, four or five days were allowed to elapse and the water and salts repeated, edema developed. This they attributed to vascular injury and increased permeability of the peripheral vessels. Pearce obtained the same result by inducing a tubular nephritis with chromium with no edema and then by the use of arsenic, snake venom, or other vascular poison produced the edema. Cohnheim and Lichtheim long ago discovered that the injection of large amounts of physiological salt solution into animals failed to produce subcutaneous edema, unless some injury were done to the part, as painting it with iodine or exposing it to the sun's rays or to heat, when edema developed promptly, and this was also explained as due to vessel injury. Magnus produced this result, but used, instead of trauma, ether, chloral, or chloroform narcosis or vascular poisons, as arsenic. He also found that the saline transfusion of a dead animal was always followed by anasarca.

Heinek found that an animal suffering with chronic nephritis became edematous if injected with serum from an animal with uranium nephritis and ascribed this to vessel injury by the serum.

Widal claims that salt retention is a very important factor, that the salt retained causes the retention of sufficient water to maintain the proper molecular concentration, and this is responsible for the edema.

Martin Fischer's theory of edema is of great interest. He states that "the cause of edema resides in the tissues." His argument is that anything which increases the acidity of the body colloids, whether an increased production or faulty elimination of acid, will cause in the presence of sufficient water an edema of the tissues. This has already been referred to in connection with the kidney itself. He has shown that anything which interferes with proper oxygenation will do this and this explains the edema of heart disease, anemia, local obstructions to circulation, as varicose veins or experimental ligature of vessels; and in connection with nephritis he attributes both the nephritis and edema to the same cause, an acid hydration of the colloids of the kidney and of the tissues in general.

Increased Blood Pressure and Heart Hypertrophy.—These are most marked in those cases of chronic interstitial nephritis, which are associated with marked arterial change. In these cases it is highly probable that the nephritis is secondary to the blood-vessel change, in other words that we are dealing with a general arteriosclerosis of which the kidney change is a part. In these instances the heart is hypertrophied to overcome the greatly increased resistance to the flow of blood in the sclerosed vessels with the great reduction in the lumen, almost always present, and the loss of elastic recoil. We have, therefore, a more powerful pump working against a greater resistance and of necessity a heightened pressure. This is probably compensatory and necessary, as otherwise a sufficient flow of blood could not be maintained through the organs.

In some forms of acute nephritis we have hypertension, developing very quickly, often within forty-eight hours of the onset. The cause of this hypertension has not been definitely determined but it is often present in acute uremic attacks and is probably due to constriction of the lumen of the vessels, either of the body in general or of the kidney alone. This is probably functional and due to some substance circulating in the blood.

Traube places the whole blame upon the renal vessels, and Alluens has shown that compression of the kidney causes marked hypertension. On the other hand the frequency of hypertrophy of both right and left ventricles of the heart in the more chronic cases would indicate an increase in the general arterial tonus involving both pulmonary and systemic circulations. What the material is that causes the increase of tonus is not known, but it has been attributed to an excessive secretion of adrenalin; this, however, has not been proven.

In the parenchymatous forms both acute and chronic, there is often no hypertension and also no heart hypertrophy and even in the secondarily constricted kidney following a parenchymatous nephritis, the tension and heart may be normal.

Uremia.—The symptoms grouped under this term are headache, nausea, vomiting, epigastric pain, diarrhea, dyspnea, delirium, convulsions, and coma. They all seem to be due to some form of intoxication. What the poison is, is not definitely known, but the consensus of opinion is that it is something retained in the body which should be eliminated by the kidneys, probably some product of nitrogen metabolism. Against this speaks the fact that in animals or man where the kidneys have been removed or the ureters blocked, uremia fails to develop though the individual may live for a number of days. Attempts have been made to produce uremia by injecting large quantities of urea and sodium chloride, both of which are at times retained in nephritis, but without result. There is no direct evidence that ammonium carbonate, creatinin, or other nitrogenous bodies are the cause, though there is always nitrogen retention in severe forms of nephritis and this is especially true in uremia. It has been claimed that uremia develops only in association with marked nitrogen retention, but von Noorden reports a case of uremia without nitrogen retention. Ascoli has ascribed uremia to the presence of nephrolysins which he believes are formed from the products of degenerated kidney cells. He has been able to produce albuminuria by injecting kidney extracts and again by injecting the serum of such an animal into a second animal, but he has not produced uremia.

Fischer attributes uremia to the same colloid reaction in the brain which produces swelling of the kidney and other forms of edema. In other words the uremic symptoms are attributed to edema of the central nervous system due to acid hydration of the colloids, and the amaurosis to the same condition in the optic nerve or retina. He cites the frequency of edema of the brain found postmortem in these cases.

Varieties.—Nephritis may be divided into two general classes, the acute and chronic. The chronic form will be considered under two headings: chronic parenchymatous and chronic interstitial nephritis.

Acute Nephritis.—This is divided by Delafield into three varieties; acute degeneration of the kidneys, acute exudative nephritis, and acute productive nephritis.

Etiology.—One of the most common causes of acute nephritis is cold. Exposure to cold and wet, especially after heavy drinking is very liable to be followed by an attack. Extensive burns of the skin surface is another cause. Probably next to exposure in frequency is the toxemia from infectious diseases and scarlet fever is easily the leader in this regard. Typhoid, typhus, diphtheria, measles, smallpox, malaria, cholera, yellow fever, syphilis, and tuberculosis are frequent causes. Other causes in this group are tonsillitis, rheumatism, exudative erythemata, purpura, streptococcus septicemia, infections by the *Streptococcus viridans* and pneumococcus, erysipelas, and meningitis. Mumps, gastrointestinal disturbances, chickenpox, and extensive skin lesions are causes, especially in childhood.

Toxic agents of a chemical nature may produce even very severe attacks; most important among these are bichloride of mercury and other mercurials, turpentine, cantharides, carbolic, salicylic, and mineral acids, phosphorus, arsenic, lead, chlorate of potassium, and iodoform. Cases have recently been reported from the use of balsam of Peru externally, but in each instance there was the skin lesion, scabies, for which the balsam was used and this might have produced the disease. I have recently had such a case, in a child of eight who developed a well-marked nephritis with edema following scabies. In this case an ointment containing sulphur and oil of cade was all that had been used and that only in small amount.

The frequency of nephritis in chronic drinkers proves the deleterious effects of alcohol, whether it acts directly as a poison to the kidneys or simply as a predisposing cause.

Acute nephritis often occurs in pregnancy; most frequently it affects the primipara in the late months of gestation. It is probably due to pressure upon the renal veins or to toxins developed from either the mother or fetus due to faulty metabolism.

Morbid Anatomy.—In very mild cases there may be no changes visible to the naked eye, but usually the organ is swollen to a greater or lesser degree, the capsule is tense and when incised the kidney substance tends to bulge through the opening. The capsule strips readily leaving a smooth glistening surface, which may show intense congestion with sometimes scattered hemorrhages, or it may appear pale and mottled, or at times areas of hyperemia and pallor alternate. On section the organ cuts readily and the cut surface shows the conditions already described, the cortex being either pale and turbid, hyperemic, or mottled. The pyramids are usually intensely red. In very mild cases the cortex only may be involved and show swelling with more or less pallor and turbidity.

Microscopically the picture varies greatly. In the mild cases the cells of the tubules may have simply a swollen and granular appearance, the so-called cloudy swelling or granular degeneration. In the more severe cases the cells may show very marked swelling with cloudiness, or apparent absence of the nucleus and the cytoplasm filled with albuminous granules or fat droplets. This may go on to necrosis and desquamation of the cells with often hyaline changes in them. In the lumen of the tube is found disintegrated epithelium, desquamated masses of epithelial cells showing the degenerations mentioned above, and in addition red blood cells and leucocytes. These are moulded into cylindrical masses and form casts of the different varieties, according to the preponderance of one or the other substance.

The *glomerulus* also shows changes ranging in the mild cases from simple cloudy swelling of the cells lining the capsules and covering the glomerulus to marked changes leading to the complete destruction of the tuft in severe cases. In the mild cases the cells show cloudy swelling and may desquamate as already described in the case of the tubules. In the cases of greater severity the desquamation is a marked feature and the space between the tuft and capsule may become choked with exfoliated epithelium, red and white blood cells, and granular débris even to the extent of compressing the tuft and shutting off the circulation in it. The capillaries are usually distended and may be plugged with cells or clots; these cells are leucocytes and larger cells, probably swollen endothelium. In some cases, especially after scarlet fever, the glomerular injury is so marked as to give the name of glomerulonephritis to the disease. In the productive form there is proliferation of the cells lining the capsule and tuft and the formation of dense fibrous tissue, which often leads to the permanent destruction of the tufts involved. A similar change occurs in the interstitial tissues in this type. The interstitial tissues are either not involved in the mild grades of nephritis or show simply an edema, but as the disease increases in severity we have in addition an exudate of leucocytes and blood cells with fibrin and proliferated cells. The exudate is usually to be found to a large extent in patches and not uniformly through the kidney. The same holds true of the new formed tissue in the productive form of the disease. Different types are referred to according to the preponderance of one lesion, as for instance the glomerular type already referred to. In addition we have the degenerative or parenchymatous type, the hemorrhagic type, the exudative type, and the productive or acute interstitial type. When the lesion involves all the structures of the kidney even though the whole organ is not uniformly involved, it is spoken of as a diffuse nephritis.

Symptoms.—Usually the onset is quite sudden. In children convulsions are not uncommon and they may occur in adults especially in pregnancy. Slight edema of the face may be the first thing noticed; usually the eyelids are first affected. In some cases this edema may appear within twenty-four hours. Following the infections, the onset is usually more gradual; anemia and some swelling about the face and ankles are often the first signs noted. Chills or chilly sensations with or without pain in the back come first in some cases.

A frequent mode of onset is with nausea and vomiting and sometimes hematuria is first noticed.

Fever is an uncertain symptom, it is more apt to be present in children than in adult life and may range rather high. In typhoid fever, I have several times noted a sudden drop in temperature coincident with the onset of an acute nephritis.

Edema is a symptom which is very common, but more apt to occur in those cases following exposure or scarlet fever. It may start in the eyelids and face or about the ankles and often becomes general, the entire body being greatly swollen. It is most marked in the soft tissues as the penis, scrotum, labia, and eyelids. With this may be found accumulations of fluid in the body cavities, ascites, hydrothorax, and hydropericardium; the second is often bilateral. Edema of the glottis occurs at times and is a very dangerous complication.

Hypertension is frequently present, the pulse being hard and tense. This often develops early in the disease. The pulse is usually slow at first, but later may be rapid. Instances of marked bradycardia have been reported. The aortic second sound is accentuated, usually, and some hypertrophy of the heart may be found. Later acute dilatation of the heart may develop.

The Urine.—Most important of all the symptoms are the urinary findings. The amount of urine secreted is, almost without exception, diminished and is often very low, only five or six ounces being voided in twenty-four hours. In some of the toxic cases complete suppression obtains. I have had two cases of complete suppression following the taking of bichloride of mercury, one for five and the other eight days, and both were fatal. When the urine is scant, as is usually the case early, the specific gravity is usually rather high, 1,025 or thereabout. As the total quantity goes up, the specific gravity drops to 1,015 or 1,010. The color is usually dark and smoky, ranging from dark brown to dark red, but rarely bright red. On standing, there is usually a heavy sediment, which microscopically shows red and white blood cells in varying amount, epithelial cells, and casts of the hyaline, granular, epithelial, and blood varieties. The reaction in the urine is usually strongly acid. Large amounts of albumin are present, as is shown by the heat and nitric acid tests and their various modifications. The amount varies from one to ten grams to the liter and in some cases even higher. The total output of urea is diminished. The freezing point of the urine is raised to from 1° C. or less, below that of distilled

water, instead of from 1.3° C. to 2.3° C. below, which is normal.

Hematuria is variable but usually present to some degree, except in the mildest cases. The most persistent case I have seen was in a carriage painter as the result of turpentine inhaled while working in a close room. Epistaxis and other hemorrhages may occur in severe cases and are probably due to the nephritis (toxins, hypertension, and vascular changes). Ecchymotic patches under the skin, hematemesis, hemoptysis, metrorrhagia, and bleeding into the brain, eye, and ear are other forms of hemorrhage which occur.

Dryness of the skin and anemia are usually present. The latter is quite marked in many cases and gives rise to a peculiar pasty color of the skin. Uremic symptoms may come on at any time and sometimes are the first indications of the disease. They consist of severe headache, nausea and vomiting, epigastric pain, diarrhea, dyspnea, delirium, muscular twitchings, convulsions, and coma. This condition is not as frequent in acute as in chronic nephritis. Dyspnea may be uremic, in which case it resembles asthma, or it may result from cardiac incompetency, from hydrothorax, or from edema of the glottis. In the last instance the dyspnea is very urgent.

Eye changes are comparatively frequent. Temporary blindness may result from edema of the optic nerve or retina or hemorrhage may occur into the retina. This last is much more frequent in the chronic forms, however. The course of the disease is very variable. In some of the milder cases there may be practically no symptoms except lassitude, very slight edema, or gastrointestinal disturbance and the diagnosis depends entirely upon the urinary findings. These cases often clear up in a few days to a few weeks. Other cases may run a very severe course without any edema developing at any time. The cases following cold and scarlet fever are the ones most apt to run the typical course described, with marked edema, etc. These cases are usually severe and may last for weeks or even months. Some permanent damage to the kidneys may result. A fatal termination may come suddenly at any time in severe cases as the result of convulsions or acute dilatation of the heart, or more gradually through edema of the lungs or coma.

The acute nephritis of pregnancy is usually gradual in its onset and if the urine is examined regularly, as it should be, is usually discovered in this way. Convulsions are particularly apt to occur in these cases and especially at the time of labor. The trouble usually begins in the last months of pregnancy and gradually becomes worse, the amount of albumin increasing and edema gradually developing. The blood pressure rises and uremic symptoms begin; headache, flashes before the eyes, and then eclampsia. Usually the symptoms rapidly clear up after delivery, but sometimes the eclamptic attacks make their appearance first postpartum.

In the acute productive type the disease fails to clear up, though there may be remissions in the symptoms, except the urinary signs. Sooner or later a typhoid state develops, the patient loses flesh rapidly and finally dies with uremic symptoms.

Diagnosis.—The diagnosis is made certain by the urinary findings, but every urine containing albumin even with casts does not mean nephritis, as both may appear for a short time after violent exercise or during febrile attacks. When, however, the urine is smoky and scant and red blood cells are found in it, with the casts and albumin, a diagnosis of nephritis is justified. Every case which appears anemic, especially if there is any sign of edema, should have a uranalysis; the same is true of all cases of persistent vomiting or high arterial tension. In fact routine uranalysis will discover the cause of many unexplained symptoms. It is sometimes impossible to differentiate an acute attack from an exacerbation of a chronic attack. The history of previous seizures would of course be of value.

Treatment will be considered with that of the chronic forms under that heading.

Chronic Parenchymatous Nephritis.—This variety is described by Delafield as the parenchymatous type of chronic diffuse nephritis; by Anders as chronic exudative nephritis and is also spoken of as chronic tubal or chronic desquamative nephritis. It is characterized clinically by marked edema, and postmortem by the large white kidney or its modifications.

Etiology.—This condition may follow the acute form of nephritis, more especially in those cases brought on by exposure or following scarlet fever or pregnancy, The degenerative lesions of the acute process giving rise to permanent lesions which are progressive. It may follow chronic congestion and chronic degeneration of the kidneys also. Most frequently, however, it comes on insidiously without any previous acute attack and is slowly progressive. It sometimes follows various infections, for instance syphilis, tuberculosis, and malaria. The cases following malaria are more frequent in those exposed to the disease over a long period of time, as those living constantly in malarial districts. Persons living and working under moist and cold conditions are more liable than others to the disease. It is most common in males between twenty and forty years of age. When it occurs in childhood it is usually after scarlet fever and may be an evident continuation of an acute attack, or the trouble may remain latent for a considerable time.

In young adults it is more apt to come on insidiously or subacutely. Alcohol, in this, as in the acute form, is a strong predisposing factor and a history of excessive indulgence is very frequently obtained. Prolonged suppuration is often a cause of this form of nephritis, and with tuberculosis and syphilis is often associated with amyloid changes.

Morbid Anatomy.—The usual finding is the so-called large white kidney, though in very chronic cases secondary contraction may have occurred producing the small white kidney. A large red or variegated kidney is also found, usually in connection with the hemorrhagic cases. The large white kidney is pale or yellow and has a thin capsule which is readily stripped off, leaving a smooth surface. The organ is usually larger than normal, though at times just about normal in size. Osler refers to thirty of his own cases which came to autopsy with an average weight of 420 grams for both kidneys, the heaviest being 580 grams. The stellate veins are congested and some hemorrhage may appear. The cortex on section is swollen and pale or yellow in color with opaque portions. The pyramids are usually congested or at least darker in color than the cortex.

Microscopically we have changes in all the tissues; the cortex is most involved. The tubular epithelium is swollen and cloudy, showing granular, hyaline, or fatty degeneration.

The cells are disintegrated to a greater or lesser extent and often desquamated. In places they are flattened, the lumen of the tube being larger than normal. The lumen itself is often distended with masses of débris from tubule cells and exudate composed of fibrin and red and white blood cells. This gives rise to casts of the hyaline, granular, fatty, and epithelial types with occasional blood or leucocyte casts.

The glomeruli are distended and show considerable capsular thickening. The cells of the capsule and covering the tufts show various degenerations or proliferation and often there is connective tissue increase sufficient to cause atrophy of the capillary tufts. The tufts not infrequently show hyaline or amyloid degeneration. The interstitial tissues often show an exudate similar to that of acute nephritis, but later

it is replaced by connective tissue, in patches, about the glomeruli and tubules. This is not extreme in the large kidney. The arterial walls may show some increase of connective tissue.

In the small white kidney we have usually a secondary or contracted stage of the large white kidney. The interstitial or glomerular connective tissue changes have become much more marked, the kidney capsule has become somewhat thickened and adherent, where wedges of connective tissue dip from it into the interstitial structures.

The kidney as a whole is reduced to normal or less in size and is usually somewhat nodular. This cicatricial or scar tissue has developed to replace the progressively degenerating tubular epithelium. The cortex has become somewhat narrower and irregular and is yellow or gray in color with red mottling. The microscope shows a marked stage of degeneration and disintegration in the tubule and glomerular cells with atrophy of many of the glomeruli and a great increase in the connective tissue. Waxy and fatty degeneration are common.

The large red and variegated kidney is about the size of the large white kidney, perhaps not so large as a rule. It is red and congested looking or mottled with red areas due to hemorrhages and yellow due to fatty degeneration. Numerous small hemorrhages are found beneath the capsule and on the cut surface of the kidney. Microscopically the hemorrhages are seen to be in the tubules and also in the interstitial tissues. Otherwise the microscopic appearance is that of a large white kidney already described.

The changes in other organs are usually those of high tension, blood-vessel thickening, and heart hypertrophy; these are usually more marked in the small white or contracted form.

Symptoms.—This condition may and frequently does follow a severe acute nephritis, especially scarlatinal nephritis in childhood, or following exposure. The patient improves, but some edema, albuminuria, and anemia persist and gradually the characteristic signs of a chronic involvement supervene.

More commonly, however, the onset is insidious and the patient complains of loss of appetite, indigestion, or general failure of health and strength. Frequent attacks of nausea and vomiting with headache and dullness may cause the patient to consult his physician or he may notice pallor and a beginning of puffiness of the eyelids or about the ankles. A certain number of cases are discovered in the ordinary routine examination of the urine, or in examinations for life insurance without the patient having noticed any symptoms. Then there gradually develops a marked anemia with a peculiar waxy pallor of the skin and mucous membranes. With this the puffiness under the eyes becomes more marked and the ankles and legs swell. For a time this may be found at night but will have disappeared by morning; later it persists and gradually spreads until nearly the whole body is involved. The skin pits on pressure about the ankles and legs, over the sacrum and sternum, and at times over the entire area. As in acute nephritis the loose tissues of the penis, scrotum, labia, and eyelids swell to the greatest degree.

The urine becomes scanty but not to the extent found in acute cases; 500 c.c. is about the average daily amount and suppression occurs only in acute exacerbations of the disease.

Later in the disease during the absorption of dropsical effusion or when secondary contraction of the kidney has occurred the amount may be normal or increased.

The color is usually a muddy yellow and a heavy sediment is generally present on standing. The reaction is usually acid but on standing it soon becomes neutral or alkaline.

The specific gravity is high, ranging from 1,018 to 1,025 and sometimes to 1,040; when the quantity increases, the specific gravity usually falls and *vice versa*.

Albuminuria is usually marked and Esbach's test may show in excess of ten grams to the liter. It may run as high as from one-fourth to three-fourths of the total volume of the urine, or 1 to 3 per cent. by weight.

The sediment consists of urates, casts, red cells and leucocytes, epithelium from the kidney and pelvis, and granular or fatty débris from the kidney.

The casts may be hyaline, fine or coarse granular, epithelial, fatty, or waxy. The last form used to be taken as evidence of amyloid change in the kidney, but this does not always follow for the degeneration may occur in the cast itself and not be found in the kidney.

In acute exacerbations the urine picture may be that of acute nephritis. Blood in the urine to any extent usually indicates an exacerbation of the process or the hemorrhagic type of the disease.

The urea is usually much reduced in quantity.

The dropsy of this form of the disease is subject to great variations. At times with a marked increase in the quantity of urine, the swelling may entirely disappear, but usually only for a short time. It is very liable to recurrence and the same holds true for the serous exudates which often occur at the same time into the pleuræ, abdominal cavity, or pericardium. At times the edema may affect the aryepiglottic folds causing acute dyspnea. Edema of the lungs may also occur, but this is usually associated with a failing heart. In the chronic hemorrhagic form the edema may fail to develop or be very slight.

Dyspnea is often a marked symptom. It may be very violent, even rapidly fatal, in those cases where the glottis or lungs are involved. It may be due to toxemia or it is mechanical from accumulated fluid, or cardiac in origin. The cardiac form is made worse by the recumbent posture. The uremic form is usually associated with a general vasoconstriction. Bronchitis is often found with these conditions and expectoration is common.

Uremia is common in this form but usually is of a more chronic type, acute attacks not coming on as in the acute and chronic interstitial forms. Convulsions are rare and when the uremic symptoms are severe, coma is much more apt to occur. Headache, vertigo, sleeplessness, nausea, vomiting, and diarrhea are much more common. The pulse tension is usually increased but not to the extent found in the indurative form; with this goes some hypertrophy of the left ventricle and an accentuated aortic second sound. Toward the last the heart usually becomes dilated, both ventricles being involved.

Neuroretinitis is fairly frequent but not as common as in the interstitial form. Its presence is shown by dimness of vision and a contracted field.

Fever is usually absent except in the presence of local inflammation such as pericarditis, endocarditis, pneumonia, or ulcerative colitis, any of which may occur though they are not common except as terminal events. In the patients who live for several years there is a gradual approach to the interstitial form. The urine becomes more profuse and the specific gravity lower and dropsy is usually not so great. The cardiovascular changes on the other hand increase greatly and arteriosclerosis becomes marked.

The average duration of an attack is from eighteen months to three years though some may last only a few months.

Diagnosis.—This has been considered in the section on the acute form. Some cases may come to a fatal issue without albumin appearing, the diagnosis being made by the clinical symptoms and the microscope.

The *prognosis* is absolutely bad, all cases terminating fatally. Some few reported cases of recovery in children can be looked upon as protracted acute cases and not true examples of this form.

Bad symptoms are the persistence of heavy albuminuria with diminished nitrogen output, extensive edema, and cardiac dilatation. Frequent recurrence of uremic symptoms is also of bad significance. Intercurrent infections may well be called terminal infections as death is usually the result. The most favorable cases so far as length of life is concerned are those in which contraction of the kidney occurs.

Treatment will be considered in the next section.

Chronic Interstitial Nephritis.—Delafield calls this the interstitial type of chronic diffuse nephritis. Anders describes it as non-exudative chronic nephritis. Other names frequently applied are the contracted kidney, cirrhotic kidney, arteriosclerotic kidney, and gouty kidney.

Etiology.—This is a slow degeneration and fibroid contraction of the kidneys with atrophy of parts of the organs and the cause is often far to seek.

It is in reality, as Osler so well says, simply a premature senility in this organ. The disease seems to some extent to run in certain families, several generations being similarly affected. It is much more common in males than in females and usually does not begin till after the fortieth year.

One who is prone to arterial degeneration is strongly predisposed to this form of nephritis, in fact the etiological factors of this disease are also those of arteriosclerosis. The kidneys, however, may be affected without much change in the arterial system at large. Emerson says that an analysis of the accepted causes of chronic nephritis shows in common a more or less prolonged stagnation of the blood supply of the kidney and has shown that this stagnation alone is sufficient to cause the disease. As causes of the stagnation he mentions cardiac disease, various bacterial toxins, and metabolic waste products. Among bacterial and other parasitic toxins may be mentioned those of syphilis, chronic malaria, and chronic articular rheumatism. Lead and alcohol are very important as causes, a large percentage of lead workers showing the disease, and the steady drinker is also very prone to it. The metabolic poisons, especially uric acid, are common causes and overeating, especially of rich and highly seasoned food with a large proportion of meat, ranks high in this particular. This probably acts by throwing excessive work on the liver so that the metabolic processes are not complete and the waste products in their excretion irritate the kidneys. Gout in England is very frequently associated with it, but is not common in this country.

In America the most frequent sufferers are those who have large responsibilities on their shoulders. Business stress and worry, irregular hours, high nervous tension, with perhaps overeating and drinking and a sedentary life, all come into play in these individuals. Excessive and prolonged muscular strain plays a part in those occupations requiring it day by day. Local irritation of the kidneys as in hydronephrosis, chronic pyelitis, or chronic congestion due to heart disease may give rise to sclerotic changes in the kidney.

Morbid Anatomy.—The kidneys are usually considerably reduced in size, sometimes the combined weight being as low as fifty to sixty grams; the majority are less than 300 grams. The organs are usually imbedded in a firm mass of fat and the two are usually about uniform in size. The capsule of the organ is very thick and adherent so that stripping the capsule is difficult and portions of the cortex are stripped off with it. The color is usually dark red in contrast to the secondarily contracted form which is usually pale.

The surface is rough and granular, due to the wedges of fibrous tissue extending into the organ from the capsule. Small cysts are often seen, filled with clear fluid. The organ is very resistant to the knife, cutting with a grating sound.

The cortex is very thin and often irregular in thickness, at times measuring only two to three millimeters. The pyramids do not show contraction to anything like the same degree. The cut surface shows in the cortex dark red streaks alternating with paler portions; the pyramids are darker. In the gouty variety uric acid or urates may be deposited as fine striations. The small arteries stand out distinctly and are very much thickened.

Microscopically there is seen everywhere a great increase in fibrous tissue. This is not uniform but in portions of the cortex heavy wedges of connective tissue are found, extending from the capsule, which have practically blotted out all the original kidney structures. These are probably due to interference with the circulation in the end arteries supplying these portions, not suddenly with the formation of infarct, but slowly as a result of arterial changes.

The tubular epithelium in these fibrous areas may be completely atrophied with the tubules or it may be flattened out to a considerable extent. Between the fibrous areas there may be tubules of a comparatively normal appearance or those in which the cells show granular, fatty or hyaline degeneration with desquamation of epithelium. Some of the tubules are constricted in places giving rise to dilatation of the proximal portion, especially near the surface, and sometimes small retention cysts are thus formed which are visible to the naked eye. The lumen of the tubes often contains tube casts.

In the earlier stages the cells of the glomerular capsule and of the tuft itself are swollen and may multiply rapidly; a small round-cell infiltration is also seen. Later these cells become fusiform and go to form heavy fibrous tissue about the glomeruli giving rise to cicatricial contraction and destruction of many of the tufts. Many of the glomeruli are completely destroyed, being converted into fibrous knobs; others show marked thickening of the capsule and even those that approach the normal show some thickening of the capsule and increase in the cells of the tuft.

The arteries are usually very much sclerosed, the intima and adventitia being greatly thickened, the latter often at the expense of the muscular coat.

Changes found in other organs are marked general sclerosis in the whole arterial system as a rule and hypertrophy of the heart. In some cases only the left ventricle is involved, but in many instances the whole heart is enlarged even to the extent that the term, cor bovinum, may be applied to it. The explanation of this has been taken up under the pathological physiology in the introduction of this article.

Symptoms.—Most of these cases are latent and are not discovered until some serious symptoms develop as for instance disturbances of vision, uremia, or hemiplegia.

The onset of mental symptoms may be the first danger signal. Many patients up to the appearance of these symptoms may be very vigorous both mentally and physically. In some instances, however, the general health may be disturbed for some time before serious symptoms come on. The patient may complain of sleeplessness or drowsiness, gastric disturbance, headache, breathlessness on exertion, or frequent micturition, especially at night.

In some cases a complicating disease, as pneumonia or pericarditis, brings on the grave nephritic symptoms. Very often a uremic attack comes on with headache, nausea, epigastric pain, dyspnea, and stupor or convulsions. The pulse shows very high tension. I have seen it as high as 270 millimeters in such a seizure. This first attack may be fatal or the bad symptoms may pass off leaving the patient with the general health much reduced and suffering from headaches, gastric symptoms, drowsiness, etc. Later the uremic symptoms return in their greater intensity and the patient dies or is further reduced by this seizure. He may live on finally to die in one of these attacks or be carried off by some complication.

At times the only symptoms may be a progressive loss of health and strength with gradual emaciation and weakness until death occurs from exhaustion.

The symptoms on the part of the urinary system are very important though not as striking as in the other varieties of nephritis. The quantity of urine is increased and thus gives rise to frequent micturition, especially at night. This is often aggravated by some enlargement and irritability of the prostate, especially in elderly men.

With the excessive urine output there is often excessive thirst, but this is not constant. The color is light amber and clear and the reaction acid. The specific gravity of the urine is low, 1,005 to 1,012, and the persistence of this symptom is of great importance in diagnosis. Traces of albumin are found in most cases though careful testing is often necessary. In some cases, however, it is entirely absent. There is very little or no visible sediment even after the centrifuge, but a few hyaline or granular casts can be found almost without exception. Usually blood is absent, but at times distinct hematuria occurs and in some there is a constant leakage of a few red cells for years.

Usually the presence of blood in any quantity indicates an acute exacerbation of the disease and is accompanied by a rise in specific gravity and an increase in albumin and casts; the quantity of urine is reduced. This same thing may occur without the hematuria and usually does in a uremic attack or with a complicating inflammation or late when the heart begins to fail.

The total solids of the urine are usually diminished, but may remain fairly normal in a few cases.

The circulatory symptoms are very marked. High tension begins early and is present all through the course; it may in some cases range above 250 millimeters and even as high as 300 in rare cases. In addition the blood-vessels in general are often greatly sclerosed and the heart enlarged to the left. The pulse is hard, tense, and full, even during diastole. It is incompressible and can be readily rolled under the finger. This is true in a high-tension pulse even if the wall is not thickened. The thickness of the arterial wall can be brought out by compressing the vessel until the blood current is shut off and then trying to locate the artery distal to the compression. If it is normal it cannot be differentiated from the surrounding tissues but if sclerosed it rolls under the finger. At first the left ventricle enlarges to overcome the increased resistance in the vessels, the apex beat is felt below and outside the nipple line, the impulse is forcible and heaving but circumscribed. The first sound is often duplicated, the second sound is very loud, especially at the aortic cartilage; sometimes it has a ringing quality. When there is emphysema present the apex beat, heart dullness, and sounds may be obscured. As time goes on the enlargement of the heart becomes more general and later dilatation begins with a systolic murmur at the apex from relative insufficiency of the mitral valves.

When dilatation becomes marked, irregularities develop and edema of the extremities, cardiac dyspnea or pulmonary edema come on. The pulse tension is apt to fall and usually orthopnea is more or less persistent. Epistaxis may come on and persist, causing dangerous bleeding. Edema of the glottis comes on suddenly at times or effusion into the pleura or lungs may occur and prove rapidly fatal.

Bronchitis, pneumonia, and pleurisy are frequent in the winter months and often form the terminal event.

Dyspnea is a common symptom; it may be uremic or cardiac. In the latter event it often takes the form of cardiac asthma coming on in paroxysms and forcing the patient to sit up in bed and gasp for breath. Cheyne-Stokes breathing usually comes on near the close especially when the patient is comatose; it may come on earlier, however.

The nervous symptoms are usually uremic; headache, neuralgias, and insomnia are frequent. Drowsiness if persistent usually indicates the onset of coma and muscular twitching often precedes convulsions. Mania or delusional insanity may develop.

Cerebral hemorrhage may be the first serious symptom of the disease; it may cause hemiplegia. Hemorrhagic pachymeningitis may also occur. At times hemiplegia or a monoplegia may develop but rapidly clear up and later no sign of gross brain lesion be found. These are uremic and probably due to the brain edema. Other nervous symptoms due to uremia are itching of the skin, numbness of the fingers or toes, and cramps in the calves of the legs.

Digestive disturbances may be among the first signs, notably persistent vomiting. This is probably uremic; it is often uncontrollable and frequently causes death. The same may be said of diarrhea. Heavy breath and a coated tongue are fairly constant.

Many cases of interstitial nephritis are first seen by the oculist because of dimness of vision or actual blindness. Flame-shaped hemorrhages occur on the retina or a diffuse retinitis or papillitis arises. Sudden blindness (uremic amaurosis) may occur without demonstrable retinal changes. Recurring hemorrhages into the conjunctiva are frequent, diplopia is rare.

Ringing in the ears and dizziness are common and deafness may occur. Edema is infrequent in this form of nephritis and usually does not occur. At times it may come on to some extent with a failing heart. The skin is usually dry and sweat is suppressed.

Toward the last urea may be deposited on the skin by the sweat glands. In one case under my care the whole body was covered with little white mounds of this substance at the time of death. They could be readily picked off the surface with the fingers.

Epistaxis has been referred to and purpura may occur to an extensive degree.

Diagnosis.—Many cases are not diagnosed till serious symptoms develop or until autopsy. If the patient is examined, however, and found to have a high pulse tension with sclerosed vessels, a loud aortic second sound, and an abundant clear urine with low specific gravity and a few hyaline or granular casts with or without a trace of albumin, the diagnosis can be safely made.

Prognosis.—It is incurable and progressive, but often the progress is very slow, ten, twenty or even thirty years sometimes passing before a fatal event. On the other hand, these patients are very liable to intercurrent affections which greatly shorten the course of the disease. The onset of uremic symptoms, dilatation of the heart, persistent vomiting and diarrhea, serous effusion, and Cheyne-Stokes breathing are all signs of serious import and usually indicate a speedy termination.

Treatment.—This must of necessity be mostly symptomatic, as there are no specific remedies for the degenerative processes in the kidney structure that have been completely proven.

In general we attempt to remove the cause and so prevent further trouble, to relieve the kidney of its work as far as possible by making the skin and bowels take over as much of the excretion of solids as they can with the body fluids as flushers, and to restore the kidney as far as possible to the normal.

Under the removal of the cause comes prophylaxis in general, the careful handling of all infectious diseases and especially scarlet fever, with care in the diet and the giving of plenty of fluid throughout the course. This should continue during the first few weeks of convalescence. Proper preventive measures should be insisted upon in those whose occupation brings them into contact with the various chemical causes of the disease, as lead and mercury, and great care should

be exercised in the use of all the drugs that have been mentioned in the etiology of the various forms.

Anesthetics should always be given with great care and not a drop more than is necessary to obtain the result desired. When the kidneys are damaged all drugs that irritate them should be discontinued.

Exposure to cold or wet for any prolonged period should be avoided or if unavoidable a reaction should be brought about by vigorous rubbing, the application of heat, and exercise. In the handling of the nephritic this principle should be observed by accustoming the patient to woolen blankets and flannel night clothing so that he may not be chilled after the use of hot packs, etc.

Overexertion should be avoided, especially by one who is subject to, or predisposed to, nephritic attacks, as it has been shown that excessive exercise can produce albumin and casts in the urine of normal individuals. In the chronic forms the relief of business care and worry is most important and overeating and drinking should be avoided.

In relieving the kidney of its work two things are possible: first, to reduce the amount of waste products to be excreted, and second, to make the skin and bowels take over this work as far as possible. To reduce the amount of excretion, rest is very important, as physical and mental exertion both require increased metabolism. In acute cases and early in the chronic cases, absolute rest in bed should be insisted upon. This should continue in the acute cases until all signs of the disease have disappeared and in the chronic cases until any acute symptoms have passed off and until we can be sure that the damage is permanent and that nothing further is to be gained by it.

Whenever an acute exacerbation makes its appearance the patient should be returned to bed. The diet should be that which will keep up the nutrition with the least possible work upon the kidneys. In acute cases milk should form the chief article of diet; in fact during the more severe stages it should be the whole diet. Buttermilk is also very useful and when things begin to improve gruels and broths may be added.

The patient should drink freely of water, best the alkaline mineral waters, and lemonade and orangeade can also be used to advantage.

Later, as convalescence is established, citrus fruits, greens such as lettuce and watercress, vegetables, cereals, and bread and butter can be added. Meat should be avoided for several weeks. The restriction of fluids and of sodium chloride in the diet is still in controversy, many authors claiming that both should be restricted in the presence of edema, while others advise fluids in quantity.

Fischer, whose theories of nephritis and edema have been referred to, claims that the use of fluids with sodium chloride and an alkali is practically a specific for these conditions in acute cases—the alkali to overcome the acidity of the kidney and tissue colloids and thus prevent their holding excess of water, the water to aid the process of leeching out the solids from the kidney cells, and the sodium chloride because he has shown that sodium chloride and other salts have the power of limiting the swelling, or water-absorbing power, of the colloids in the presence of acids. The technique of this will be referred to later. Those who favor the restriction of fluids and chlorides do so on the theory that both tend to increase the edema. Certainly when there is suppression the free use of fluids in the form of alkaline waters, physiological salt solution, lemonade, or Fischer's solution affords valuable aid in bringing up the quantity of urine.

In the chronic cases of parenchymatous type the diet during exacerbations should be the same as the above, but when the edema is slight, meat in moderation, especially white meat, may be allowed with eggs, vegetables, and fruits.

In the interstitial type the diet should be sparing on meat; all liquors should be dropped; eggs, vegetables, greens, fruits, and cereals can be taken, however, but excess in quantity should be avoided.

Whenever acute symptoms appear, milk and buttermilk should be returned to. Tea, coffee, and cocoa can be allowed in moderation under ordinary circumstances and mineral waters are desirable.

To relieve the kidney by increasing vicarious elimination through the bowel and skin, many forms of hydrotherapy and catharsis have been recommended.

Sweating is valuable for the relief of edema and also for elimination. It can be best produced by hot air or hot water baths or by the hot wet pack. The first can be given in a cabinet or by driving hot air under the bedclothes which are held away from the body by some form of frame. Hot tub baths are also valuable and comforting. The hot wet pack is very generally used and can be applied by wrapping the patient in blankets wrung from hot water and covering this with dry blankets and a rubber sheet. The duration and frequency of these measures depend upon the patient's condition. In acute uremic cases they should be employed every few hours and last for twenty to thirty minutes.

The pulse must be carefully watched. In the chronic cases one hot air bath a day is usually enough except when the symptoms are aggravated. After these treatments the patient is dried and wrapped in hot dry blankets and usually sweats profusely.

In severe uremic cases which do not respond to these methods pilocarpine may be used in doses of one-eighth to one-sixth grain by hypodermic. This is not without danger and the heart should be watched. Hydragogue cathartics are also valuable, magnesium and sodium sulphate and in children milk of magnesia. They should be given on an empty stomach. Various concentrated cathartic waters may be used in the same way. Compound jalap powder in half dram doses or elaterium one-sixth to one-fourth grain of the extract may be used. Calomel is very useful, combined with soda especially so.

To return the kidney to normal we are helpless as yet, but many methods can aid to this end.

In the early stages where the process has just started a brisk cathartic with a hot pack or hot fomentations to the back may abort the trouble. Local blood-letting by means of leeches or cupping over the kidney may help in some cases. The use of certain substances which act directly as stimulants to the renal function is of value also. Among these diuretics water is most valuable, but certain salts are also of great service. Potassium citrate, potassium acetate, potassium bitartrate, and sodium benzoate are much used. Fischer explains the action of these salts as follows and adds many others to the list, especially sodium chloride. In his own words, "the saline diuretics are nothing but those salts which without being markedly poisonous are the most powerful dehydrants of the body colloids. . . . . They owe their action primarily not to any effect upon the kidney but to an effect upon the body as a whole. . . . . By diffusing into the tissues of the body they liberate water from them and their diuretic activity is but an expression of the amount of water they are thus able to liberate." The juice of the lemon, orange, and grapefruit acts in the same way by virtue of the sodium citrate which is formed. Fischer's solution previously mentioned is composed of sodium carbonate, 10 to 15 grams; sodium, chloride, 14 grams; water, 1,000 c.c.

The sodium carbonate is the crystalline form and is used for its antacid properties, while the chloride is used for its diuretic properties already referred to. This solution can be given by mouth, rectum, or intravenously, but never hypodermically. The weaker solution is used intravenously, the stronger by rectum and by mouth.

According to Fischer it is indicated in all acute forms

of nephritis and especially in the presence of suppression and edema. In the chronic form it is useful during acute attacks. Fischer and others have reported very favorable results and in my own hands it certainly has acted as a very efficient diuretic in many cases.

By vein a liter or more may be given at one time and repeated as often as necessary to render the urine alkaline to litmus paper. By rectum it is given by the drop method and can be given almost continuously if retained. I use it frequently by mouth in small doses one-half to one glass every hour or oftener as needed and find it well retained if given with lemon juice. I have seen no bad effects except in the case of a boy of fifteen with postscarlatinal nephritis, general edema, and loss of vision, who died suddenly six hours after the intravenous injection of 1,000 c.c. of the solution. He apparently died of acute dilatation of the heart. Hot saline solution has been used by rectum also for the relief of suppression with good results.

Another set of drugs which act as diuretics indirectly are certain heart stimulants. They act by increasing the flow of blood through the kidneys. Digitalis and strophanthus are useful in this way especially when the blood tension is low and the heart flagging. Caffeine citrate and caffeine sodium benzoate act somewhat in this same manner and also as salines.

Vomiting is sometimes a difficult symptom to control but it often ceases as the general condition improves. A preliminary dose of calomel will frequently help. Vichy water by mouth with the feeding of peptonized milk by rectum has done well in my hands. Drop doses of phenol creosote or iodine may be tried, or dilute hydrocyanic acid with bismuth. Cracked ice will sometimes relieve.

Anemia should be treated with the various iron preparations. Basham's mixture is a good example as it carries iron and a diuretic. The iodide of iron is useful for children. The citrate of iron by hypodermic is useful also. Tyson has cautioned against the too free use of iron, insisting that harm may result.

The treatment of uremia has already been touched upon as to the use of baths, cathartics, and diuretics; in addition we must consider the control of convulsion, coma, and delirium. For all of these conditions packs and cathartics are used and diuretics, especially Fischer's solution by vein, are indicated. It is often advisable to bleed the patient to the extent of twelve to twenty ounces if the pulse is tense and the patient full blooded, before injecting the fluid. The venesection may be done without the use of the fluid or physiological saline solution can be used. Inhalations of chloroform may be given if the convulsions are severe or chloral by mouth or rectum. Morphine is very useful for convulsions and also for the restlessness and delirium so often encountered. It is the best remedy for the severe dyspnea also.

In chronic cases and in convalescence from acute cases a change of climate may be desirable, especially in the winter time. The best places are those with a dry warm climate; in this country Texas, Arizona, New Mexico, and southern California, and abroad Egypt, southern Italy, and Sicily.

A course of the waters of certain mineral springs is of value in the chronic cases, Poland, Bedford, and Saratoga in this country and Vichy and others in Europe.

Hypertension as has been said is compensatory but when it becomes excessive may require special treatment. It is desirable to keep it within certain limits; if it gets too high it puts too much strain upon the heart and endangers the blood-vessels, while if too low it is apt to be accompanied by serous effusion and a falling off in the excretion of urine.

If the light diet, baths, and purges do not bring about a sufficient lowering of pressure, nitroglycerin is indicated, best in the alcoholic solution, one, two, or more drops being given three times daily until the desired result is obtained. Sodium nitrate may be used in doses of gr. iii-v, t.i.d. For quick action in the presence of convulsions amyl nitrite or better veratrum viride may be used. This last is used extensively in the convulsions of puerperal eclampsia and should be pushed till the pulse rate drops to sixty.

In the late stages of the interstitial form the signs of cardiac incompetency may come on and then the treatment for this condition is indicated. Strychnine and digitalis, especially the infusion, are valuable, and morphine for the dyspnea and restlessness.

The surgical treatment of Edebohls will be considered in a separate article.

Henry Lynde Woodward.

Nephritis, Operative Treatment of.—While it is true that nephrotomy, usually undertaken because of a mistaken diagnosis of calculous, or other admittedly surgical, disease of the kidney, had been noted to result in clearing up the evidences of nephritis by Newman, Harrison, Israel, and others, it remained for the late Dr. George M. Edebohls, Professor of Gynecology in the New York Post-Graduate Medical School and Hospital, to grasp the significance of these results and appreciate the fact that the course of a frank nephritis might be influenced by surgical measures. To him, therefore, belongs the credit for the establishment of a definite surgical procedure as a recognized therapeutic measure in certain cases of acute and chronic nephritis; the operation itself being styled *renal decapsulation*, or *Edebohls' operation*.

Having noticed that in many cases of movable kidney there were urinary symptoms pointing to renal congestion or mild degrees of nephritis, and that these symptoms were diminished or disappeared entirely after the partial decapsulation incident to nephropexy, he came to the conclusion that mild nephritis, which had previously been looked upon as a contraindication to nephropexy, really constituted a strong indication for anchoring the kidney. Consequently, on January 10, 1898, the first nephropexy with the deliberate purpose of favorably influencing the coexisting nephritis was performed by him. Early the following year he published his observations along this line under the title: "Chronic Nephritis Affecting a Movable Kidney as an Indication for Nephropexy."[1] In May, 1901, as the result of further observation and experience in similar cases, Edebohls stated:[2] "I am now prepared to go a step further and to propose surgical intervention for the purpose of attempting a cure of chronic nephritis, whether the affected kidney be movable or in place;" and in December of the same year he published a paper entitled: "The Cure of Chronic Bright's Disease by Operation."[3] At that time he reported his first series of eighteen cases.

Effects of Decapsulation.—What causes increased functional activity of the kidney after decapsulation? The immediate improvement may be due to (*a*) relief of tension, especially in acute nephritis from various causes, including nephritic eclampsia. In cases of the acute type there may be positive tension on the true capsule as shown by a bulging of the parenchyma when the fibrous capsule is incised. In the chronic forms, however, tension is never marked and rarely, if ever, seen. Except in the cases of almost pure parenchymatous nephritis the true capsule fits the kidney in a normal manner or the kidney seems contracted within a loosely applied capsule; and this is true even when there are occasional fibrous wedges running from the capsule into the substance of the kidney, as is seen in many cases of chronic diffuse, and chronic interstitial nephritis. (*b*) A second cause for immediate improvement is

found in the free bleeding that occurs when the capsule is stripped from the kidney and the massage unconsciously or intentionally applied during the necessary manipulation to bring the kidney into the field and steady it during the process of stripping and cutting away the fibrous capsule; for by these means intrarenal congestion must necessarily be markedly decreased, a certain amount of toxic products of metabolism escape with the free bleeding that is excited, and the excretory cells can thus perform their function under more favorable conditions. Finally (*c*) the continued and often lasting improvement Edebohls believed to be due to the creation of a new source of arterial blood supply to the kidney through the adhesions formed between the fatty capsule and the raw surface of the kidney. His contention in this regard has been borne out by many observers through (1) autopsy findings; (2) redecapsulations of the human kidney; and (3) animal experimentation. Those who are interested will find a number of autopsy reports bearing upon this phase of the subject in the literature. J. H. Larkin studied four kidneys from Edebohls' cases and his report of establishment of collateral circulation, as quoted by Edebohls,[4] seems convincing.

Increased vascularization, as found upon redecapsulation, was well shown in one of my cases already reported in detail elsewhere.[5] Upon redecapsulating the right kidney six years after the original operation, I found numerous small vessels passing from the perinephritic tissues into various portions of the reformed fibrous capsule where they were lost; while two rather large vessels penetrated the capsule and entered the kidney parenchyma near the center of the convex border giving considerable hemorrhage when the capsule was stripped from the cortex. The reformed capsule was found by the pathologist to be very richly vascular. Edebohls and others have also had occasion to redecapsulate and a number of cases are on record where the invasion of the parenchyma by vessels originating in the perinephritic tissues was plainly in evidence.

Almost innumerable animal experiments have been made, both here and abroad, in the attempt to prove or disprove Edebohls' theory of hypervascularization as the ultimate result of decapsulation. The most conclusive experiments along this line that have come under my observation are those of Siter,[6] of Philadelphia. In his final experiment, a dog's left kidney was decapsulated and wrapped in omentum; nine days later the vessels of that kidney were tied off; six days later the right kidney was removed and the animal left with only the decapsulated kidney whose vessels had been tied off, thus making it entirely dependent upon the establishment of collateral circulation during the fifteen days which had elapsed since decapsulation for its nutrition and function. Three days later the dog was killed by gas, the left kidney was found hypertrophied and there was normal urine in the bladder.

We thus see that the evidence furnished in these three separate ways seems to prove the correctness of Edebohls' theory that while possibly relief of tension and massage are responsible for the immediate improvement, it is the permanent improvement in blood supply and *not simply relief of tension* that is responsible for the prolonged improvement in renal function which follows decapsulation in the majority of cases. It has been claimed that as a new capsule, consisting of fibrous tissue, is always formed, this will contract and finally compress the kidney. In the redecapsulations, four in number, in which I have been concerned as operator or assistant, the reformed capsule has never seemed unduly snug and there has never been any bulging of parenchyma when such a capsule was incised, as would be the case if the capsule actually compressed the secreting structures. Experimentally, Anzilotti found no tendency to contraction of the new capsule in dogs as late as 150 days after decapsulation.

The Operation.—(For position of the patient, line of incision and other details of the exposure of the kidney see section on operative treatment in the article, Kidneys, Movable.) When the kidney is exposed it is brought into the wound and delivered onto the back if this can be done without exerting too great tension on the pedicle. When delivered, the capsule is incised on a grooved director the full length of the convex border, the two halves of the capsule are then stripped back to the hilum and cut away. Care must be taken not to open the peritoneum or injure the gut which crosses the lower pole and lies to the outer side of the kidney. If the kidney pedicle is short or if it is infiltrated, as is very apt to be the case in parenchymatous cases accompanied by marked edema, the kidney must be decapsulated in the depths, most of the work being done by touch rather than by sight. For this reason, if for no other, only those who have had a considerable experience in renal surgery should attempt renal decapsulation. For the expert in renal surgery the operation is extremely simple and may be rapidly performed, requiring not over thirty minutes for the complete operation on both kidneys in the average case. For the novice, some cases are very difficult, much time may be needlessly consumed, and this is hardly fair to a patient who is in no condition to stand a long anesthesia, to say nothing of the shock of prolonged mishandling of the kidneys. When the kidney cannot be delivered, a portion of the kidney is exposed in the depths of the wound and steadied there while an incision is made in its fibrous capsule. Each edge of the incised capsule is then grasped in forceps, the gloved finger is insinuated between capsule and cortex and the capsule stripped from the kidney, traction on the capsule by the forceps, which are reapplied from time to time, serving to tilt the kidney in one or another direction so that gradually all portions of the kidney are brought within reach. Meanwhile the incision in the capsule has gradually been lengthened, and finally the entire capsule is stripped free. All portions of the capsule that can be safely cut away with the scissors are then removed, and any remaining portions tucked down around the hilum where they curl up and seldom show any tendency to become reapplied to the surface of the kidney. The wound is then closed without drainage, in the manner described in the section on operative treatment of movable kidney. As an occasional exception when there is marked edema of the tissues of the back, a few strands of silkworm gut, laid over the fascial suture line and emerging at each end of the skin incision, will provide sufficient capillary drainage. Such a drain, removed at the end of forty-eight hours, does not preclude the probability of primary union.

What Types of Nephritis are Most Benefited by Decapsulation?—From an experience in the surgical treatment of Bright's disease gained through assisting Dr. Edebohls in approximately two-thirds of all his decapsulations, together with the examination of about 1,000 specimens of urine from those patients, and by personally operating upon sixteen cases, I believe that those cases which present the clinical symptoms of parenchymatous nephritis, acute and chronic, are most benefited by decapsulation. Those with chronic diffuse nephritis (the old "second stage of Bright's disease") also usually show marked improvement or cure if the operation has not been too long delayed. With chronic interstitial nephritis there is less chance of permanent improvement and practically none of cure unless the process is in its incipiency, as, for example, with the mild nephritis not infrequently accompanying movable kidney. One would never think of operating on an ordinary case of chronic interstitial nephritis as long as the patient seemed to

be progressing favorably under medical, dietetic, and hygienic treatment. When, however, the physician sees that the patient is gradually beginning to lose ground, I believe that decapsulation is indicated. Decapsulation in the late stages of interstitial nephritis has often resulted in marked improvement in the patient's general condition and afforded at least temporary relief from mild uremic manifestations, particularly the almost unbearable headaches that form so distressing a feature of this type of the disease. One patient (Edebohls' case No. 14) who had a nephritis of this type, herself requested a *third* decapsulation because of the relief experienced along these lines after the previous two operations.

Final Results.—Of my own sixteen cases, fourteen were private patients; two were hospital patients. Both of these latter were operated upon as a last resort when it had long been evident that nothing further could be hoped for from medical treatment; both were in very poor condition at the time of operation, and both died soon afterward. I now feel that these two patients should have been operated upon much earlier or not at all; for complete failures, even in such desperate cases as these, have been responsible for much undeserved criticism of decapsulation. Still, I have seen a number of patients afflicted with the chronic parenchymatous or chronic diffuse type of nephritis, where operation apparently offered very little hope and yet the *only* hope of rescue from impending death, make the most marvellous recovery after operation; so that in some cases not only has the span of life been lengthened months or years but the patient, previously incapacitated for weeks or months, has been restored to active business life. Hence, it may be readily understood that after a few such experiences it is hard to refuse a patient the one desperate chance remaining; and the statistics generally are not so favorable as they would be if operation were undertaken solely in those cases affording a reasonable hope of actual cure and eliminating those where the operation is undertaken merely in the hope of prolonging life for a comparatively short period. Two of my fourteen private patients died; one within ten days, the other about six weeks after operation. This gives a total mortality in my series of twenty-five per cent. The remaining twelve private patients (seventy-five per cent.) are alive, clinically cured or much improved in every instance, the length of time having elapsed since operation ranging from six months to a little over ten years. In considering these unusually good results it must be borne in mind that these are (with the exception of the two hospital patients) carefully selected cases; that the selection was made with the unusual advantage of intimately knowing the progress of Edebohls' cases, of frequent discussion of the subject with him, and early information as to what constituted, in his opinion, contraindications to operation; and consequently the number of private patients operated upon is far from including all that have been referred to me for an opinion as to the advisability of decapsulation of the kidneys within the past ten years. Shortly before his death Edebohls[7] reported the results in his first 102 cases at the meeting of the American Medical Association in June, 1908. The mortality percentage is unduly high for the reason that his earlier cases include not a few having complications, such as retinitis albuminurica and marked cardiac insufficiency, which he found later to be absolute contraindications to decapsulation.

Of these 102 cases, forty-nine had died and fifty-three were living in 1908. Of the forty-nine deaths: ten were operative (within two weeks); ten died from causes outside of nephritis; twenty-nine died from chronic nephritis and its complications. Of the fifty-three survivors: three patients were lost track of; six were unimproved; eleven were improved; thirty-three were considered clinically cured. The time elapsed since operation in these fifty-three cases ranged from fifteen months to nearly fifteen years.

In conclusion, I would plead for the more general recourse to this operation, particularly in the parenchymatous types of nephritis, acute and chronic, as soon as it is apparent that the kidneys are not doing well under expert medical treatment. If this were done, and done *promptly*, I believe that the yearly death toll from nephritis would be much decreased.

Wesley Grove Vincent.

References.

1. Edebohls, G. M.: Medical News, April 22, 1899.
2. ———: Medical Record, May 4, 1902.
3. ———: Medical Record, December, 21, 1901.
4. ———: New York Medical Journal, May 21 and 28, 1904.
5. Vincent, W. G.: Medical Record, July 19, 1913.
6. Siter, E. H.: Surgery, Gynecology and Obstetrics, December, 1912.
7. Edebohls, G. M.: Journal of the American Medical Association, January 16, 1909.

Nephropexy.—See under *Kidneys, Movable.*

Nephrophages.—A genus of mites, Family *Sarcoptida*, which is related to the itch-mite. *N. sanguinarius* is a somewhat doubtful parasite of man. See *Arachnida.* A. S. P.

Nephroptosis.—See *Splanchnoptosis.*

Nephrotomy and Nephrostomy.—The first of these terms signifies exposure of the kidney and incision into its substance for some purpose, upon the accomplishment of which the incision is closed by suture or allowed to close by granulation. In nephrostomy the wound in the kidney is kept open by gauze or tube drainage.

Indications.—By far the most frequent indication for nephrotomy is furnished by stone in the kidney, either as shown by the *x*-ray or suspected from the clinical symptoms. Nephrotomy is also occasionally performed as an exploratory measure; when otherwise unexplained hematuria leads to the suspicion of a lesion in the pelvis, tuberculous or otherwise; and, rarely, for the relief of renal tension in cases of nephralgia or acute nephritis, though in these latter cases complete decapsulation is far more efficacious and takes but a few minutes more time. Nephrostomy finds its special indication in suppurative conditions, notably calculous pyonephrosis, in calculous anuria, and occasionally in hydronephrosis and tuberculous pyonephrosis; in the latter case usually when there is ureteral obstruction and the patient has a solitary kidney or both are badly diseased, or as a preliminary stage to tide the patient over or to reduce the size of the mass before nephrectomy.

Operation.—Exposure of the kidney is always by the lumbar route. When it seems certain from the *x*-ray and physical examination that we are dealing with a non-septic condition affecting a small or freely movable kidney, the incision may be made along the outer border of the erector spinæ muscle from the last rib to just above the crest of the ilium. The position of the patient and steps in the exposure of the kidney will then be as for nephropexy (see *Kidneys, Movable*). When, however, the kidney is large, fixed, or the seat of a septic process, the lateral position and oblique lumbar incision as for nephrectomy should be employed. The incision should be relatively short at first, to be lengthened after exploration of the kidney if necessary.

In operating for stone the kidney may be found to be nearly or quite normal in size and appearance and with little or no perinephritis, or moderately or enormously enlarged, surrounded by dense adhesions and pyonephrotic, or atrophic and buried in a dense fibro-

fatty capsule. In the simple cases the fatty capsule is incised and the kidney delivered into the wound by blunt dissection with little or no difficulty. The kidney is then palpated and if the stone is felt clearly, an assistant compresses the pedicle while it is cut down upon in a line radiating from the pelvis (Marwedel's transverse incision) or the incision is made longitudinally on a line a little posterior to the convex border of the kidney. If the stone cannot be felt, the longitudinal incision is made opening into the lower calyx, the finger introduced, and the pelvis and calices thoroughly explored. When the finger has been introduced, compression of the pedicle can usually be dispensed with since the finger acts as a tampon and hemorrhage practically ceases. After the stone or stones shown in the radiogram have been removed, the entire kidney should be palpated between a finger inside and the thumb (or fingers of the other hand) outside the kidney, and if any other calculi are found they are removed. The ureteral opening is now located and its condition determined, while if there is any suspicion that a small calculus has entered the ureter, a ureteral catheter is passed down to the bladder. The pelvis is then flushed with hot saline solution and in the absence of evidences of infection the wound in the kidney is closed by suture, the kidney dropped back and the lumbar wound closed with or without the introduction of a cigarette drain. When the stone is felt to be small and low in the pelvis, while the urine shows little or no evidence of infection, the stone may be removed by incision of the posterior aspect of the pelvis in the line of its course to the ureter—pyelotomy. Eisendrath (*Journal A. M. A.*, 1913, vol. lx., page 1145) is particularly enthusiastic about this method and has well described its indications and limitations.

When we deal with a large calculous kidney there is usually marked perinephritis which has led to more or less dense adhesions of the fatty capsule to surrounding structures. Here the freeing and exposure of the lower pole may be comparatively easy, that of the upper pole exceedingly difficult. Under these circumstances, and especially when there is a large branched calculus or multiple calculi firmly embedded in the tissues of the upper pole, mobilization of the lower thoracic wall by subperiosteal division of the lower one or two ribs may be necessary in order to get room to separate adhesions and free the kidney sufficiently to allow proper and safe handling of the situation. If the calculi can be safely removed and sufficient secreting structure remains to make it worth while, the kidney is drained by gauze and rubber tube or by tube alone, otherwise the kidney is removed at once, or drained and removed later as soon as conditions are favorable.

The atrophic calculous kidney is usually practically worthless as far as secretory activity is concerned and usually nephrectomy is indicated. Nephrotomy in such a kidney is usually performed by stripping the fibrous with the fatty capsule as in subcapsular nephrectomy. With this out of the way the kidney is palpated and if a stone is felt a long aspirating needle is thrust through the corresponding portion of the convex border and its point made to impinge upon the stone, incision then being made along the needle. If the stone cannot be located by palpation an attempt is made to open into the lower calyx, as in the simple cases described above, and with the finger in this as a guide the kidney may be laid open to the desired degree. There is but little danger of serious bleeding since atrophy of the renal vessels has usually kept pace with or exceeded that of the kidney itself. WESLEY GROVE VINCENT.

Nerve Tissues.—These are the most highly differentiated and specialized tissues of the body. By means of these the various organs and structures are united and associated so that they can work together and accomplish some definite object. By means of the nerve system the individual is made cognizant of his environments through his sense organs. Nerve tissues consist of cells and intercellular substance like the other varieties of tissue and as in connective tissues the intercellular substance predominates.

There are two varieties, *gray* and *white*. The *gray* is characterized by a grayish color; in the cerebrum and cerebellum it is divided into layers while in the spinal cord, brain stem, and ganglia the arrangement is somewhat different. It consists of cells, their processes, myelinated and amyelinated nerve fibers, and neuroglia, the special supportive tissue of the nerve system.

NERVE CELLS.—These are found only in gray nerve tissue. A typical cell comprises a cell body, its processes, a nucleus, a nucleolus, and a centrosome. The whole structure constitutes a *neuron*, or *neurocyte*.

The *cell body*, or *cytom*, is composed of a granular and fibrillar protoplasm. A fine network, seemingly containing myelin, has been found by Golgi in the protoplasm. It stains darkly after prolonged exposure to osmic acid and is unconnected with the

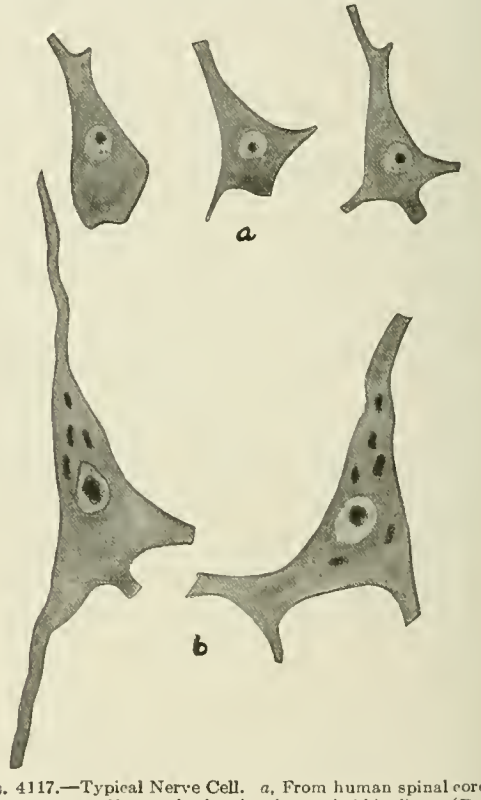


FIG. 4117.—Typical Nerve Cell. *a*, From human spinal cord; *b*, from motor area of human brain, showing typhoid bodies. (Drawn from slides.)

neurofibrils. The *granules* are of two kinds, oxyphilic and basophilic. The *oxyphilic granules* are the more numerous and small and are seen only after special stain methods have been employed. The *basophilic granules, corpuscles of Nissl*, or *tigroid bodies* are large but inconstant. They consist of nucleoprotein containing organically combined iron, as pointed out by MacCallum in 1905. These are usually large, flake-like granules that respond readily to methylene blue or toluidin blue stains. The presence and the position of these bodies depends upon the functional activity of the cell; they may be scat-

tered or arranged in two groups, one near the nucleus and the other near the periphery of the cell, or arranged concentrically around a well-defined centrosome. In fatigued cells they disintegrate and disappear, although Dollay (1909) has shown that if the activity is not excessive they may first increase in amount. These changes are called *chromatolysis*, or *Nissl degeneration*. Similar changes occur in these granules, if the axones of the cells be cut, beginning twenty-four to forty-eight hours after section and being completed in fifteen to twenty-four days. Various poisons including toxins produce like effects. With removal of the causes regeneration usually takes place. In section or disease of the axones, however, regeneration does not always occur. In certain portions of the nerve system other granules, usually brownish-yellow or black, are found in the protoplasm; this is the *substantia nigra* of the locus cœruleus. This pigment contains lecithin and tends to increase with age, making its appearance about the third year. It is more common in man than in other animals.

Schrokogoroff has studied the *mitochondria* in the nerve cells of the rabbit. He found them more or less abundant in all such cells. They were best developed in the nerve cells of the spinal cord and oblongata and in the Purkinje cells of the cerebellum; in the small cells of the basal ganglia of the brain they were small and few in number. Their presence in the axones is doubtful.

Neurofibrils, first described by Max Schultze, are seen passing into and through nerve cells, extending into all of the cell processes without forming junctions with one another. These fibrils are of a semi-solid nature, apparently, as they easily become varicose in form; they vary, apparently, with functional activity. Cajal and Tello have found that in the hibernating lizard, during winter sleep, these fibrils are less numerous and thicker while in the active animals they are more numerous and finer. They are readily stained by the *intra vitam* methylene-blue method, or by the Golgi silver-nitrate method.

Holmgren has found a network of fine juice-canals in the protoplasm of many of the cells, especially those of the ganglia. He believes that these canals may undergo constant changes.

Golgi and others have described a reticular investment covering the nerve cell and extending for a variable distance along the processes. Its nature and function are unknown. Some believe that it represents the interlacement of the terminal ramifications of axones of other cells about the cell body; others (J. Turner) believe that it is of neuroglial origin.

The *nucleus* is usually large, spherical, pale and eccentrically placed. It contains little chromatin while the karyosomes are few and small; at times chromatophilic granules are found in the achromatic nucleoplasm.

The *nucleolus* is very large and darkly staining. Nucleolar substance is said to extend into the protoplasm at times as noted by May and Walker, while Menele has observed the nucleolus connected by a chromatic fibril extending into the cytoplasm.

Centrosomes with attraction spheres have been found in *nerve cells* of the lower vertebrates and in some mammals. When the centrosome is prominent the corpuscles of Nissl are often arranged around it in a concentric manner.

Cell Processes.—Extending from the cytom will be found one or more processes and cells are classified according to their number, as *unipolar*, *bipolar*, and *multipolar*. The unipolar cell has but one process, the bipolar two, and the multipolar more than two. The main process is called the *axone*, *axis cylinder*, or *neurit*, and represents a direct continuation of the cell protoplasm and neurofibrils. It starts at the *axis-cylinder hillock* and consists of a cylindrical collection of neurofibrils imbedded in neuroplasm and surrounded by a delicate membrane called the *axilemma*. It is uniform in diameter, smooth in contour, and may give off branches called *collaterals;* near its termination an axone may bifurcate but ultimately ends in a brush-like mass of branchlets called *telodendria* (better teleneurites). Occasionally an axone may arise from a dendrite. The axone extends a variable distance from the cytom and its course as to whether it remains in the gray substance or leaves to enter the white gives rise to a classification of nerve cells into *first* and *second types*. A cell of the *first type* (*Deiter's cell*) is one in which the axone leaves the gray substance to become a myelinated nerve fiber, or a sympathetic nerve fiber. A cell of the *second type* (*Golgi's cell*) is one in which the axone does not leave the gray substance. In a unipolar cell the process soon divides into two, one the axone and the other the dendrite.

Dendrites are secondary processes. When they arise from the cytom they are relatively thick, but as they branch repeatedly they taper rapidly. These branches do not usually extend far from the cell and terminate in fine branches, *telodendrites*, that end in relation with the telodendrites or teleneurites of neighboring cells. The network produced by the various telodendrites forms a considerable portion of the gray nerve tissue.

Unipolar cells are found in the ganglia in the dorsal roots of the spinal nerve and in the ganglia connected with the trigeminal and vagal nerves and occasionally among the cells in the ventral horns of the spinal cord. The cells are usually spherical, or nearly so, in shape and the process, close to the cytom, is surrounded by a myelin sheath. At a short distance from the cell the process divides like a T, or Y, one process entering the central nerve system (axone) and the other extending to the periphery (myelinated dendrite). Embryologically these were bipolar cells in which the cell body grew unequally so that gradually the two processes were thrown side by side; at the same time the cell protoplasm became extended so as to form the undivided portion of the process. As a result this seemingly unipolar cell is functionally a bipolar element.

Bipolar cells are found in the cochlear and vestibular ganglia connected with the cochlear and vestibular divisions of the auditory nerve, respectively; in the olfactory mucosa; as the rod- and cone-cells of the retina; as the Purkinje cells of the cerebellum.

The *multipolar cells* are most numerous and are found in the cerebral cortex, the gray substance of the spinal cord and brain stem.

Nerve cells vary in size from 4 to 9μ in diameter for the smallest and 75 to 150μ for the largest. The former are the granule cells of the cerebellum and the latter are those of the ventral horns of the spinal cord. The next largest cells are the large pyramidal cells of the cerebral cortex (motor area).

According to the "neurone theory" the nerve system consists of a series of closely related and physiologically related elements from the central system to the surface; in other words one cell does not extend from center to periphery. These related neurones are not directly connected to one another, although the processes of one cell may end around the body of, or in contact with the processes of another cell. This has been shown by special stain methods (see the article on *Histological Technique*) by the study of the nerve system in certain diseases and injuries and by the study of the development of nerve cells and fibers. In the diseased condition, whether produced experimentally or otherwise, only certain cells or cell-groups are affected. The cells and their processes alike are affected by degenerative processes, but the preceding or succeeding neurons are not affected. The ramifications of the axone of one cell about the cell body (investment) or processes of another cell (interlacement) constitute a *synapse*. Occasionally synapses may occur between the dendrites of two cells. Some-

times the axone does not branch at its termination but ends in a bulb-like enlargement upon the body of the other cell, as in the trapezoid and acoustic nuclei of the brain stem.

The *neuroglia*, or *glial substance*, is the peculiar supportive substance of the nerve system. Like the nerve cells it is of ectodermal origin. Unlike the other tissues it is not the result of the activity of the functionating (nerve) cells but the glial substance itself consists of cells and intercellular substance. The glial cells give rise to the glial fibers.

Fig. 4118.—A Synapse of the Investment Type.

Glial cells are of two kinds, ependymal cells and astrocytes. The *ependymal cells* are apparently some of the original elements of the neural tube. They are simple ciliated epithelial cells that are found lining the canal of the spinal cord and the ventricles of the brain. The cilia lie in the cavity of the spinal cord and brain

Fig. 4119.—Typical Neuroglia Cells, from a Cross-section of the White Matter of the Human Spinal Cord. (Huber, "Studies in Neuroglia Tissue," Vaughan Festschrift, 1913.)

while the basal ends of the cells are usually branched; these branches extend into the surrounding nerve tissue where they soon disappear.

The *astrocytes* are usually stellate elements with many processes. In some cells the processes are short and thick (*mossy cells*) and these are usually found in the gray substance. Other cells have fewer but larger processes (*spider cells*) and are found chiefly in the white substance. Intermediate forms are noted. Andriezen and Robertson believe that glial cells act as intermediaries between nerve cells and the blood-vessels in the nutrition of the nerve cells.

The *glial fibers* are delicate filaments of protoplasm that form a network for the support of the nerve cells and glial cells. Some of the fibers have a very intimate relation with the glial cells passing close to the cell body or even through its peripheral protoplasm.

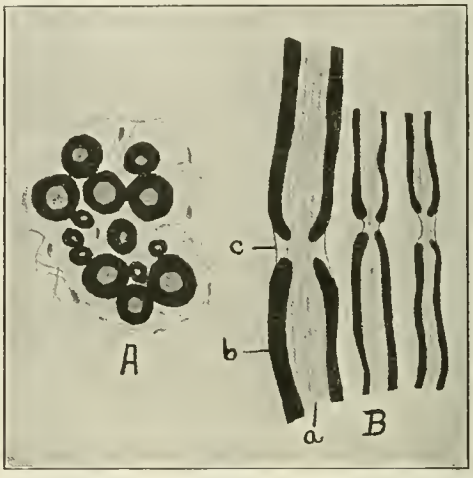


Fig. 4120.—Osmicated Nerve Fibers. *A*, Cross-section; *B*, longitudinal section; *a*, axis-cylinder; *b*, osmicated myelin sheath; *c*, neurilemma showing at node of Ranvier. (Drawn from slides.)

The *white nerve tissue* consists of myelinated nerve fibers supported by neuroglia and a small amount of white fibrous connective tissue. It constitutes the medulla of the cerebrum and cerebellum, the columns of the spinal cord and the cerebral and spinal nerves and constitutes a large portion of the brain stem.

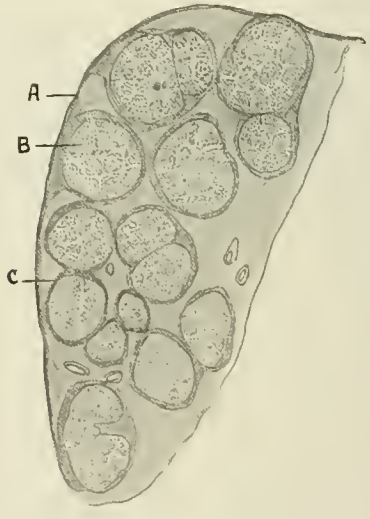


Fig. 4121.—Cross-section of Human Sciatic Nerve. *A*, Epineurium; *B*, funiculus of nerve fibers; *C*, perineurium.

Nerve fibers are of two kinds, myelinated and amyelinated. The axone is the essential part of any nerve fiber.

An *amyelinated*, or *gray nerve fiber*, consists of a bare axis-cylinder and is said to be exclusively connected with the sympathetic nerve system. Ranson, however, found these fibers were more numerous in the

ordinary nerve than had hitherto been supposed. He considers them as arising from small ganglion cells of the spinal ganglia. Such a fiber consists of a bundle of neurofibrils, arising at the axis-cylinder hillock of the ganglion cell, imbedded in the homogeneous neuroplasm. It is continuous throughout its course and terminates in a set of branches called teleneurites. These sympathetic axones are the smallest and measure from 1.8 to 3.6μ in diameter. The neurofibrils seem to converge from the dendrites through the cell body to the axis-cylinder hillock. Although some authors claim that these neurofibrils branch and interlace in the nerve fiber, most investigators hold that they are individual throughout their course. These fibrils are semi-solid and readily become varicose. Under high magnification each fibril seems to be tubular in character, the center of the tubule being filled with the fluid-conducting substance, as pointed out by Carlson. Surrounding the axis-cylinder is a delicate sheath called the *axilemma;* the existence of this is denied by some. It probably represents differentiated neuroplasm. It is stated that all protoplasm contains the constituents of myelin and that some spinal ganglion cells have an envelope of myelin. At frequent intervals nuclei are seen along the amyelinated nerve fibers as though they might indicate and belong to a separate investing sheath.

Amyelinated nerve fibers are distinctively sympathetic and grayish in color. They terminate in the smooth muscles of the various organs, including the heart, upon the epithelial cells of mucous membranes and glands. These fibers are also seen in several of the cerebral and ventral roots of the thoracic, most of the lumbar and some of the sacral spinal nerves.

A *myelinated*, or *white nerve fiber* consists of an axis-cylinder, a myelin sheath and a neurilemma. The *axis-cylinder* consists of a bundle of neurofibrils imbedded in the homogeneous neuroplasm and probably surrounded by an axilemma, as above described. The largest axis-cylinders (to the skeletal muscles) are from 8 to 16μ in diameter, though sensor fibers may be as small as 4μ. The *myelin*, or *medullary sheath* is, apparently, an insulating sheath found only in the cerebrospinal nerve system. This sheath is not continuous but is interrupted at regular intervals called *nodes of Ranvier*. This sheath consists, after fixation, of a *reticular substance* and the *myelin*. The former is composed of *neurokerotin* and is arranged in the form of a network after fixation, but in fresh material it is invisible. Here the myelin sheath has an homogeneous appearance. It seems to be a coagulation product as the meshes of the reticulum vary in size according to the strength of the reagent used. Alcohol and ether produce the best results and these results may be obtained with isolated myelin. Pieric acid solution produces a different coagulation effect. When this reagent has been used and transverse sections of such nerve fibers are studied the myelin sheath has the appearance of fine delicate rods radiating from the axis-cylinder to the neurilemma. The myelin substance is a phosphorized fat and responds readily to osmic acid, which quickly stains it black, thus showing the presence of fat.

In degeneration of nerve fibers the myelin sheath shows the first signs. This is of importance in the study of diseases of the nerve system and in tracing the fiber tracts.

At regular intervals the myelin sheath is interrupted and the neurilemma dips in toward the axis-cylinder. These areas are the *constrictions of Ranvier*, and because the myelin sheath at these areas may be somewhat bulbous, giving a nodal appearance, they are also called the *nodes of Ranvier*. These are seen only upon longitudinal section of the nerve fibers. The intervening parts constitute the *internodes*.

External to the myelin sheath is seen a delicate, nucleated, homogeneous membrane called the *neurilemma*. This is very thin and in each internode there is a nucleus. Although the sheath seems continuous over the nodes it is thought that it really ceases here and that successive nucleated segments, constituting individual cells, are connected by intercellular cement substance as is seen in epithelioid cells. Upon staining with silver nitrate black crosses are formed at these constrictions, as though the reagent penetrated more readily here, staining the cement substance, and the axis-cylinder but a short distance each way. The nerve fibers that constitute the white substance of the brain and spinal cord are devoid of a neurilemma (*alemmal*) and along such fibers no nuclei are found. The neurilemmal sheath probably represents specialized ectodermal cells of the neural tube.

A *nerve*, or *nerve trunk* consists of a variable number of nerve fibers collected into a compact mass and bound together by various sheaths. Upon the outside is a sheath of loose areolar tissue called the *epineurium*. This contains the larger blood-vessels and lymphatics and also the nervi nervorum, the sensor nerves of the nerves. In addition a variable quantity of fat is present. The epineurium is usually thin and sends in septa (for the support of vessels) that divide the nerve into large secondary bundles; from these septa others extend in to surround individual bundles of nerve fibers called *funiculi*. The sheath surrounding each funiculus is called *perineurium* and it is usually thicker in proportion than the epineurium. Although the perineurial sheaths seem compact their layers are readily separable from one another, indicating extensive tissue or lymph spaces that are continuous with the spaces around the brain and spinal cord. By this means the cerebrospinal fluid may pass into the nerves toward the periphery (Keyes). From the perineurial sheaths bundles of connective-tissue fibers pass into each funiculus forming here a delicate reticulum (*endoneurium*) which supports not only the nerve fibers but also the capillaries that nourish the nerve trunk.

The funiculi as well as the nerves vary greatly in size. A nerve, as the optic nerve, may consist of a single large funiculus comprising 450,000 to 800,000 fine nerve fibers, or it may consist of many funiculi but of fewer fibers, as the vagus nerve with its 10,000 nerve fibers. The nerve fibers in a funiculus rarely branch but the fibers themselves may start in one funiculus and cross over and join another. When a single fiber runs individually to an organ it is usually surrounded by a delicate sheath derived from the perineurium, called the *sheath of Henle*.

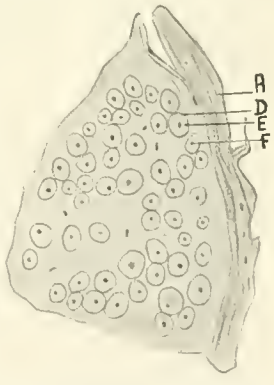


Fig. 4122.—Small Area of Fig. 4121. Highly Magnified. *A*, Perineurium; *D*, neurilemma; *E*, myelin sheath; *F*, axis-cylinder.

A *sympathetic nerve* has the same general structure but the sheaths are usually thinner. In the larger nerves are found many myelinated nerve fibers representing the white rami communicantes of the cerebrospinal system.

A *ganglion* consists of a sheath of white fibrous tissue that supports the structures within. This sheath sends in trabeculæ that form a delicate network in which are found the ganglion cells, myelinated and amyelinated nerve fiber and some neuroglia. The neurilemma sheath is continuous over each ganglion cell and in the case of the cells of the sympathetic ganglia this sheath continues for a short distance over the dendritic processes. The cells of the cerebrospinal ganglia are usually ovoid or round and of the unipolar

or bipolar type. The unipolar cell is now considered bipolar as the single process is looked upon as an extension of the cytoplasm and not as a mere process. The cells of the vestibular and cochlear ganglia of the auditory nerve retain their bipolar character throughout life. The cells of the sympathetic ganglia are multipolar in type. Each nerve cell in a ganglion is a distinct and independent neuron, but they are all linked together in a communicating chain by the various processes, whether dendritic or neuritic, ter-

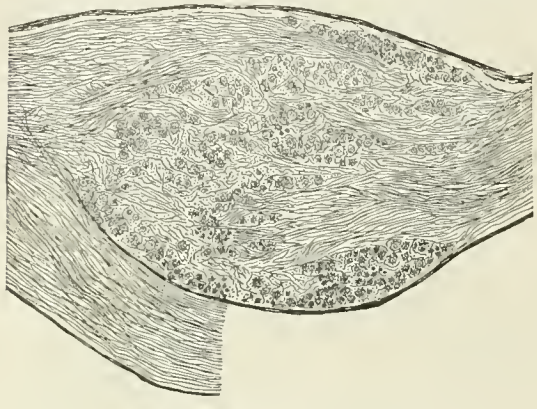


Fig. 4123.—Longitudinal Section of Spinal Ganglion of Cat. (Bohm, Daridoff, and Huber: Text-book of Histology.)

minating in a basket-like network about the various cells. Each ganglion cell is surrounded by a lymph space lined with endothelial cells.

Nerve Organs.—These structures, also called *nerve terminations*, may be classified as *motor* and *sensory*. It is the axis-cylinder alone that continues to the real terminal organ in the cerebrospinal and sympathetic systems. For a description of the different forms of nerve organs the reader is referred to the article, *End-organs, Nervous.* H. E. Radasch.

Bibliography.

A. B. MacCallum: Jour. of Phys., vol. xxxii., 1905.
Dollag: Amer. Jour. of Phys., vol. xxv., 1909.
May & Walker: Quart. Jour. Exp. Phys., i., 1908.
Mencle: Arch. fuer mic. Anat., vol. lxviii., 1906.
J. Turner: Brain, 1906.
Ranson: Anat. Record, vol. iii., 1909.
A. J. Carlson: Amer. Jour. of Phys., vol. xiii., 1905.
J. J Schrokogoroff: Anat. Anz., April, vol. xliii., 1913.

Nerves, Injuries of.—See *Nerves, Surgery of.*

Nerves, Physiology of the.—General Functions.—The nerves are connecting lines between the sensorium and the central nervous system and between the central nervous system and the muscles, the glands, and the blood-vessels. Every nerve is made up of a number of nerve fibers. Each fiber is the continuation of a process from a nerve cell which is usually situated within or close to the collected masses of nerve tissue known as the cerebrum, the cerebellum, the medulla oblongata, the spinal cord, and the chain of sympathetic ganglia. Some of the cells which give rise to processes which are parts of nerves are located in other regions of the body, for example the ganglion of Bidder, but the general statement of fiber relations is true in these cases as well as in those related to the massive collections of cells which have previously been mentioned. Certain of the fibers are medullated, while others are non-medullated. The latter arise mostly from the cells in the chain of the sympathetic ganglia, but some take their origin from ganglion cells in other regions.

There is only one general normal function of nerves, namely, the conduction of the so-called nerve impulse.* These impulses are conducted from the masses of nervous tissues (nerve cells) to the peripheral mechanisms (these are known as *efferent*), and others which arise in the peripheral end organs are conducted to the nerve centers (these are called *afferent*). Each nerve, therefore, has for its normal function that of the conduction of some sort of excitation. The kind of "impulse" which is conducted depends upon the connections which are made by the nerve, whether it be with sensory end organ or with motor or secretory or other cells. Many nerves have the twofold function of conducting both afferent and efferent impulses, and it is believed by some that few, if any, nerves have solely afferent or efferent functions.

At the same time it should not be overlooked that the nerves may be stimulated directly without recourse to the nerve cell body or to the receptor organ, and because of this it is proper to say that the nerves also show irritability, although in the intact living animal the normal and usually exclusive function is that of conduction, as has been said above. The main facts regarding the irritability of nerves will be dealt with in a subsequent section of this article.

Efferent Functions.—The efferent function of a nerve may well be considered in relation to the apparatus which is connected with or which is supplied by the nerve. Thus, we speak of the *motor*, the *inhibitory*, the *electrical*, the *secretory*, and the *vasomotor* nerves, because the efferent impulses go respectively to organs which are caused to move, or which are stopped in their movements, or which produce electrical currents, or to elements which secrete substances, or to blood-vessels which change their calibers. In addition some physiologists believed that there were special nerves concerned with the nutrition of parts of the body, and hence spoke of *nutritive* nerves.

The *motor* nerves are best represented by those nerves which supply the voluntary muscles. The impulses which, for example, arise in the cells that are located in the anterior horn of the spinal cord, pass downward by means of the nerve fibers to certain muscle cells and cause changes in the latter so that the muscle as a whole shortens and thickens. Similarly, if a nerve be excited directly by a blow, or by an electric shock, a change known conveniently as a nerve impulse takes place in the nerve which is evidenced by a similar contraction of the connected muscle.

The *inhibitory* nerves are those which by their activity produce a cessation of activity, or a slowing of response, of the parts with which they are physiologically connected. The inhibition is most frequently of motor activities. This type of function is best represented by certain fibers in the vagus nerve which act upon the heart in such a manner that in certain animals (such as the tortoise) the heart may be stopped and in other animals the heart may be slowed. Although inhibitions of voluntary muscles are produced by the activities of the nervous system it is still an open question whether or not there are special nerves or special nerve fibers which convey inhibitory impulses to the striated muscles.

Electrical nerves are found in some fishes. They are connected with the different plates or organs whose activity generates an electrical current. In man and in other mammals they have not been found for there are no known specific electrical organs.

The *secretory* nerves are connected with the different secreting organs of the body. Because of, or in connection with, their activity secretions differing by as much as do bile, saliva, sweat, adrenalin, and urine are produced by the respective glands. Some doubt exists that there are real nerves of secretion, at least for all the bodily secreting organs, for most of the

*The nature of these nerve impulses will be discussed below. In the discussion the term is used for convenience in place of a more cumbersome one, which might better describe the reaction.

phenomena of secretion may be explained as the results of increases or decreases in the blood supply and as processes of filtration, osmosis, and the like. On account of the lack of a satisfactory understanding of the reason for the production of the different kinds of secretion by the different glands (for example, why the salivary glands secrete saliva and why the kidneys secrete urine, and why the liver secretes bile), and also because not all the facts of secretion are at present explainable in terms of osmosis and as the result of changes in blood pressure and blood flow it seems best to retain the term (secretory nerve) for the present. In this connection it may be mentioned that the stimulation of two different nerves which supply a gland may result in secretions of different compositions, and while this may be assumed to be due to differences in innervation of different cells of the gland there are no available facts which unequivocally point to this conclusion.

The *vasomotor* nerves supply the blood-vessels. Of these there are two kinds, those which cause constriction and those which cause dilation. In general these may be considered to be special kinds of motor and inhibitory nerves, since by their activity they produce in the blood-vessels phenomena of contraction and of inhibition similar to those which are produced in other muscles of the body by the so-called motor and inhibitory nerves.

The conclusion that there are special nerves of nutrition has been strongly opposed by recent investigators of the nervous system. The explanation of *nutritive* nerves has been offered mainly because when nerves have been sectioned, or diseased as in neuritis, certain changes in the nutrition of parts that are connected with these nerves have been noted to accompany the other changes of a motor, vasomotor, secretory, and sensory characters. The facts are not clear enough to warrant a definite statement although they point to the conclusion that the nutritive alterations following the section, or injury, or disease, of nerves may be explained without invoking that of the absence of special nervous mechanisms for the normal metabolic activities. All the nutritional changes can readily be concluded to be due to variations in the blood supply and in movement, for activity and a sufficient amount of circulation of blood and lymph are necessary for the normal repair and upkeep of the different bodily parts.

Afferent Functions.—The afferent functions, because of the multiplicity of end organs or because of the cerebral centers, are more numerous than the efferent. All of the so-called organs of special sense are connected with nerves which transmit impulses of such characters that they bring about appropriate sensations. We speak, therefore, of *visual, auditory-gustatory, olfactory, tactile, pressure, temperature* (*hot* and *cold*), *pain, kinesthetic, tickle, vibration sense, cenesthetic,* and other kinds of afferent nerves. It should be understood, however, that in thus designating certain nerves we mean only that the combination of (*a*) the stimulation of certain end organs, (*b*) the transmission of the impulses to the central nervous system, and (*c*) the reception of the impulses by the cerebral cells, gives rise to certain definite mental states which we call sensations. At the same time we must not exclude the possibility that there are certain afferent nerves which conduct afferent impulses which eventually do not give rise to sensations, for there are facts which make it appear certain that some of the afferent impulses which are conducted from the periphery have a character or have characters which do not give rise to any conscious conditions. The latter may, for convenience, be termed the *subsensory* afferent functions, and those which were previously mentioned are properly designated the *sensory* afferent functions. Whether or not the same nerve, or more restrictedly the same nerve fiber, may conduct impulses which at one time give rise to sensations of temperature, and at another time give rise to sensations of pain or pressure we do not know. We do know, however, that the phenomena of regeneration of afferent nerves and especially the phenomena of regeneration of cross-sutured nerves, which will be discussed in a subsequent section, give an indication that the transmission of different impulses at different times by the same nerve is a possibility.

The *visual* nerves are those which receive fibers from cells in the retina. Any form of stimulation that is intense enough, whether the stimulus be the vibrations of the ether, or an electric shock, or a pressure upon the eyeball which is transmitted through the media of the eye to the retina, produces the characteristic form of experience which is called visual. No distinction has yet been made between those fibers which convey impulses that are consciously interpreted as color, and those which convey impulses that are interpreted as white or gray light. It has recently been shown that the electrical variations of the optic nerves when stimulated by light differ according to the character of the stimulation. It appears possible that the same nerve fiber may convey all kinds of impulses of a visual character, and therefore, that color perception is due to functional alterations in the cortical cells rather than in the retinal cells with their nerve fibers.

The *auditory* nerves receive impulses from end organs in the inner ear. Whether or not differences in pitch, or loudness, or quality, of a tone is a function of the end organs (it has been supposed that the smaller portion of the cochlea contains end organs which when stimulated produce the sensations of low tones, or of those which are produced by the physical lower vibration rates) or a function of the cerebrum or of the transmitting nerve fibers, is not known.

Although there are now recognized to be four different and distinct taste qualities (sweet, bitter, sour, salt) and also that the taste buds in certain circumvallate papillæ may be stimulated by only one or by two or by three of the specific forms of stimulation we are as far as ever from an understanding of the relations of the forms of sensations in terms of *gustatory* nerve transmission. All that we may safely say is that the impulses originating in the taste goblets do give rise to gustatory sensations and that whenever a characteristic stimulation has been given the effect is transmitted through the nerves to the cerebral cortex. Some indication of a difference in the analysis of stimuli by the end organ or by the nerve is given by the fact that the same kind of stimulation on different portions of the tongue occasionally gives rise to different kinds of taste (for example, saccharine).

With regard to the *olfactory* nerves all that we are warranted in saying at the present time is that the nerves are stimulated through end organs in the Schneiderian membrane of the nose, the stimuli being chemical. No differentiation of end organ or of nerve function has been determined.

In connection with the nerve endings in the skin and in the subadjacent tissues there are found nerves, which conduct impulses resulting in sensations of *touch, pressure, pain, hotness* (or *warmth*), *coldness* (or *coolness*), *kinesthesia* (including impulses from the muscles, the joints, and possibly also the bones), *vibration, tickle,* and, possibly, also some less universally recognized forms of sensation. With the exception of those for warmth and cold transmission these nerves (or their end organs) are normally stimulated by mechanical means. In most cases in normal life it is very difficult to differentiate the sensations of touch and of pressure, and at times the kinesthetic, vibration and tickle sensations are bound up with those of touch and of pressure. In cases of nerve division (see the discussion in a subsequent section) it is possible to separate some of these from others, and it is because of the analyses of the variations of the sensations following nerve division, or after the destruction

or degeneration of nerves, that we have been able to differentiate many of the sensory processes in a definite manner.

In addition to the better known and the more generally recognized forms of sensory impulses which arise from the bodily periphery, other impulses of an afferent nature are doubtless always present. Much is yet to be learned both regarding the analysis of the sensations and also regarding the kinds of nerves which are involved, but it is quite generally admitted that we have experiences, which are due to stimuli which affect certain end organs and therefore nerves, and which give us knowledge of the general conditions of the body and the general bodily welfare. These are called *cenesthetic* sensations. Thus, we experience those sensations, or feelings to use a more general term, which are called nausea, well-being, ill-being, lassitude, and the like. It should not be concluded too hastily that these sensory, or sensory-like, experiences are as simple as those other experiences connected with the stimulation of the end organs and the nerves connected with the appreciation of temperature, pain, touch, etc., for the experiences may be the result of stimulation generally distributed over a large part of the body, or they may be due to the stimulation of special small areas of the viscera. Such experiences as the feelings of oppression, of impending harm, and of power, are probably not due to simple stimuli, but to complexes of stimulations in which many (and perhaps different kinds of) afferent nerves and their end organs are involved. In this connection the possibility of chemical stimulations by the secretions of the glands of internal secretion and also the chemical stimulations from exogenous and endogenous toxins as the causes of these generalized but potent sensations or feelings should be kept in mind.

Irritability of Nerve.—*General.*—That the nerve fiber has an irritability independent of the receptor organ with which it is connected and apart from the nerve cell of which it is a part is easily demonstrated. If a nerve-muscle preparation be prepared and the nerve fibers (which are thus separated from the cell bodies from which they arise or of which they are parts) be stimulated either by a sharp blow or by an electric current the muscle contracts. Due to the application of the stimulus which we have used, the blow or the electric shock, some change has taken place in the nerve which has been effective in bringing about the characteristic shortening and thickening of the muscle. If, now, there be prepared a decerebrate frog in which the seventh to the tenth dorsal roots of the spinal cord be exposed and cut between the ganglia and the spinal cord, the reflexes which ordinarily are produced by pinching the toes are no longer produced, but if to the severed central ends of some of the dorsal roots stimuli be applied, there result reflexes similar to those which normally are produced in the decerebrate, but otherwise uninjured, frog. The results of the first experiment permit us to say that the stimulus which has been applied to the nerve fibers connected with the muscle produces a something similar to the normal impulse which begins in the spinal cells and which is normally sent outward to the muscle through the nerve fibers. The results of the second experiment permit us to conclude that some kind of change has taken place in the nerve fibers (1) which is transmitted into the spinal cord, (2) which acts upon the anterior horn cells, and (3) which activates these efferent elements in a manner similar to that which is produced when the sensory endings or the receptor organs in the skin are stimulated.

Other experiments of a like nature have shown that the nerve fibers may be stimulated by means of the four different kinds of stimuli which are available, namely, chemical, thermal, mechanical, and electrical.

Mechanical stimulation may be applied to the nerve either in the form of stretching the fibers, or in the form of applying pressure to them. If a pressure of a sufficient amount be applied suddenly to the nerve of a nerve-muscle preparation the muscle contracts. A similar muscular reaction results if, instead of pressure, we cut the nerve (a convenient method of applying sufficient pressure to sever the nerve strands), or if we stretch the nerve to the breaking point. These different methods of applying mechanical stimuli to the nerve result in the changes which bring about in the muscle the conditions necessary for contraction. Moreover, although the use of mechanical stimuli cannot be governed as readily as those of an electrical nature it has been shown that mechanical irritants when applied to the nerve of a nerve-muscle preparation in insufficient amounts to bring about muscular contractions also produce changes in the nerve irritability similar to those which will be described later as accompanying electrical stimulation.

The *thermal* irritability of nerves may be demonstrated by an experiment of a similar nature in which the mechanical stimulus is replaced by a hot or cold stimulus, for we find, for example, that if a hot wire or a rod be placed upon the nerve of a nerve-muscle preparation the muscle contracts. The cold rod, unless the cold is extreme, is not as effective a stimulant as the hot rod.

The *chemical* stimuli which may be effective in bringing about nerve activity are numerous. In general, it may be said that any chemical compound or chemical solution which has an osmotic pressure different from that of the nerve has a stimulating effect, such stimuli causing the characteristic activities of different organs or reducing the activity in accordance with the kind of stimulus, the amount and the time of application, and the kind of nerve which is stimulated. Thus, the placing of the end of a nerve in distilled water sets up changes, chemical and also those which may now be described as nerve impulses, which in a nerve-muscle preparation, for example, are evidenced by irregular contractions of the muscle. Strong salt solutions produce similar effects and the simple chemical changes accompanying drying of the nerve are productive of results in the initiation of impulses to the connecting tissues.

Electrical stimuli have been used for the investigation of the fundamental facts regarding nerve activity more than other kinds of stimuli on account of their convenience (regulation of intensity and of place of application, etc.) and because of the possibility of utilizing a number of these stimuli at one time and of regulating the time and the intervals of application. The results which have been obtained following the application of electrical stimuli, are, in general, the same as those which follow the application of mechanical, thermal, and chemical stimuli, but certain peculiarities are to be noted.

If a weak electrical constant current be applied to a nerve, no observable changes occur at the closing, the opening, or at any time during the passage of the current. If the stimulating electrical current be increased in strength it is found that characteristic changes occur at the make, but neither at the break nor during the passage of the current. With stronger stimuli the effects are obtained at both make and break, or at closing and opening, of the current. We shall see later that although during the passage of the non-effective stimulating current there is no directly observable change in the tissue attached to the nerve, for example the muscle of a nerve-muscle preparation, changes do exist in the nerve but these are determinable in a less direct manner than those of muscular activity which have been mentioned.

If instead of using a constant battery, or galvanic current, there be used a current from an induction coil, somewhat similar results are obtained. There is, however, a peculiar difference in the effects of the make and break in that the weaker current gives rise to a contraction from a break stimulation without

causing a make contraction and that a stronger current is necessary for the production of the similar effect on the make. Without going into the details for the reasons for these different results it may be stated that the apparently opposite results in the two kinds of electrical stimuli are not really opposed but that the greater effect at the break of the induced current is due to the physical phenomenon of greater strength of irritant at that moment. Many other peculiarities of nerve stimulation by electrical currents will be found explained in the article on *Electrodiagnosis*.

Changes in Irritability.—In general it may be stated that every condition which alters the normal chemical composition, the temperature, etc., of a tissue alters its irritability and this statement applies to nerve. Thus, if the end of a nerve be immersed in distilled water and its irritability tested by means of an electrical current, it will be found that the strength of current necessary to bring about characteristic changes in the nerve is at first less than the normal, but that after a few minutes the amount of irritant necessary to produce such changes is greatly increased, and if the nerve be kept immersed for a sufficient length of time no amount of stimulus will bring about a reaction. There have been, we may conclude, changes from the normal (1) to a condition of hyperirritability, then (2) to hypoirritability, and finally (3) to a loss of irritability.

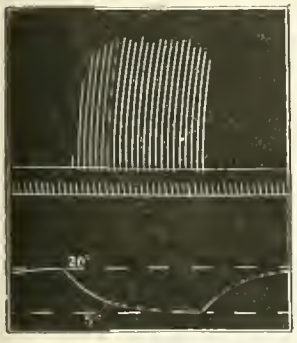


Fig. 4124.—Figure of Records Showing the Effect of Changes in Temperature on the Irritability of Nerve. The upper lines show the heights of muscular contractions as affected by the warming and cooling of the stimulated part of the nerve from 5° to 20° C. The lowest unbroken line shows the variations in temperature of the nerve. (From Starling, after Gotch.)

Other chemicals produce similar effects, and temperatures and mechanical stimuli are equally effective in producing changes in irritability. Thus, if the temperature of the nerve be slightly altered, either lowered or heightened, an increase in irritability is produced. With greater changes in temperature the irritability is lowered, and with still greater deviations from the normal temperature the irritability is abolished. In the last condition, if the change has been brought about by cold and this is not kept up for too long a time the irritability may return to the normal amount if the temperature is gradually brought back to the normal temperature. With heat, however, if the point of loss of irritability be reached the loss is a permanent one.

If the galvanic current be applied to the nerve and the irritability be tested (1) before and (2) during the passage of the current, and (3) after the current has been broken, it is found that there are irritability changes in accordance with the location of the point whose irritability is being tested. In other words, it is found that the irritability variations are different in the regions of the two poles of the galvanic current. About the anode, or positive pole, it is found that the irritability is lowered during the passage of the current, and is increased after the opening of the current, but at the cathode, or negative pole, the irritability is increased during the passage of the current and is decreased on opening the current. These facts are conveniently summarized as follows: An increase in irritability is present in the region of the cathode on closing and in the region of the anode on opening, and a decrease in irritability is present in the region of the anode on closing and in the region of the cathode on opening.

Conductivity of Nerve.—*General.*—It has already been said that conductivity is the main function of nerve. This property is, however, intimately bound up with that of irritability and it has been simply defined as the propogation of an excitation (or a change in irritability) from one point to another. In

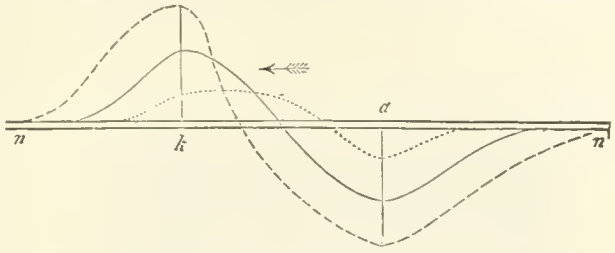


Fig. 4125.—Diagram to Illustrate the Changes in Irritability of the Nerve when a Galvanic (Polarizing) Current is Applied. n–n', Nerve; k, cathodes; a, anode. The curves above n–n' indicate increases in irritability; those below, decrease in irritability. The dotted line shows the changes with weak currents; the unbroken line, those with medium currents; the broken line, those with strong currents. (From Kirke's Physiology, ed. by Greene.)

general the external conditions which affect the irritability of a nerve also affect its conductivity and in the same direction. Several facts have been brought forth to show, however, that conductivity and irritability are not reciprocally related and that they are not the same, the results of the classical experiments

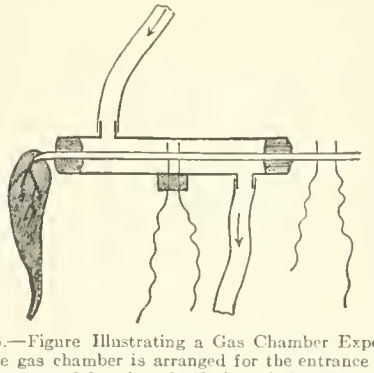


Fig. 4126.—Figure Illustrating a Gas Chamber Experiment on Nerve. The gas chamber is arranged for the entrance and exit of different vapors, and for the stimulation of the nerve within (for tests of irritability), and for stimulation without (for conductivity tests). (From Starling.)

of Grünhagen being typical. If part of the nerve of a nerve-muscle preparation be placed in a gas chamber, which is so arranged that a stimulus may be given to the part of the nerve within and another to the part of the nerve without the chamber and the chamber is arranged that it may be filled with different gases, the results of "inside" and "outside" stimulations differ in accordance with the gases which are employed to act upon the nerve fibers. Thus, if carbon dioxide is used, "inside" stimulation becomes ineffective, although "outside" stimulation gives normal results, even though the impulses which are initiated "outside" must pass through that part of the nerve which has been acted upon by the carbon dioxide. This has been interpreted to mean that irritability is lost but conductivity is retained when the nerve is acted upon by carbon dioxide. When alcohol vapor is used instead of carbon dioxide "outside" stimulation is ineffective, but "inside" stimulation gives normal results, indicating that conductivity is lost but that irritability is retained. These results, although valuable as giving an indication of a difference in conductivity and irritability, are not necessarily to be interpreted in this manner, for by more careful methods Lucas has been able to show that the

conditions within the gas chamber may be due solely to "increased difficulty in setting up the propagated disturbance."

The Rate of Conduction.—A number of methods have been used for the determination of the rate, or speed, of the conduction in afferent and in efferent nerves. The differences in results of the individual investigators may be partly due to differences in method, but in view of the very brief intervals of time which are measured the results show a surprising amount of uniformity.

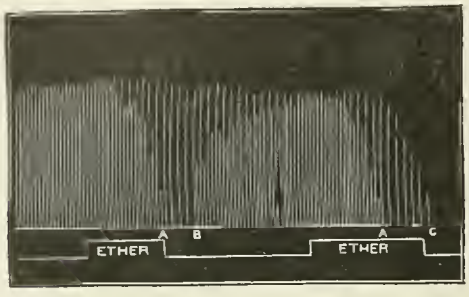


Fig. 4127.—Figure of Record Showing the Affect of Ether on Irritability and Conductvity of Nerve. The duration of ether application is shown by the lowest line, the muscular contractions are from alternate stimuli within and without the gas chamber. At A there is a disappearance of irritability; at B, return of irritability; at C, the conductivity is also abolished.

The earliest results, those reported by Helmholtz, were obtained by stimulating the nerve of a nerve-muscle preparation at different points in successive tests and by noting the differences in the latent periods of the muscular contractions which were produced. It was found that when the nerve was stimulated near the muscle the latent period was shorter than when the nerve was stimulated at a considerable distance from the muscle, and the difference in time as compared with the difference in the amount of the nerve which was traversed by the nerve impulse gives the rate of conduction. By this comparatively simple method Helmholtz found the rate of conduction in the efferent nerves of the frog to be from 27 to 30 meters in a second. In other animals the rate of conduction of the motor impulses varies. Carlson found that in Limax the rate for the pedal nerve is 1.25 meters per second, and in the ambulacral nerve of the lobster the rate is about 12 meters per second. In man and in other mammals the rate is faster than that in the frog, and by different investigators has been estimated to be from 50 to about 100 meters per second. Substantially the same results are obtained if, instead of using the latent periods of muscular contractions as indices of the speed, the time of the passage of electrical variations (action currents) of the nerve be determined.

The rate of transmission in afferent nerves has been determined by the differences in the action currents of he nerve, and also less directly by the comparison of simple reaction times. The latter method depends upon the assumption that if, for example, we stimulate the toe and record the time of the simple reaction of the finger, and at a second trial we stimulate the thigh and record the time of reaction of the finger again, the differences in time will represent the difference in the time of conduction. In the first part of such an experiment the nerve impulse has to be conducted from the toe to the spinal cord, thence to the brain, then in the brain, next from the brain to the spinal cord, and finally from the spinal cord to the muscles of the finger. All of these elements, presumably the same tracts, are used in the second test with the exception of the first, and it is this difference in conduction which is represented by a difference in the time of the reaction. By this method the time of conduction in the sensory nerves of man has been calculated to be from 50 to 70 meters per second.

It has also been found that the rate of conduction differs for the different kinds of nerve, the medullated nerve having a faster rate of conduction than the non-medullated. This fact accounts for some of the differences in the rates of conduction which have been recorded by Carlson, and which have been noted above. This fact has also been made use of to deduce an "insulating" function for the medullated sheath of the nerves.

Changes in Conductivity.—In general it may be stated that the conductivity, like the irritability, is altered with every alteration in the chemical composition or physical character of the nerve. Mechanical irritation, such as stretching, lowers the rate of conduction, and also the ease of conduction. Chemicals, which differ from nerve, also alter its conductivity, and the effects of alcohol have already been noted. All anesthetics, ether and chloroform for example, reduce the conductivity. Cold decreases the rate of conduction, but if the initial temperature at 0° C. be taken as the "normal" the rate increases proportionately up to 30°.

The changes in conductivity which are produced when electrical currents are used are of general interest in connection with some therapeutic applications as well as of specific physiological importance. If two electrodes connected with a battery be arranged upon the nerve of a nerve-muscle preparation in such a manner that the nerve may be stimulated between the electrodes and between the electrodes and the muscle, and other stimuli be given before, after, and during the application of the galvanic (polarizing) current the following phenomena are observed. With the anode nearer the muscle when a normally effective stimulus is applied midway between the polarizing electrodes there is no response of the muscle. When

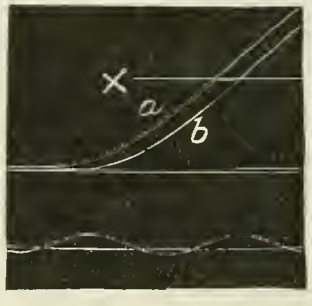


Fig. 4128.—Figure of Record Showing the Method of Determining the Rate of Conduction in a motor Nerve. The distance between the origins of the curves, or between the curves, *a* and *b*, gives the difference in time of the muscular reactions when the nerve is stimulated near the muscle (*a*) and 49 mm. farther away (*b*). The lower tuning fork record line shows hundredths of a second. The rate calculated from these curves is about 30 meters per second. (From Howell.)

the cathode is near the muscle and a similar stimulus is given the muscular response is obtained, and is often quicker and larger. After the opening of the current with the anode between the stimulating point and the muscle, the muscular contraction is obtained (also greater and quicker) on stimulating in the mid-polarizing region, and with the cathode nearer the muscle with a similar stimulation no reaction is obtained. If with the cathode near the muscle strong currents are used the results of stimulating during the application of the polarizing current may be the same as those with the anode near the muscle. These results lead to the conclusions that there is a lowering of conductivity in the region of the anode during, and

in the region of the cathode after the passage of the polarization current, and an increase of conductivity in the reverse conditions. On the side of practice the results show that the suitable application of the galvanic, polarizing, current to nerve will prevent the impulses, which in a sensory nerve for example start at the periphery, from passing through the area of decreased conductivity and that a "blocking" is the result.

Under this heading we may also briefly consider the question of *fatigue* of nerve. If a nerve be stimulated repeatedly, the reactions of the connected muscle soon decrease and show "fatigue." The early experiments gave evidence that was interpreted to indicate an indefatigability of the nerve fibers, for if the central end of the nerve was stimulated repeatedly and the normal impulses were blocked by a polarizing current or by alcohol during the course of the continued stimulations the nerve impulse was found to proceed to the muscle in a normal manner or to produce a normal effect after the blocking had been taken away. If, therefore, the long-continued stimulation could produce an effect in the nerve like that in the muscle, viz., fatigue, there would have been little or no conduction after the series of blocked stim-

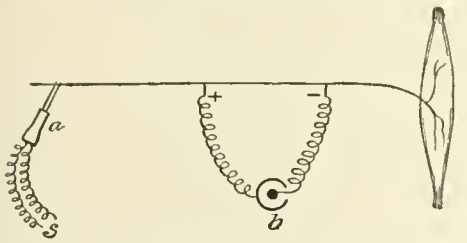


Fig. 4129.—Diagram Illustrating the Method of Determining the Infatigability of Nerve as Shown by Muscular Contractions. *b*, Polarizing current; *s* and *a*, stimulating electrodes. The nerve impulse which normally should start from the stimulation by *a* is prevented from passing through to the muscle by reason of decreased conduction produced by the current *b*. (From Howell.)

uli. These facts do not, however, demonstrate the indefatigability of the nerve, for there remains the possibility of explaining the effect as an indication of a rapid recovery of the nerve after each stimulation. If a nerve be stimulated and after a very short interval (about 0.004 of a second) be stimulated again the second stimulus fails to produce the normal amount of activity. This may be called, as some have called it, the refractory period, but the general effect is so much like that of fatigue that it may also be properly designated by that term. At the same time it may be noted that Tigerstedt has contended that medullated nerves do fatigue readily in low temperatures, especially with respect to the retardation of the impulse.

Nature of the Conduction Process.—Several hypotheses, mechanical, electrical, and chemical, have been advanced to account for the stimulation and for the

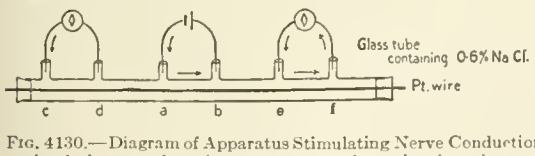


Fig. 4130.—Diagram of Apparatus Stimulating Nerve Conduction. On stimulating at *a–b*, action currents are shown by the galvanometers connected at *c–d* and *e–f* respectively.

conduction in nerve. One of these is that there is a wave of deformation which travels along the nerve trunk, which produces oscillations in the nerve substance somewhat similar to those which are produced in jelly when it is shaken. A chemical hypothesis, widely accepted some years ago, is that at the point of excitation there is produced a slight chemical difference which causes a somewhat similar change in the next molecule and that this change is transmitted from molecule to molecule throughout the course of the fiber. Against this second hypothesis the fact has been brought forward that no chemical change in the constituents of the tissue has been demonstrated in the different parts of the nerve after prolonged stimulation, but this fact is not conclusive. Nor is the other fact that no characteristic metabolic change has been demonstrated to accompany normal nerve activity more conclusive. The most widely accepted hypothesis is that the nerve impulse is a change of an electrical nature in which no interchange of material takes place, but in which there is only a rearrangement of the ions in the nerve fluid. The electrical phenomena accompanying the stimulation of nerve (action currents) can be duplicated in an artificial nerve constructed of a core of platinum wire surrounded by a solution of sodium chloride. Since with this arrangement all the important changes in nerve may be demonstrated it has been concluded that the conditions in nerve during its activity are similar. Lillie says: "the wave of excitation is accompanied by, or equivalent to, a wave of depolarization, *i.e.* of increased permeability. . . and it is to be assumed that this region, acting then as a cathode, influences electrically the adjoining regions, depolarizing these in turn and causing a corresponding increase in permeability; in this manner the effect is propogated along the membrane at a rate which in any particular case will evidently depend on the sensitivity or quickness of response of the tissue."

Phenomena Accompanying Nerve Division.—When nerve fibers are cut away, or otherwise separated, from their cell bodies they undergo degeneration. They break up into segments of myelin, which are later absorbed. The degeneration changes in many mammals begin in a few days and proceed so rapidly that they appear to take place simultaneously throughout the extent of the fiber, but in some animals the course of degeneration can be traced from the point of injury toward the periphery. In the hibernating frog (or when that animal is kept in the cold) the nerve fibers separated from the central nervous system may retain their normal appearances for many days before degenerative changes appear, but in frogs which are kept in a warm place the changes may occur almost as rapidly as in mammals. Degeneration also proceeds for a few millimeters into the central portion of the sectioned nerve, but an outgrowth of the fibers begins very soon after the injury.

Immediately the nerve has been sectioned all of the normal functions disappear. The stimulation of the sensory end organs does not result in the transmission of impulses to the central nervous system, nor is the effect of the activity of the efferent spinal cells conducted to the peripheral apparatuses. The functional phenomena following nerve section have been carefully investigated, especially on the sensory side. They have resulted in a new statement regarding the combination of sensory functions in the skin (and nerves). It has been found that in certain areas the sensory loss is complete for only a few of the forms of sensation (A, light touch, intermediate temperatures, discrimination), in other areas the loss includes those just mentioned and in addition other forms of sensation (B, dermal pain, extremes of temperature, etc.), and in still other areas the loss is complete and includes in addition to A and B the sensations of movement, deep pressure, pain on pressure, etc. These successive increments of loss, and therefore nerve function combinations, have been called by Head and his collaborators respectively "epicritic," "protopathic," and "deep." It has also been found that the fibers subserving the forms of deep sensibility are in combination with the efferent fibers.

All kinds of efferent fibers, it is known, do not

degenerate simultaneously. The citation of a single experiment will suffice in this connection. If the sciatic nerve of a frog be divided, care being taken not to injure the accompanying femoral blood-vessel, and the nerve be immediately stimulated while the web of the foot is examined under a microscope, the blood stream will be observed to be slowed, indicating that the vessels have been contracted during the time of stimulation. If now, four days after the section has been made, the nerve be stimulated again, the blood stream will be found to be quickened, and it is apparent that vasodilatation has occurred. It appears, therefore, that in the sciatic nerve there are fibers both for vasodilatation and for vasoconstriction, and that the latter degenerate (or lose their irritability) more readily than do those which convey the vasodilator impulses.

It has been mentioned above that almost immediately after the injury the process of regeneration begins. The outgrowth from the central stump of the severed nerve proceeds into the old sheath and continues down to the muscle or to the sensory endings in the skin or other tissues. The time for the regeneration varies according as the length of the nerve from the cut to the peripheral mechanism is short or long, but in general the recovery of functional control is more rapid for efferent than for afferent nerves. The motor functions begin to return in ninety days or less, and complete control (except in cases in which the length of the nerve is great) is found in less than a year. Sensory functions begin to return in from 100 to 150 days, and the normal amount of discriminative ability may not be present in less than four years.

The return of function following the cross-suturing of nerves brings up many interesting practical and theoretical problems regarding the functions of the central nervous system, but with regard to the peripheral nerves the problems are no more complicated than is that of recovery after suturing the cut ends of the same nerve. At present we do not know what physical or chemical processes are involved in the selection of the correct sheaths by the new outgrowths of nerve fibers, nor is it even known, although it is assumed, that the same fibers grow into their own old sheaths. In mixed nerves for good results after suturing it has been found important to have the central and peripheral ends in their approximately normal anatomical relations, front and back, etc., for if one part of the nerve be turned through an angle of ninety degrees regeneration (or return of function) does not proceed in a normal manner. However, that there are other elements than that of the mixing of the cut ends of the afferent and efferent fibers is well indicated by the recently reported work of Boeke, who has shown that it is possible for regeneration to take place when the central end of an efferent nerve is cross-sutured to the peripheral end of an afferent nerve. This investigator joined the central end of the hypoglossal nerve (efferent) to the peripheral end of the lingual nerve (afferent) and some of the fibers which had regenerated were found to have penetrated the taste-buds and other cells. There remains much to be done before we may conclude that we thoroughly understand the fundamental conditions in the process of regeneration and functional recovery.

Chemical Composition of Nerve.—Nerve is composed of from 57 per cent. to 64 per cent. of water. It contains about 38 per cent. of solid material, which includes proteins, nucleins, neurokeratin, lecithin, kephalin, cerebrin, cholesterin, gelatin, mucin, various extractives such as kreatin, and inorganic salts. An analysis of the organic material in the nervus ischiadicus of man, which may be taken as representative of all nerves showed the following constituents: Albumin, etc., 33.57 per cent.; cholesterin and fat, 12.22 per cent.; cerebrin, 11.3 per cent.; neurokeratin, 3.07 per cent.; other organic material, about 4 per cent. In its normal condition the reaction of nerve is alkaline, but it becomes acid after death. Not much is known regarding the metabolic interchanges in nerves, but it has been found that like other parts of the body oxydation, or oxygenation, takes place and this is well illustrated by the fact that in one-half hour one gram of nerve produced eleven cubic millimeters of carbon dioxide.

Shepherd Ivory Franz.

Nerves, Surgery of the.—A neuron is a nerve cell giving off two kinds of processes: first, a dendritic or protoplasmic process, which repeatedly bifurcates; second, axone or axis-cylinder process which runs for a variable distance to end by breaking up into a brush or plexus of fibrils. It is the axis-cylinder process which is the conducting part of the neuron, by which it communicates through the nerves to those portions of the body outside of the nervous system. There are two kinds of nerve fibers: (1) non-medullated fibers, which occur principally in the sympathetic system, and (2) medullated fibers. The latter are the kind which go to make up the nerves with which we have to do surgically. The axis-cylinder in such nerves soon after leaving the nerve cell, acquires a cylindrical sheath of myelin, the medullary sheath or white substance of Schwann. This sheath gives the white appearance to such nerves. Outside of the medullary sheath there is a delicate connective-tissue sheath, the neurilemma or nucleated sheath of Schwann. At regular intervals the myeline sheath is interrupted by constrictions called the nodes of Ranvier, at which points the neurilemma dips in so that it comes in contact with the axis-cylinder, which passes straight on through the nerves without any interruption at the nodes. In the walls of the neurilemma sheath are large nucleated cells which have a great deal to do with the processes of regeneration. An axis-cylinder with its attending sheaths constitutes a nerve fibril. This is connected with a nerve cell and depends on certain trophic stimuli received from its nerve cell for its continued anatomical and physiological existence. Hence a part of a nerve fiber separated from its nerve cell undergoes degeneration. Groups of nerve fibrils are held together by delicate connective tissue into bundles which form a nerve. Around the outside of the nerve there is a stronger connective-tissue sheath or so-called epineurium from which there passes dividing septa between the bundles of nerve fibers holding them together and carrying the blood-vessels and lymphatics of the nerve. If a nerve be injured or divided a characteristic tissue reaction follows. That portion of the nerve below the injury degenerates while a characteristic scar is formed at the point of trauma. This new tissue or scar formation is made up of proliferated cells and nuclei which have their origin from the cells of the neurilemma or nucleated sheath of Schwann. These new-formed cells run in all directions and a histological examination at such a point will show these cells running in all directions, and inclosing perhaps the remaining myeline globules from the degenerated myeline sheaths. This proliferation continuing for some time forms a swelling which has been called a neuroma. Eventually the scar becomes supplied with new blood-vessels coming into it from the surrounding tissue or perineurium. New nerve fibers are eventually laid down between the cells. These new nerve fibers are not parallel as they were in the original nerve, but seem to run in every direction as though the pattern were distorted by the previous conglomerate arrangement of the regenerative nerve cells. Later on after many months the scar diminishes in size, the cells diminish in number, the swelling grows much smaller and the nerve fibers tend to arrange themselves more or less into their original parallel conformation. The form of regeneration cited above will take place no matter how the ends of the

nerve are united. It makes no difference whether the stumps be accurately sewed together by the most painstaking suture or whether they be roughly tied together by means of ligature passed around the circumference of the two ends. This has been shown very clearly by the excellent work of Feiss by whom our technique has been much simplified and his work ought to give an impetus to operations on the nerves. We shall take the liberty here because of its importance to quote his conclusions as they bear on the surgery of the subject. "To attempt to establish connections in the hope of conveying fibers directly from one nerve into another by suturing them together, or in fact by any

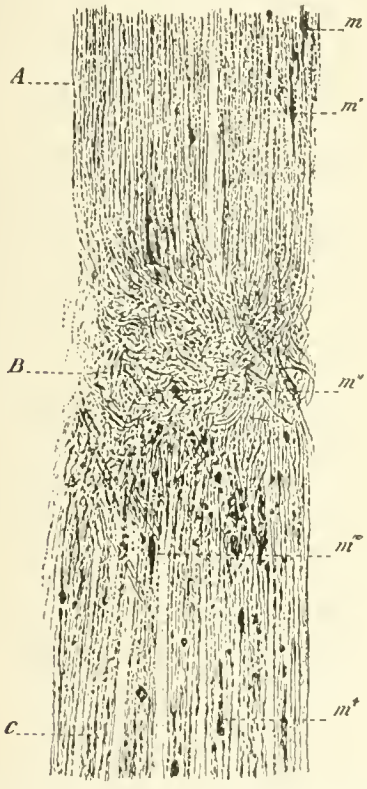


Fig. 4131.—Longitudinal Section of Vagus Nerve of Dog, Twenty-one Days after the Nerve had been Divided. *A* is the central end, *B*, the cicatrix of union where the new fibers are seen in great numbers, and taking an irregular course. Into *C*, the peripheral end, many fibers have already successfully penetrated. *m*, *m'*, *m''*, etc., are the terminal swellings of fibers growing from the central stump, and directed toward the periphery, except in the case of *m''*, where the twisting of the new fiber in its efforts to grow had at the time when the animal was killed directed the termination backward. (Marinesco.)

method whatsoever, is to attempt the impossible. Anything in the nature of a trauma to a nerve calls forth a marked tissue reaction, due partly to ordinary pathological changes occurring in the connective tissue constituting the outer sheaths and more particularly owing to the peculiar proliferative process of the neurilemma sheath cells. Moreover, the presence of the suture material, which acts as a foreign body, increases the tendency to tissue reaction in a marked degree. As a result a neuromatous mass of new connective tissue, containing leucocytes, vessels, and proliferating sheath cells, necessarily forms and comes to intervene between the cut surfaces of nerves thus sutured together, no matter how accurately the operation is done. It is safe to state that no fibers growing from the central stump of one nerve can be guided directly into another. They must one and all enter and pass through the mass of new tissue which forms between the divided nerve ends. So, if suturing is resorted to, the operator must face this anatomical fact and deal with it as an unavoidable condition."

For this reason the author gave up the method of grafting nerves by division and suture, and substituted that of "nerve-fusion." This procedure consists simply in tying absorbable ligatures about the ends of nerves which are to be joined. The ligatures must be tied tightly enough to crush the outer sheaths. The proeedure has for its chief aim the utilization of the peculiar properties of the interposed scar in neurotization at the same time ensuring at least a theoretical chance for a new central connection for every sheath in the peripheral segments.

If two normal nerves, such as the internal and external popliteals are united by this procedure, there

Fig. 4132.—Semidiagrammatic Representation of a Longitudinal Section through a Neuroma with Popliteal Nerves Attached. The external (*b*) and internal (*a*) popliteal nerves have been anastomosed by fusion at the point of neuroma formation. (After Feiss.)

results a marked cellular proliferation at the point of fusion, thus constituting a neuroma. If the perineuria of the nerves are sufficiently traumatized, the proliferating sheath cells in the scar lose the parallel arrangement which these cells had originally, and grow into every conceivable direction. This is significant, because, being laid down before the regenerating fibers, the latter must assume positions and directions necessitated by the arrangement of these cells. The result is that the new fibers derived from the central nerve segments run in all directions and cross each other frequently. There is also evidence that many of the fibers form branches.

The essential fact derived from these experiments is that the scar tissue or neuroma forms the means of distorting the nerve pattern, because every fiber from the central segment has to pass through it, and in passing through becomes subject to the mechanical conditions of the cells of which it is made up. On account of the indiscriminate arrangement of these cells, the influence for reneurotization are no greater in one part of the scar than in the other, therefore, at a certain stage after the operation each square millimeter of the cross-section presents about an equal amount of newly formed nerve-substance. The same is usually true in the nerve fascicles of the peripheral nerve segment.

This being true for normal nerves, what is the effect of interposing such a neuroma in the course of nerves which are abnormal? Does the uniformity of reneurotization, which occurs when normal nerves are fused, apply to nerves some of the fibers of which have been degenerated by primary lesion? Will such a neuroma, by thoroughly mixing the pattern, serve to supply the sheaths in the peripheral segments, both good and bad, with the means of deriving a new and equal neurotization?

With reference to this point the author describes a number of experiments done on dogs and also one human case and comes to the following conclu-

sions: (1) Nerves containing degenerated tracts do not have their anatomical pattern much altered by the interposition of surgical neuromata; the empty sheaths do not become refilled. (2) In the neuromata themselves, marked distortion of pattern may occur, as in cases where normal nerves have been fused, but this is only a local thing and does not affect the anatomical pattern of the nerves below it. At the same time, such fibers as were not affected by the original lesion may form new central connection. (3) Taken all in all, the evidence is to be regarded as rather unfavorable for justifying nerve anastomosis after lesion in the cord or roots, unless possibly, the time interval between the original lesion and the anastomosis is very short."

Nerve Injuries.—The function of a nerve may be partially or totally impaired through injury. If rupture of a few of the nerve fibers has taken place, the function of the nerve will be only partially affected. Complete severance of the nerve is followed by motor and sensory paralysis. It must not be forgotten, however, that an injury to a nerve may be followed by a complete paralysis due to a severance of some of the nerve fibers and pressure of the exudate on others, but after the lapse of some time owing to the absorption of the exudate a partial recovery may take place. The signs and symptoms of nerve injury vary with the

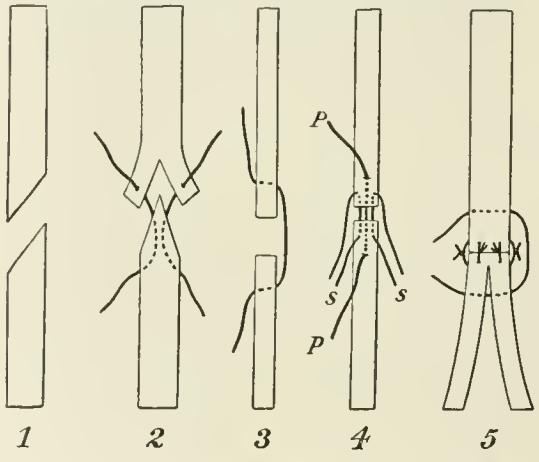


Fig. 4133.—Nerve Suture. 1, Oblique freshening of the ends; 2, nerve-suture, wedge-shaped freshening of the ends; 3, simple suture; 4, *P,P*, supporting sutures; *S,S*, adjusting sutures; 5, transverse supporting sutures and adjusting sutures.

amount of nerve destruction. Following an ordinary contusion or strain there may be a sensation of tingling at the periphery with some slight weakness in certain muscles. This may persist for a varying period of time. The prognosis is usually good. These cases are to be handled in an expectant way with gentle massage, warm applications, etc. Injury to a part followed by immediate paralysis of a group of muscles supplied by a definite nerve means a break in the continuity of that nerve. The presence of zones of anesthesia indicate that the nerve involved is a mixed nerve. The peripheral segment of the nerve undergoes Wallerian degeneration, beginning after about the fourth day, in consequence of the separation of the nerve fibers from their trophic centers. The electrical reaction changes. Reaction of the muscles to the faradic current is rapidly lost and may totally disappear in from two to three weeks. The galvanic excitability remains for weeks or months and even then only slowly diminishes, so that a condition may develop in which the galvanic current produces a muscular contraction when the faradic stimulus is without result. The muscles rapidly atrophy and deformities are not uncommon. As a rule there is complete anesthesia, but usually the area of absolute anesthesia is much smaller than that corresponding to the peripheral distribution of the nerve in question. This is due to the fact that the areas of distribution of cutaneous nerves overlap one another. Hyperesthesia is usually due to inflammatory conditions in the nerves. We may also have certain so-called trophic changes occurring in the skin. This trophic change is more apt to occur when the wound is septic and is followed by irritative lesions in the nerve trunk. The skin may become red, smooth, shiny, painful, and may lose its hair, a condition known as glossy skin; there may be an herpetic eruption or large vesicles may be formed. The nails may become dry, scaly or clubbed; the sweat secretion may be excessive or entirely wanting. The skin may be cold and livid, due to vasomotor paralysis.

Nerve Suture.—In order to obtain a restoration of function it is necessary to have a regeneration of nerve fibers. This regeneration process will occur the more quickly and the more completely the severed ends are brought together. The greater the amount of scar tissue between the ends, the more tardy and incomplete will the regeneration be. Under favorable circumstances it is possible for an interval as great as one and a half inches to be bridged over by the regenerative process. In the treatment of the cases of divided nerves, one ought to strive for a primary aseptic nerve suture. If, however, a case is seen some time after the injury, then secondary nerve suture with a removal of the fibrous scar around the divided ends must be resorted to. In all cases where a nerve lesion accompanies a fracture, particularly in fractures of the arm, both the bone and the nerve should be exposed. The bone should be plated and the nerve sutured and isolated from possible pressure by callus so far as it is possible.

The diagram (Fig. 4133) will explain the various methods of nerve suture and anastomosis.

The method of Feiss which he has called nerve fusion (Fig. 4134) has much to recommend it.

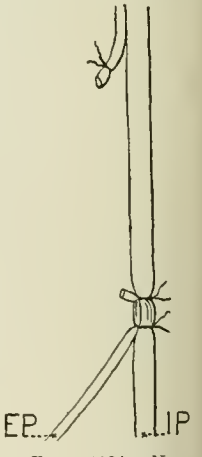


Fig. 4134.—Nerve Anastomosis by Fusion. The external popliteal nerve (EP) has been divided and fused to the internal popliteal nerve (IP). (After Feiss.)

Injuries and Diseases of Special Nerves.—*Facial Nerve.*—The function of the facial or seventh nerve is not infrequently interfered with through disease and injury. This may occur at any point in its long course. If the lesion involves the corda tympani there will be in addition to the paralysis of the muscles of the face a loss of taste in the front half of the tongue; if the lesion be central to the stapedius branch there will be great sensitiveness to sound; if the lesion is central to the geniculate ganglion there will be paralysis of the muscles of the palate. The diagnosis of facial paralysis is usually easily made. The affected side of the face is immobile and expressionless, all the natural folds are lost; the eye cannot be completely closed and on attempting to do so the eyeball usually moves upward and outward. Ulceration of the cornea may result from this exposure. The tears escape over the face, due to lack of apposition of the lower lid to the eyeball. The face is drawn to the opposite side; food collects between the cheek and teeth owing to paralysis of the buccinator. The lips cannot be firmly closed and whistling is impossible.

The most frequent form of facial paralysis encountered is that known as Bell's palsy. Pathologically this is probably primarily a neuritis beginning in the Fallopian canal, which through pressure by inflammatory exudate on the nerve fibers produces a low grade of secondary degeneration in the periphery. It is supposed to be due to exposure to cold, possibly also infection. The electrical reactions vary with the severity of the case and may amount to a complete reaction of degeneration; usually, however, only partial degenerations are found. After five or six weeks the return of the faradic irritability should begin, but this may be very much delayed. The prognosis in Bell's palsy is as a rule good, but the recovery is rarely complete. The electrical reaction is a valuable guide in determining the prognosis. If a typical reaction of degeneration is found and this persists, the prognosis as to recovery is exceedingly doubtful. If after electrical and general tonic treatment the paralysis remains complete then an operation of nerve anastomosis may be considered. If the paralysis was due to a direct injury to the nerve and the severed nerve cannot be sutured as it should be when possible, then anastomosis should be done as early as possible, before a marked degeneration of the muscles has occurred. When the paralysis is due to disease, then the operation should be put off until sufficient length of time has elapsed to determine whether or not there will be a fairly good recovery without the operation. It is hard to set a period, but one may say that if after six months the muscles are completely paralyzed and there is reaction of degeneration the anastomosis should be performed.

Operation.—The peripheral end of the facial nerve has been anastomosed either with the spinal accessory or the hypoglossal and the opinions of surgeons differ as to which is to be preferred. The spinal accessory has the advantage in that it is easily reached and united with the facial. Any loss of function that may result from injury of the spinal accessory is unimportant. The objection to the use of this nerve is, that should the operation succeed, movements of the shoulder are usually accompanied by those of the face. This, however, does not always happen and in cases in which it does, the cortical centers may become educated so that the accompanying shoulder movements may be inhibited. To make this anastomosis the incision is made through the skin along the anterior border of the sternomastoid muscle from a point an inch above the tip of the mastoid process to a point opposite the thyroid cartilage. The parotid gland is now drawn forward and the muscle backward and the facial nerve is found entering the gland about one centimeter above and an equal distance internal to the tip of the mastoid process. The nerve trunk is followed back as near the stylomastoid foramen as possible. Two fine silk sutures are passed through the sheath at the most central point and the nerve trunk is divided centrally to the sutures. The spinal accessory nerve is now easily found at its point of entry into the undersurface of the sternomastoid muscle about five centimeters below the tip of the mastoid process. The nerve is exposed for a sufficient length in its course up to a point where it emerges from under the posterior belly of the digastric muscle. If possible now, the peripheral end of the facial is brought down over the digastric muscle and united to the spinal accessory by fusion, *i.e.* by tying a loop of fine catgut around the circumference of the nerve and tightly bringing them together. If this is not possible without tension then the spinal accessory is divided at the point where it enters the sternomastoid muscle and the two ends united by end-to-end suture. Some operators divide the posterior belly of the digastric or carry the accessory stump under this muscle. The hypoglossal nerve is not so easy to expose. It is found below the posterior belly of the digastric as this muscle curves forward to cross the external carotid artery. It is dissected carefully until sufficiently exposed so that the stump of the facial nerve may be tied or fused to the hypoglossal without tension.

The Brachial Plexus.—The common cause of brachial paralysis is an injury by which the brachial plexus is stretched or lacerated by some form of pressure or traction, which forces the head and neck away from the shoulder. It may be demonstrated that such traction will put the plexus on the stretch and more especially its upper roots. This is the mechanism of the causation of the brachial birth palsies. In this form the disease is always brought about by traction of the head away from the shoulder. Pressure paralysis may, however, occur from displaced fragments of broken bones, exuberant callus, crutches, dislocations of the shoulder, tumors, exudates, or cervical ribs. There are three types of brachial palsy, varying with the portions of the plexus involved in the injury. (1) Total palsy of the arm; (2) palsy of the lower arm; (3) palsy of the upper arm (Duchenne-Erb). The last is the common type. Here the fifth and sixth cervical roots are involved, because these roots suffer most when the head and neck are pulled away from the shoulder. The arm is adducted and rotated inward, the forearm is pronated and extended at the elbow. The arm cannot be abducted or rotated outward nor can the forearm be flexed or supinated. The disturbance of sensation is often very indefinite and slight; the reaction of degeneration is usually present. There are frequently tenderness and trophic and vasomotor disturbances. The extent of the lesion is to be accurately diagnosed only by a careful examination of all the muscles of the arm. The muscles found involved will be an index of the nerve roots which have been injured. Sometimes a thickening and induration of the plexus may be felt at a point above the clavicle and external to the sternomastoid muscle. The extent of the lesion cannot be accurately determined until some months have followed the injury.

In mild cases rest and massage and general treatment are all that is called for. When the paralysis is permanent the only treatment that is to be considered is the excision of the scar tissue which may be surrounding the injured nerve, or suture of the divided nerves. It is well to wait from six months to a year after the injury in order to determine what portion of the paralysis will be permanent. In the treatment of the birth palsies there is of course the added advantage that the older the child the less the shock.

Musculospiral Nerve.—One of the commonest nerve injuries is that of the musculospiral nerve. It occurs in connection with a fracture somewhere in the lower two-thirds of the humerus. It may be a primary paralysis due to stretching or laceration by a displaced fragment of bone; or secondary, due to compression by callus. The nerve is very rarely divided. In the commonest form paralysis affects the supinator and the extensors of the wrist, thumb and the phalanges. This produces a characteristic wrist-drop. The anesthesia, if there be any present, is on the dorsum of the forearm and hand and varies a great deal in extent. Supination as well as extension of the elbow are generally weakened. Usually a proper reduction of the fracture and retention of the reduction will relieve a primary paralysis. Should paralysis follow a compound fracture, the wound is to be enlarged and the nerve exposed and sutured if necessary. In other cases, if the paralysis does not disappear after reduction of the fracture, the nerve should be exposed by an incision above and below the seat of the lesion. Anything in the nature of a scar or callus pressing upon the nerve should be removed. If the nerve has been divided the ends should be brought together in whatever way is possible. The after-treatment consists in maintaining the nutrition of the paralyzed muscles by massage and electricity.

Ulnar Nerve.—Next to the musculospiral, wounds of the ulnar are the common nerve injuries of the arm. It occurs in connection with fractures or dis-

locations about the elbow. If the nerve has been divided primary suture should be done. If one is not sure of this one may wait for a few weeks. If after four months there is reaction of degeneration the nerve should be exposed, freed from adhesions, and treated as the individual case indicates.

Peroneal Nerve.—The external popliteal or peroneal nerve is the nerve of the lower extremity, which is most subject to injury. This is because of its exposed position as it winds about the fibula, just below the head. Paralysis of the peroneal nerve produces a characteristic foot-drop. The muscles affected are the peronei, the dorsal flexors of the ankle, and the extensors of the toes. The treatment is the same as that described in injuries of the other nerves. After anterior poliomyelitis this same group of muscles is the one in which paralysis most often persists and the condition may be treated with some hope of success by anastomosing the peroneal with the internal popliteal nerve by means of nerve fusion or the Feiss operation.

Resection of the Posterior Spinal Nerve Roots (Rhyzotomy).—This operation was first performed by Abbe in 1888 for the relief of pain. Since then its use has been extended by Foerster and others for the abolition of muscular spasm associated with spinal lateral sclerosis and for the relief of visceral crises in tabes dorsalis. In lesions involving the pyramidal tract, the resulting hypertonicity of the muscles depends in part upon afferent stimuli to the lower motor arc. It was proposed by Foerster to relieve this muscular spasm by breaking the path of these impulses through section of the sensory roots coming from the region involved. The operation should not be done on children under the age of three and only after such measures as massage, exercise, and tendon operations have been given a thorough trial. It should be done only after the condition from a functional standpoint has become stationary. Cases with high grades of mental deficiency, with epilepsy, cases of multiple sclerosis and those in which the muscular paralysis is excessive are not suitable for operation. Frazier has drawn up a table of the sensory distribution to the muscles of the lower extremities as follows: Adductors of the thigh L-2, 3, 4, 5; Extensors of the thigh, L-5, S-1, 2; Flexors of the leg, L-5, S-½; Plantar flexors of the foot, L-5, S-1, 2.

Appropriate after-treatment must be carefully carried out. After the reduction of spasticity by section of the posterior roots has been accomplished and that portion of the disability due to the overaction of the muscles removed, the patient must be taught how best to utilize those muscles power over which he still possesses. In many cases postural deformities will need correcting; tendons and ligaments division, and joints will need splinting and manipulation. Where the voluntary power in the affected muscles is good, exercise may be instituted early. Such cases may soon learn to walk and in other cases some kind of a supporting apparatus will be necessary and the patient may be taught to walk with the assistance of the apparatus. The section of the posterior spinal roots for the relief of gastric crises has been highly recommended by Foerster. In his later communication he has stated that it is necessary to divide the roots from the fourth to the twelfth dorsal. This, of course, means a very severe operation and even then results are uncertain. As the operation is a very formidable one, it should be used in only the most severe cases and in those in which relief may be obtained in no other way. A performance of the operation for the relief of pain other than those due to tabes will be governed by the same considerations. In the absence of an associated muscular paralysis or areas of anesthesia pointing to a localized spinal condition, a division of certain predetermined posterior roots may be tried. In cases involving the brachial plexus a laminectomy of the fifth and sixth cervical and first dorsal vertebræ would expose the roots from C-5 to D-2. In the dorsal region the spine of the first dorsal vertebra is the landmark for the sixth dorsal nerve and the eighth for the eleventh. The roots in this region are quite separate and enumeration and identification are very simple. It is in the lumbosacral region that the real difficulty arises. The third sacral nerve is the lowest nerve of considerable size. It has been shown that exact recognition of the various roots in the lumbar sacral region is not necessarily essential. Ataxia and loss of sensation only result when three or more consecutive roots are divided and usually only when there are five involved in the section.

Nerve Blocking.—If one inject into the sheath of a nerve a solution of cocaine or one of its derivatives there will ensue after a varying period of time, depending upon the substance and its concentration, a loss of conductivity in that nerve; that is to say, neither motor nor sensory impulses will go through the blocked area of that nerve. This physiological fact has been used for the purpose of obtaining anesthesia in the area supplied by the nerve or nerves. To-day for this purpose novocain is the agent principally used. This agent is non-irritating and its action may be intensified by the addition of adrenalin. From a systemic point of view it is less poisonous than any of the other agents that are used, and large amounts of a one-half to a two per cent. solution may be injected into the nerve sheath without any injurious effects. The action of novocain is not as prolonged as that of cocaine, but because of its lessened toxic properties, it is deemed the safest for nerve blocking. If a nerve is superficially situated, it may be more or less accurately reached with the needle, without any incision; but the deeper nerves must be exposed and the trunks injected. A sterilized syringe from 2½ to 10 c.c. capacity is to be preferred. The needle is to be as fine in caliber as stability will admit. For the larger trunks a one to two per cent. solution will usually suffice. The total dosage that is permissible at an entire operation is in the neighborhood of eight-tenths gram of novocain. This would make 40 c.c. of a two per cent. solution and will be found to be ample. The practical application of nerve blocking may be well demonstrated in the blocking of the brachial plexus. It is possible to anesthetize almost the entire area supplied by the plexus by injecting the plexus through the skin. It is suitable for all operations in the upper extremity. Whenever possible the patient should be sitting when being anesthetized. He should be informed that when the needle penetrates the plexus, he will experience a paresthesia penetrating to the fingers and he should tell the physician when he feels this. This is the only way possible to determine when the needle has hit the right spot. The subclavian artery is located by gentle pressure above the clavicle. In some cases the pulsation of the artery will be seen. The skin is infiltrated with novocain at a point directly external to the place where the artery disappears behind the edge of the clavicle. This usually corresponds to the middle of the bone. A fine needle from four to six centimeters long is now inserted, without the syringe, in a direction as though one wished to strike the spinous processes of the second or third dorsal vertebra. The plexus lies rather close to and under the fascia and as soon as the needle touches it, radiating pains are felt in the fingers. If you have reached a depth of from one to three centimeters and the first rib is encountered, it means that you have gone too deeply and the needle must be brought out. If the paresthesia is not obtained at once, the position of the needle must be changed. As soon as the patient experiences the paresthesia in the fingers a syringe is attached to the needle and 10 c.c. of a two per cent. solution

of novocain is injected. Finally another 10 c.c. of the solution is distributed in the immediate neighborhood of the first injection and this is done by altering the direction of the needle slightly. If the injection has been successfully administered paralysis should come on in from three to fifteen minutes. The same process may of course be applied to any other nerve plexus. Crile's "anoci association" is a method of combined general and local anesthesia by which it is hoped to prevent shock. It is based on the following physiological work: When an animal is anesthetized by inhalation anesthesia it is found that although consciousness is in abeyance, yet afferent impulses may reach the brain which may produce a condition of nerve-cell exhaustion. That is to say, that even though the animal does not feel pain, the irritation of afferent nerves will still carry impulses to the vital centers of the brain, which may effect in a deleterious manner the vasomotor, cardiac, respiratory, and other centers. If now, in addition to the general anesthetic the afferent nerves are blocked by the injection of novocain either into the sheaths of the nerves or into the tissues, thus indirectly infiltrating the terminal fibers, then these noxious impulses will not reach the brain. Thus in addition to loss of consciousness under this form of anesthesia one may provide that no noxious effect reaches the central nervous system through irritation of afferent nerves. Crile believes that herein lies the prevention of post-operative shock.

S. P. Kramer.
Samuel Zielonka.

Nervi.—The Mediterranean Coast east of Genoa is called the Eastern Riviera or "Riviera de Levante" in contradistinction to the western Riviera which embraces the coast to the west of Genoa. In general, the winter climate of both districts is similar except that that of the Western Riviera is, on the whole, warmer and dryer than that of the Eastern, and with the exception of Nervi there is less complete protection from the northerly winds in the latter district.

Nervi is the oldest winter resort on the Eastern Riviera and its situation, directly at the foot of the mountains, gives it exceptional advantages as a well-protected winter station. Its accessibility, only seven and one-half miles from Genoa, still further adds to its advantage.

So far as the climatic data at hand indicate, there is but slight difference in temperature and moisture between this resort and that, for example, of Mentone which may be taken as illustrating the climate of the Western Riviera. The winter temperature of Nervi, from observations extending over a series of years as quoted by Dr. Sparks (The Riviera, by Edward J. Sparks, M. A., B. M., Oxon.) is as follows:

November	55.31°	February	47.8°
December	47.84°	March	49.0°
January	46.36°	April	58.1°

The following table gives a comparison of Nervi and Mentone temperature for a single winter.

It will be seen that the climate of Nervi is a mild one, as also the luxuriant semi-tropical vegetation, such as olives, oranges, and lemons, indicates.

The mean relative humidity is given as between 60 and 67 per cent. The rainfall is more copious and the period of dry weather less prolonged than in the Mentone Riviera. The average rainfall for the six colder months of the year, from seven years' observation as quoted by Dr. Sparks, is as follows:

November	6.00 in.	February	3.23 in.
December	4.88 in.	March	4.49 in.
January	4.78 in.	April	2.20 in.

The daily variation of temperature is very small, from 5° to 6°, which is a signal advantage for a health resort.

Temperature at Nervi and at Mentone, Winter of 1874–75 (Sparks).

	Nov.	Dec.	Jan.	Feb.	March.
Mean temp. at 8 A.M.,					
Nervi	56.0°	52.0°	51.0°	44.0°	49.0°
Mentone	54.0°	48.2°	50.5°	44.5°	49.8°
Mean temp. at 2 P.M.,					
Nervi	59.5°	56.5°	58.0°	50.3°	55.4°
Mentone	59.2°	53.6°	56.0°	59.0°	57.5°
Max. temp., Nervi	70.5°	56.0°	66.0°	61.0°	64.0°
Mentone	70.5°	64.0°	64.0°	55.0°	66.0°
Min. temp., Nervi	44.0°	41.0°	44.0°	36.0°	44.0°
Mentone	46.0°	42.0°	46.0°	36.0°	48.0°

With regard to the winds, one of the most important climatic factors to be considered in connection with health resorts on the Northern Mediterranean Coast, Nervi is well protected, quite as much so or more than the resorts of the Western Riviera. A spur or side range of the Apennines comes close to the shore, leaving only a narrow plateau not exceeding a quarter of a mile, upon which Nervi is situated, and this range affords effectual protection from the northerly winds. From the easterly winds the town is protected in common with all points along the Eastern Riviera by the main chain of the Apennines. The northeast and northwest winds are not completely shut out, but gain access through gaps in the hills. The southeast wind ("sirocco") is the most frequent, especially in November, and is warm, damp and relaxing. The shore line of Nervi runs nearly due east and west, and the spur or side chain of the Apennines already mentioned extends parallel with the shore immediately back of the straggling town.

The scenery is exceedingly picturesque and beautiful, on the one side the blue waters of the Mediterranean and on the other the luxuriant vegetation, the olive trees extending far up on the mountain spurs.

One of the principal features of the place is the dust-free and sunny promenade running along the shore above the rocky beach, which is protected on the land side by a high wall. This promenade is said to be one of the finest seaside walks in Europe. At frequent intervals are pleasantly placed benches where one can comfortably remain in the open air without the exertion of walking. In this sheltered, sunny coast walk the temperature is considerably higher than in the High Street of Nervi, and in returning from the shore to the town one must be provided with wraps as protection against the sudden change of temperature.

There are a number of hotels and pensions affording good accommodations. From November to April there is an English church service, and there are English physicians. The short distance from Genoa is traversed at frequent intervals both by the steam railroad and electric trams.

Owing to the nearness and steepness of the high hills at the back of the town Nervi offers but a limited field for excursions, and rod-fishing seems to be the principal diversion.

Where rest in a mild atmosphere and amidst picturesque surroundings is desired, Nervi would seem to be ideal. From what has been said above, it will be seen that Nervi as a winter health resort is but little, if any, inferior to any of the localities of the Western Riviera, and it is superior to many in that the climate is somewhat less exciting and the location affords excellent opportunities for a restful and quiet existence.

With regard to the class of invalids who should be

recommended to pass a winter at Nervi, they are the same, in general, who would be sent to the Western Riviera resorts, except that some patients who find the Western Riviera too exciting, find Nervi more soothing and more conducive to sleep and rest. According to Huggard (Handbook of Climatic Treatment, 1906), "For patients with dry irritable catarrh of the bronchial tubes and larynx the winter air at Nervi has a calming influence."

EDWARD O. OTIS.

Nettling Insects.—The larvæ of various lepidopterous insects have urticating hairs which may cause much pain and irritation if they enter the skin. Important among these are: *Lagoa crispata*, etc., the flannel moths; *Sibine simulea*, the saddle-back caterpillar; *Automeris io*, the Io moth; *Euproctis chrysorrhœa*, the brown-tail moth. Ammonia or soda will relieve the pain. The hairs should be removed and scratching should be avoided. Ichthyol ointment is good. See *Insects, poisonous.* A. S. PEARSE.

Neumann, Isidor.—Born at Mähren, Austria, on March 2, 1832. He studied medicine at Vienna, chiefly under the direction of Prof. Hebra, and was given the degree of Doctor of Medicine in 1858. After he had served for a certain length of time as a Privatdozent, he was made a full Professor of Diseases of the Skin, in the University of Vienna, and also the Director of the corresponding Clinic. He died in 1906.

The two larger treatises published by Neumann bear the following titles: "Lehrbuch mit Atlas der Hautkrankheiten," and "Handbuch der Syphilis."

A. H. B.

Neuralgia.—This is a loose term which in general stands for a transitory disturbance in a cranial or peripheral nerve distribution which is manifested chiefly by pain. Apart from a knowledge of what is causing it, it means nothing. Used as a symbol for a definite disease it is ignorant pedantry. Thus a diagnosis of facial neuralgia means nothing except facial pain. It may be from carious teeth, a tumor of the brain, syphilis of the basal meninges, a neuroma of the trigeminus, a psychical hysterical conversion, or a psychotic projection as seen in dementia precox.

Neuralgia is best regarded solely as a symptom description, meaning pain in a certain sensory area and which may be due to a variety of different disease processes. Neuralgias are therefore only the expression of many diverse lesions which may involve the body in general, as toxic and infectious states such as in influenza, myxedema; the disease may invade a nerve trunk itself as in a neuritis, or a bullet wound. The sensory ganglia may be the site of an infection as in herpes zoster. Trauma, pressure of bone, or other foreign bodies lying contiguous to a nerve trunk, or a root plexus, may determine severe neuralgia pains. They may be the reflex expression of a disorder in a viscus remote from the site of the pain. They frequently are purely psychogenic in origin, mostly hysterical conversions, while occasionally they are delusional projections.

ETIOLOGY.—An extraordinarily wide range of causative factors are known to be accompanied by mild or severe neuralgias in very diverse regions of the body. The most frequent causative factors are:

Anemias due to inorganic and organic parasites, hemorrhages, pernicious anemia, and chlorosis.

Toxins of exogenous origin or purely endogenous toxins: thus poisoning by arsenic, lead, mercury and copper, alcohol, and tobacco. As an abstinence symptom in morphinism the vegetative mechanism adjustment breaks down and causes neuralgia. The toxins of many infectious disorders are especially prone to bring about neuralgias. Tonsillitis, typhoid fever, influenza, measles, gonorrhea, possibly syphilis, and streptococcic infections are frequently accompanied by neuralgias. The endogenous toxemias of diabetes and latent nephritis are also causes.

Inflammation of the sensory ganglia, which may be either of infectious or non-infectious nature, gives rise to some of the severest forms, generally as seen in herpes zoster.

Ganglion involvements of non-infectious types give rise to neuralgias, such as tic douloureux, while tumors involving the substance of or pressing upon the sensory ganglia (trigeminus) may occasion persistent and obstinate neuralgias in the affected sensory nerves.

Involvements of the nerve trunks themselves, either by mild neuritic processes, perineuritis, pressure from anatomical structures, pressure from lesions, cuts, bullets, wounds, tears, tumors, aneurism, exostoses, fractures, or displacements may cause severe neuralgias.

Reflex neuralgias are numerous and puzzling. Pulmonary, cardiac, gastric, hepatic, renal, ureteric, intestinal, vesical, uterine ovarian, prostatic, testicular, and affections of other viscera give rise to painful, sensitive skin areas and neuralgias. Head and Mackenzie have analyzed many of these cases.[1] Thus prostatic disturbance may be accompanied by severe sciatic pains. An anemic woman may not suffer from pain, but on menstruation her referred neuralgic pains may become very severe over the tenth dorsal nerve, and pain and tenderness are frequent over the areas of the sixth dorsal (heart), seventh dorsal (stomach), and there may be occipital and midorbital neuralgia.

In organic disease of the nervous system such as general paresis, tabes dorsalis, spinal or cerebral disease, thalamic disease, syphilitic meningomyelitis, neuralgic pains are frquent. Thalamic lesions often give rise to most intractable neuralgic pains.

Constitutional Factors.—The arthritic, gouty, rheumatic, and scrofulous suffer from neuralgic pains. Unknown factors thought to be related to atmospheric pressure, humidity, high electrical tension etc., play a rôle in many of these cases, in which undoubtedly the psychogenic element is large. Many arthritic cases are to be classed with the infections. Gonococcus, *Streptococcus Pyogenes*, *Streptococcus Viridans* and others are frequent pre-existing factors in throat, dental and other locations.

Chronic vascular disease, and especially arteriosclerosis is frequently, particularly in the aged, the senile and the presenile, accompanied by neuralgic pains.

Exposure to cold is an important factor. It is not certain that all neuralgias caused by cold are not really mild types of neuritis or perineuritis; discussion of the distinction is fruitless. The older writers found colds a predisposing cause in from twenty-five to forty per cent. of the cases. In damp, cold countries this is particularly noticeable.

Psychogenic Factors.—These play a large part in practical medicine in determining neuralgic pains, so-called. Numerically speaking they probably outnumber all the others, and yet at the same time it is important to bear in mind that the so-called psychogenic cases are often mixed cases. There is usually some organic basis behind them, which is fixed upon by the sick psyche.

SYMPTOMS.—Pain is the main factor in neuralgia. It is the chief expression of the nerve disturbance. The character of the pain varies considerably, but in general is described as unilateral and paroxysmal. Most neuralgias are not primarily localized in the periphery. The pain seems to begin beneath the

surface, and may then shoot out to the periphery. It is described as boring, biting, tearing, darting, cutting, like a hot iron, like an electrical shock, etc. It comes and goes in lightning-like flashes, or throbbing pulsations, persisting for a shorter or longer time, then stopping for minutes, hours or days, then recurring. When continuous, the pain varies considerably in its intensity.

The painful area usually conforms to the peripheral distribution of the sensory nerves. In the herpetic and referred neuralgias the root zone area is involved.

Certain points of election seem to be starting points for the pain. These are usually situated along the nerve trunks, and pressure upon them is often sufficient to cause an exacerbation of a mild attack, or to provoke an attack in a period of intermission. Valleix has attached considerable importance to these points. According to him they are chiefly located (1) at the point where the nerve trunks emerge; (2) at such points where the nerve trunk transverses a muscle to reach the skin; (3) where the nerve fiber breaks up into branches; (4) where the nerve becomes very superficial; (5) at Trousseau's apophyseal points. Valleix's points are of diagnostic importance particularly in distinguishing the neuritic from the neuralgic types of pain.

In some patients a sense of apprehension or vague sense of discomfort may precede the coming on of an attack. Ripples of pain, like pin-pricks, short twinges, etc., herald the outbreak of a more serious attack, or may be the sole evidence of an abortive one. Such mild phenomena manifest themselves very frequently in certain of the so-called predisposed or neuralgic individuals. Some feel that they cannot live at high altitudes; others dread rain or an east wind; others suffer twinges on occasion of a thunder storm; while again others complain of painful twinges for days following indiscretions in diet. It may be difficult to determine just what conditions are at the basis of these features. They are none the less real even if the physician hides his ignorance by calling them imaginary. If imaginary, what are they images of, is the question. In other words, a psychogenic pain is a symbol of something. The meaning of the symbol must be found for all psychogenic pains if they are really to be understood. Fortunately for the practitioner they get well in spite of his ignorance of what they mean.

Skin hypersensitiveness is frequent. It may precede or accompany an attack, and persist after an attack has ceased. Epicritic sensibility is mostly implicated. Light touch, a pin-prick, or slight degrees of heat or cold are magnified. Deep pressure and extremes of heat and cold are usually palliative.

Following an attack of pain anesthesia is not infrequent and the exact topographical distribution of the sensory modifications on the skin throw considerable light on the location and possible cause of a neuralgia. Paresthesias are frequent and certain distributions, such as are those involving the cutaneous branches of the femoral, are frequently symbolic of some image.

Cramp-like contractions or paralyses are not infrequent in accompanying conditions. The painful contractions of tic douloureux and the oculomotor paresis of ophthalmoplegic migraine are familiar examples of this.

Vasomotor and secretory symptoms are frequent. The blood-vessels contract in the early stages of a neuralgic attack, with resulting blanching and cooling of the skin. Following this there often results a period of warmth, of redness, of free perspiration, from secondary dilatation of the vessels. In trigeminal neuralgia, other secretions may be modified. Crying, coryza, or salivation are not infrequent. In widespread neuralgic attacks an increase in the amount of urine and of milk secreted is frequently found.

Loss of hair, premature graying of the hair, thickening of the skin, erythemata, eczema, pemphigus, herpes, thickening of the bones, and, occasionally, muscle atrophy are among the rarer trophic by-products. During an attack irregularities of the pulse are not unusual; slowing is the rule. The pupils are frequently dilated.

The general physical and psychical reactions are extremely important. Loss of sleep and anorexia cause the patient to lose strength and flesh; and anxiety, irritability, and petulance are almost inevitable. Mental depression, sufficient to lead to suicidal attempts, is not infrequent, especially in severe cases of trigeminal and sciatic neuralgia. The contracting of a drug habit is usual.

Course.—This will depend upon the underlying disease. Many neuralgias are acute and transitory, persist three or four days, and never reappear. Such are the mild herpetic and toxic types. Reflex neuralgias often run an acute recoverable course, but show a marked tendency to recurrence. The neuralgias which accompany the chronic cachexias of nephritis, carcinoma, brain or spinal cord disease, usually progress in a markedly chronic manner. In those hereditarily disposed individuals the tendency to chronicity with longer and shorter periods is proverbial. Most neuralgias in which the causative factor is undiscoverable (the so-called idiopathic or primary neuralgias) run a benign course, while the neuritic types are less amenable to treatment.

From the standpoint of clinical course alone, which is an unsafe classification, the neuralgias may be regarded as neuralgic neuroses, subacute neuritic neuralgias, and chronic neuritic neuralgias.

In the first type the disorder is more or less limited to the neuropath. The attacks come with appreciable cause or follow a nervous shock. Exposure to cold or dietary indiscretions are not causes though frequently claimed as such. The onset of the pain is very sudden and its disappearance usually violent; both occurring apparently in inexplicable manner, and not accompanied by painful nerve trunk nor trophic disturbances. There is recovery at times, with recurrence at intervals of a year or years.

Exposure to cold or pressure, especially in arthritic patients, determines an attack in the subacute neuritic neuralgic type. As a rule the attack develops gradually, the pain at first being mild and intermittent but gradually growing worse and more continuous, until after a day or more the paroxysms become extreme, with intervals marked by dull pain. Valleix's points are characteristic in this form.

There is muscular atrophy or other trophic signs when a mixed nerve is involved. This marks the occurrence of a neuritic process. Local edema and herpes zoster are frequently present. In this type recovery usually commences to take place in from two to three weeks, and can ultimately be expected to be complete. There are recurrences, however, and a sudden shifting to the third type of chronic neuritic neuralgia. With the aged this form is frequent. There have usually been several subacute attacks with increasing tendency to chronicity. Trophic disturbances in muscle and skin are here more marked. The paroxysms are remittent.

Diagnosis.—The need for a searching analysis of the causative disease underlying every neuralgia should be insisted upon. As has been pointed out these diseases are many. The most widespread diagnostic error is the overlooking of an early tabes dorsalis in young to middle-aged adults and calling it a neuralgia, rheumatism, or similar absurdity.

Very frequently organic disease of a viscus will show unilateral pain of special localized type, occurring in irregular attacks, which is in turn almost the sole criterion of neuralgia. It is possible, however,

in the majority of cases to detect the underlying organic lesions, though occasionally it remains difficult to locate. Not infrequently the diagnosis of a persistent neuralgia may be cleared up by the finding of malarial organisms in the blood or, more rarely, through the presence of a marked eosinophilia, trichina will be discovered as the cause of an obstinate neuralgia; or an anemia underlying a severe neuralgia will be brought to attention through the discovery of the eggs of an intestinal parasite in the feces (uncinaria). Syphilitic neuralgias, either toxic or vascular, are of frequent occurrence.

As a rule the diagnosis of myalgia from true neuralgia is not difficult, but occasionally becomes uncertain, especially in the intercostal and lumbar regions. These neuralgic-like myalgias are usually isolated in their location, are not as a rule, accompanied by acute exacerbations, nor are the regions usually painful on pressure. Myalgias are, however, usually aggravated by motion.

Neuritis of a mild grade offers a specially difficult problem. The question to be solved concerns the likelihood of a more severe degree of neuritis. In this case the usual signs of neuritis are painful, swollen nerve trunks, trophic disturbances, more continuous pain, Lasègue's phenomenon, weak, flabby muscle fibers, and electrical changes. New growths, pressing upon or involving the nerve trunks, within or without the spinal canal, in the early stages particularly, begin as pure neuralgic syndromes. A distinct diagnosis may at times be impossible in the earliest stages, but it usually may be cleared up by minute analysis of the sensory phenomena.

A neuralgic affection may be one of the earliest signs of a multiple sclerosis. A severe tic douloureux has been found by Oppenheim as the earliest sign of this disorder. Syringomyelia may begin as a localized neuralgia. Minute hemorrhagic lesions of the spinal cord traumatic in origin give rise to neuralgias.

Great caution is demanded in the diagnosis of hysterical neuralgia. These neuralgias, which partake of the nature of a pseudoneuralgia, are very diffuse, and react very rapidly and markedly to analytic influences. They are almost invariably accompanied by other conversion phenomena. Hysterical neuralgias, mostly headaches, usually present a most marked symbolic character. Thus a patient complains of a pain in the top of the head, persisting for several months. It is described as coming on just after the death of a child, and increasing in severity just before and after the menstrual period. Her dreams are frequently of falling on the head, hitting the top of the head, catching the head in a door, in a window. She is literally beating her head as a battering ram against her difficulties; that is her alcoholic husband, her degradation, and her misery. The whole thing is symbolic. It is social.

Neurasthenic pains are commonly only a source of diagnostic confusion and error. The forms of neurasthenic, hypochondriacal and hysterical neuralgic pains are mixed but should be differentiated each through its own characteristic side lights. The diagnosis of these types of neuralgia is of grave import for these syndromes may but arise from some more fundamental organic lesion to which they form the reaction on the part of the nervous system. What may be called only severe neurasthenia with cachexia or severe intercostal neuralgic pains may cover carcinoma of the stomach, mediastinum, etc.

In tabes dorsalis the neuralgic pains have a wide range, are rarely localized in a peripheral nerve distribution, and are apt to be radicular in their distribution. Pain on pressure of the nerve trunk is usually absent. The diagnosis is established through the objective findings in the pupils and cerebrospinal fluid.

Severe neuralgias may arise as a result of the pains, cramps, and muscular weakness of intermittent claudication. Reflex neuralgic pains arise from aortic aneurysm. These pains are usually very severe, burning or boring in character. Aneurysms in other regions must be carefully excluded.

The site of the original lesion in reflex neuralgias may be determined by exclusion, through the use of cocaine or other local anesthetic. An orthoform suppository pressed well against the prostate has been known to relieve a severe sciatic neuralgia. Tumors of the pelvis frequently give rise to sciatic and crural neuralgias, while persistent neuralgic pains of the knee are often a reflex from hip-joint disorder.

Neuralgic pains are a frequent indication of disturbed nerve fiber metabolism with a hyper- or a hypothyroid affection behind it.

For the precise localization of the areas involved the physician should consult any schematic nerve chart, where both the peripheral and radicular nerve distributions are figured.[2]

Prognosis.—This is dependent upon the underlying pathological process. A better understanding of these underlying conditions as well as a much more adequate therapy have created a much brighter outlook for the more chronic neuralgias, which formerly tended to chronic invalidism or inveterate drug habits. In those neuralgias which apparently are idiopathic as well as those due to alcohol, lead, or other toxic agent, the prognosis is more favorable for the younger and stronger individuals, and those less burdened by hereditary disposition. The prognosis is bad, on the contrary, in the more chronic forms which are not due to removable condition.

Treatment.—The chief indications are to quiet the pain and ascertain the cause. This necessitates a painstaking study of the history and an exhaustive physical examination in all cases. The therapy will, of course, vary widely with the ascertained cause; while quinin will cure one patient, a surgical operation may be necessary in another. General rules are only misleading. One should never treat a neuralgia *per se* as it is solely a result due to one or more of many causes.

Taking up the general therapeutic indication for quieting pain, the analgesics which have proved useful may be discussed first. Phenacetin, acetanilide, antipyrin, aspirin, pyramidon, lactophenin, and phenocoll are among those that have been valuable. The salicylic acid group combinations are at times useful, especially in the milder cases and in patients with arthritic tendencies. In influenza and tonsillitis neuralgias the salicylates are useful. Combinations of these with soporifics, such as chloral, paraldehyde, sulphonal, trional, or veronal are useful in procuring sleep, and thus prevent the reduction of the patient's resistance.

If it is necessary to use any of the opium group it is better to give such in sufficient doses. Smaller doses may usually be given when in combination with the analgesics mentioned. Aspirin gr. vij. (0.5 gram), codeine, gr. ½ (0.02 gram), and trional, gr. vij. (0.5 gram), for instance, is a useful combination to be taken at night. Other combinations are equally effective. In the chronic neuralgic pains morphine is to be avoided as long as possible, but this need not apply to a very old person or to one in whom the neuralgia is simply the manifestation of some chronic incurable disorder, like carcinoma. The gradually acquired immunity, with the need for increasing doses, and the pernicious effects of a habit apply to all the members of the opium group.

In all this it must be remembered that the use of analgesics is only temporary, simply to give relief until the cause of the pain can be found. The use of analgesics in neuralgia is not scientific therapy if it stops with these purely provisional means of relief.

Other drugs are quinine, which in combination with

the salicylates is specially valuable in malarial neuralgias; arsenic being serviceable in the neuralgias due to anemia, especially in combination with iron. The antipyretic analgesics have taken the place of atropine and aconitine, whose definitely poisonous qualities have driven them into the background. Cannabis indica, otherwise useful, is avoided because of its unreliability. The iodides are useful in many neuritic neuralgias but are especially indicated in the syphilitic neuralgias.

Counterirritation is an important measure in many cases of severe neuralgia, especially when the acute onset is over. It may be secured by means of mustard paste, cantharides, turpentine, chloroform, ether, or acupuncture; the Paquelin cautery, however, is the best means. Ethyl chloride, methyl chloride, ether, or other volatile substances may be used to produce local freezing. Mild neuralgic pains may be treated advantageously with menthol, or other similar derivatives.

In many deep-seated neuralgias, especially of medullary origin, recourse may be had to direct application of local analgesics, either to the nerve trunk or within the spinal canal. Cocaine, tropococain, eucain, are all useful given by the Corning or Quincke method.

Hot-water bags, hot sand, electrical pads, etc., may be used for local applications of heat, which are grateful as well as valuable. General or local hot-water baths or hot-air baths (baking) are at times of advantage.

The general hygiene must at all times be considered. This demands a generous diet, full sleep, healthful occupation, and freedom from worry. Things concerning which it is easier to advise than obtain. Cod-liver oil, nitrogenous diet, with iron, arsenic, strychnine, calcium salts, are indicated. Fatty diets are to be avoided. Even in arthritic neuralgias it is doubtful if meat does any particular harm. The infecting agent should be sought. Alcoholic beverages are to be denied. An alkaline therapy often helps many fugacious, persistent neuralgic pains. Fruits containing the citrates seem to give relief. Preparations of the internal secretions, particularly thyroid and pituitary, clear up some intractable neuralgias of unknown origin. They may be given in doses of from one-tenth to one-half gram twice or thrice daily.

Little benefit is derivable from climatic changes. Certain patients should avoid low-lying, damp, and humid atmospheric conditions. A dryer, higher atmosphere, though colder, is generally favorable, even if without direct effect upon the pain.

Electrotherapy is of great value in some neuralgias if well managed and properly selected. Most efforts must be experimental as the adaptation of certain forms of current to certain types of neuralgia is not yet clearly understood. Leduc's modifications of d'Arsonval's rapidly interrupted current is probably the most valuable form of electrical application known at the present time and offers in general a ready and widely applicable form of current in the treatment of neuralgic pain. Though solely palliative it is very grateful, producing, in fact, a type of electrical anesthesia. These seem to give the most reliable results, and must suffice until replaced by newer applications.

Faradic currents, as heretofore employed, act for the most part simply as counterirritants, with but little advantage over the actual cautery. Galvanism with mild currents is useful for many topalgias.

If pressure is demonstrable and the cause removable, as in the case of tumors and new growths, pressing upon nerve structures, surgical intervention is plainly indicated. It may also be of radical service in many of the reflex neuralgias of obscure origin, which are probably related to visceral ptoses. Here psychotherapy is preferable in the earlier stages. Only in chronic cases when long-continued psychical causes have produced these visceral ptoses is surgical interference justified. Nerve stretching should be condemned.

In the psychogenic cases, notoriously the most difficult to differentiate, but which make up about twenty-five to thirty per cent. of the neuralgic affections treated from all points of view, psychotherapy is imperative. It may be for some that a skilled dialectic such as is outlined by Dubois will be effective. For many others the emotional appeal so well described by Dejerine[3] will prove the best mode of approach. While for the most intractable, persistent and difficult cases only a sound reconstruction by a psychoanalytic therapy will prove satisfactory. The most intricate and severe cases need a psychoanalysis. Such a therapy is worthless in any but purely psychogenic cases. To psychoanalyze a tabetic neuralgia is silly, but it is equally absurd to treat a psychogenic neuralgia by means of drugs, massage, hydrotherapy, surgery, or electricity. Smith Ely Jelliffe.

References.

1. Head and Mackenzie: Brain, xvi., 1; xvii., 339; xix., 153.
2. Dana: Text-book of Neurology, 8th edition, Wm. Wood & Co.; Jelliffe and White: Diseases of the Nervous System, Lea and Febiger, 1915.
3. Déjerine: Psychoneuroses, J. B. Lippincott, Philadelphia.

Neurasthenia.—There have been so many different views expressed in regard to neurasthenia, that it seems appropriate, before trying to define it, to outline a few of the more important theories as to its cause. It is generally agreed that in this condition, the resistance of the nervous system is lowered to such an extent that it becomes fatigued out of all proportion to the work done. This lowered resistance shows itself not only in a diminution of efficiency, but also in a lowering of inhibitions, so that there is an increased irritability of the nervous system as a whole. These two manifestations, which are really different phases of the same process have given the condition its subtitle of "Irritable Weakness."

Etiology.—Such conditions of weakness may be seen as a result of debilitating disease, metabolic changes, infections or toxic conditions, and so we have the various organic theories of the etiology of neurasthenia.

The most important of these are *autointoxication* and *exhaustion*.

Autointoxication, often associated with bad postures and visceroptosis, is theoretical. It has never been proved nor does it seem to cover the field, especially when put forth as a universal cause for neurasthenia. But the idea appeals to the patient as it relieves him of all responsibility for the cause of his condition, and offers the physician a clearly defined and easily understood reason for altering the patient's hygiene, habits of life, and environment all of which may often be desirable. The patient does not know what autointoxication is, but it sounds as if it must be the cause of all his sufferings, and when it is cured, he will be well. The suggestive effect is wonderful, the encouragement is very helpful. Undoubtedly the elimination of a patient whose whole neuromuscular system is relaxed is very poor, and he will be greatly benefited by having this improved, but I believe that the poor elimination with the consequent absorption of toxins is usually secondary to his generally relaxed condition, and while it may cause a vicious circle, aggravating his symptoms, it is not the primary cause of his neurasthenia.

The other important organic view to be considered is that of *exhaustion*. It has been shown physiologically that an excised muscle of a frog can be repeatedly stimulated electrically until it fails to

contract. Toxins have been formed by the activity of the muscles, catabolic products, which inhibit its further action. When these are washed out with physiological saline solution, the muscle will again contract when stimulated. This fact has been used to explain the fatigue, which is the most frequent presenting symptom of neurasthenia. The view is in accord with that of autointoxication, the origin of the toxin here being in the muscles instead of in the alimentary canal, but the application of it to a living animal from whose muscles the blood and lymph stream are constantly removing waste products is purely hypothetical, especially in the case of a patient whose activities are only to a very slight extent muscular. It has also been shown that in fatigued animals degenerative changes take place in the protoplasm and nuclei of their ganglion cells, and that a normal regeneration takes place during rest. These observations do not explain the fact that the neurasthenic, when he gets sufficiently interested in anything else to forget himself, is often able to do what the moment before seemed to him quite impossible.

This fact leads us directly to the consideration of a possible *psychological cause* for neurasthenia. The most highly developed theory to account for it on this basis is the doctrine of Freud, which ultimately traces all of the functional nervous disorders to the repression of emotions which are, broadly speaking, of sexual origin. This does not mean that all neurasthenics are sexual perverts, though some are, or that they have had abnormal sexual experiences, though some have. Both of these facts would apply equally well to many who are not neurasthenics. It may merely mean that normal sexual emotions, often recognized as such, are so repressed that the balance of nervous energy is upset and we have functional disturbances of all sorts; or that in a sensitive individual, brought up under conventional social conditions, sexual emotions or experiences, being thought improper, are magnified out of all proportion, and the resulting conflict between what is thought to be right and what is felt to be wrong puts such a strain on the nervous system that it ends in a breakdown. In regard to this doctrine a great deal is available in recent literature for any one who wishes to make a special study of it, and it is only after a careful study that one is able to accept or discard it. Suffice it to say here, that while it may apply to a certain proportion of neurasthenics it is much more applicable to certain profound cases of hysteria which are not amenable to simpler methods of treatment.

Undoubtedly where there are so many explanations there is no one simple cause. It has been said that without worry there is no neurosis. Déjerine speaks of *preoccupation* as the determining factor in neurasthenia, this being dependent on emotional conflict, or as we generally put it, worry. But why should worry lead to neurasthenia in one person and not in another? There must be another factor, and this we find in congenital predisposition or temperament. Oppenheim puts inheritance as the most important factor.

In some neurasthenics, heredity seems enough to account for everything, in others the cause seems wholly in environment. The child of a neurasthenic brought up by its parent, naturally acquires habits of thought and reaction similar to those with which it is surrounded. Here the forces of heredity and environment both come into play. In such a family in which there are several children, some will, according to the Mendelian law, probably escape the neuropathic inheritance, and the fact that these will grow up normal, not becoming neurasthenic in spite of environment, seems good evidence that the chief predisposing cause is in the inheritance.

The family history may show any form of nervous or mental weakness or disease. The hereditary taint may be in the form of alcohol or other chronic poison, tuberculosis, syphilis, or other chronic debilitating disease. The importance of these is in the fact that the individual is started in the world with a lowered resistance to all forms of strain, nervous as well as physical, and it is this which determines the effect of the apparent or exciting cause.

Let us take the analogy of tuberculosis.

We are all exposed to the tubercle bacillus as we are to worry. Some of us escape infection. Some become slightly infected, but, owing to the fact that we have good constitutions and adequate resistance, never know it as we develop no symptoms. This class according to pathological statistics includes the vast majority of people living in civilized communities. Finally a relatively small minority develop tuberculosis. These are the ones who have a congenital predisposition or for some other reason a lowered resistance. The analogy may be carried still farther. Tuberculosis may attack any organ in the body, thus making its manifestations protean. The same is true of the symptomatic manifestations of neurasthenia. The treatment of tuberculosis is in some cases local, but since the cause of the disease has become known, and its scattered manifestations correlated, it has been found that the rational line of attack consists in treating the disease as a whole, in order that the cause may be removed, and the patient's resistance built up against future attacks.

In neurasthenia, it is the patient's habit of worry which must be removed at the same time that his resistance is being built up. One of my teachers used to say that worry was the worst waste of time in which any one could indulge. If an undesirable situation can be remedied, then seek the remedy. If not, make the best of things as they are, but whatever you do, don't waste your time and make yourself unhappy worrying about it. That leads only to more trouble. It is very easy to preach such a doctrine, but quite different for any one with a worrying nature to practise it. Nor does it help them much to be preached to in that way. They must be given a better outlook than they already have, and something else in which to take an interest. The removal of the worry implies its replacement by some more wholesome frame of mind.

In inheritance or temperament, we have the soil; in emotional conflict, worry, preoccupation, or habits of thought, we have the seed. On this basis it is possible to explain the fatigue and irritability, those cardinal symptoms of the condition. The individual is working so hard within himself, his emotions are so active, that any additional effort or exertion is like the straw that breaks the camel's back. If, however, his interest and complete attention can be held, so that for the time at least his mind is relieved of his preoccupation, he can do as much as any one else. This fact, without a proper understanding of the cause, is the reason why the neurasthenic is so much abused, and misunderstood. The average person finds it difficult to see why an individual should be able to dance all night, when he finds it too exhausting to write a letter in the morning. Aside from the relative interest in these activities, the neurasthenic usually does feel more tired when he wakes in the morning than when he goes to bed at night.

It seems fair to say that in neurasthenia, as a result of the two factors, temperament which is congenital, and worry which is acquired, there is a certain loss of perspective, a warping of the judgment of the relative value of things, so that reason becomes subordinate to emotion, and one's feelings assume an importance out of all proportion to their value in the general scheme of events. This process may lead to all sorts of self-sacrifice where sympathy or sentimentality happen to be the emotions at issue,

or on the other hand, it may lead to the height of selfish egotism. In any case the reaction is carried to an extreme, and often where the self-sacrificial aspect is prominent, it seems as if more was being done for the sake of the resulting self-satisfaction, and desire for commendation, than for the sake of the person for whom the sacrifices are made.

Another point which sometimes comes up is the question: How much does the patient want to lead the sort of life, which, as a result of his trouble, he is prevented from leading? How much does he want, really and truly, down in his soul, to do the things, usually requiring a certain amount of effort, which his symptoms make it impossible for him to do? If he were well he would have to do them. There would be certain obligations expressed or implied. He would not have the strength of character simply to refuse. He is not sufficiently independent. He cares too much what people think. But if he is sick he can't do them, and there all responsibility ends. He would be grieved and insulted if you told him this, for he honestly thinks he wants to do just those things. Certainly in hysteria, the presenting symptom often acts as an unconscious defense mechanism, and I am sure that there are cases of neurasthenia in which the patient does not really want to get well. He cherishes the symptoms, for with them he at least deserves and often gets much sympathy and consideration which are food and drink to him. Without them, he would lose his shelter and be thrown out into the cold hard world of endeavor. This does not mean that the neurasthenic is a maligner. He is not. He is sincere, but he does not understand his own feelings.

Simple worries by a system of brooding upon them may develop into *morbid fears*. Sometimes the habit of worry becomes fixed, but the particular worries are not specifically defined. In such a case we have a condition of anxiety, or as some patients express it, apprehension. This is a state of unformulated fear of impending disaster, and is most distressing. Various other manifestations may be associated with or take the place of these worries and fears. In the gastrointestinal tract the fear may lead to a sinking feeling in the epigastrium, so familiar to any one who is easily startled. There may be nausea, vomiting, indigestion, eructations, belching of gas, profuse watery evacuations of the bowels, flatulence, tympanites, and all other imaginable disturbances in the normal functioning of the digestive tract. The other systems of organs may similarly be functionally disturbed. We may have tachycardia, blushing, sweating, polyuria, and many other symptoms too numerous to mention. These may occur with or immediately following a sense of fear or apprehension, or they may come on independently without apparent cause. In the latter case, they act as substitutes or replacements for the emotional conflict which may have been successfully repressed below the level of consciousness. Such cases in which the repressed conflict has been replaced by the symptom are often of a Freudian nature and may respond to psychoanalytic treatment.

As an example to show the mechanism of the replacement of a fear by a symptom, let as assume that John Brown, a sensitive, introspective, young married man, finds that he needs more money than he has on hand. Perhaps he is a cashier with the handling of a good deal of money. No one but a fool could help thinking of the possibility of taking some of it to supply his own needs. But John at once realizes that if he does he will probably be caught and put in jail. This thought is associated with fear just as if he had taken it and was about to be arrested. He also blames himself, for thinking of anything so base. The desire for money then becomes associated with a feeling of fear and inferiority, which may in time give rise to epigastric distress, nausea, and vomiting. He does not see the relation in the development of these symptoms. He successfully represses the desire to steal the money, all thought of jail is dismissed, but whenever any idea related to money comes into his head, consciously or unconsciously, it results in vomiting. Being sensitive and introspective, he begins to worry about his health and ability to support his family, and we now have all the ground work of a full-fledged neurasthenic.

A few years ago, I saw a young woman of the sensitive repressed type, who had great difficulty in eating, as a large part of her food was regurgitated before reaching the stomach. There was no nausea or vomiting. The food simply came back as soon as swallowed. On analysis it appeared that various things in life seemed to her disgusting. She did not like to have this feeling of digust and in fact thought it was wicked of her to feel as she did about certain people and things. She, therefore, decided to repress her feelings and was so successful that she thought she had conquered her emotions, but about that time the regurgitation began. The disgust which she still felt below the level of her consciousness was manifesting itself symbolically in her regurgitation.

A very familiar type of nervous breakdown is well illustrated by the young stenographer who has worked hard for her education, is sensitive, ambitious, and perhaps has to help support her family. Competition is keen. She knows that if she makes mistakes, she may lose her position. But she must have speed in order to keep it. After a while, one day when she does not feel well, or when she has some home trouble on her mind, she makes one or two mistakes. This worries her, and she can't quite concentrate her attention on her work. Next day, as a result of her worry and preoccupation, she makes more mistakes. Perhaps she is tired and needs a vacation. She gets upset about her mistakes. The third day she makes more. She is now sure that there must be something the matter with her. Her first idea is that she is losing her mind. She must be going insane. After coming to this conclusion, she loses here grip entirely. I saw one girl of this type who on account of a slight abrasion on her skin for which she could not otherwise account, and having read some medical books, decided that she had leprosy. Her delusions built up on this as a foundation were for a while quite systematized and I was very much worried about her. But, after a good rest, and a series of talks in which the true nature of her trouble was explained to her, she recovered entirely and at last report was working harder and more efficiently than ever before.

It must not be forgotten, however, that neurasthenic symptoms may be only the first signs of a more serious condition. The systematized delusions of paranoia, or the insidious beginnings of multiple sclerosis, brain tumor, general paresis, and cerebral arteriosclerosis may all start in this way. It is not safe to make a diagnosis of neurasthenia unless you can absolutely rule out everything else.

Hypertension, with or without obvious cardiorenal disease may be discovered in the course of examining what appears otherwise to be a pure case of neurasthenia. The debility of a low-grade tuberculosis, or of a diabetes, in which a urinary examination has been passed over, is not infrequently treated as neurasthenia.

Although we usually think of neurasthenia, or as it is more popularly known, nervous prostration, as a feminine complaint, it is probably in its various forms almost as common in men as in women. It manifests itself most frequently soon after puberty, though it may not become apparent until much later in life, when it comes as the result of some special strain through which the individual has passed. But the temperament which is destined to become neurasthenic can generally be seen in the child who is apt

to be of the sensitive, self-conscious, self-distrustful type, more high strung, more obviously the product of civilization than the tough young animal who goes through anything without a second thought, not caring what any one thinks as long as he has a good time. With the temperament are often certain fairly well-defined physical characteristics, such as a general tendency to muscular relaxation, and consequent bad habits of posture and poor chest expansion due to inadequate respiration. There is often visceroptosis.

Symptoms.—The manifestations of disturbed functions may indicate almost any organ in the body, but the cardinal symptom is a fatigability out of all proportion to the effort expended. This fatigability occurs most frequently as a sense of being tired out but may occur as inefficiency or irritability, or both, in almost any function, as for instance, disturbances in digestion. These digestive disturbances as a group form the second important symptom, and show clearly the dual aspect of irritability and weakness characteristic of neurasthenia. The symptoms presented in a given individual may be entirely psychic as shown by a feeling of inadequacy to meet the requirements of life, such feelings often being associated with morbid fears; or the symptoms may appear entirely somatic, as in cases of "nervous indigestion," backache, etc. This fact accounts for the attempt to separate two types of neurasthenia, the cerebral and the spinal, but in the light of recent investigation this differentiation seems not to hold.

The neurasthenic *headache* is an important symptom to recognize. It is often described as a sense of pressure, or weight, or constriction. Sometimes it is figuratively spoken of as the helmet headache, the feeling of tightness passing around the forehead, over the ears and down the nape of the neck, but a constant suboccipital headache should require very careful investigation as it suggests an organic rather than a functional cause. The headache may at times be of a migrainoid type, but it is better to consider true migraine apart from neurasthenia as its close relation to epilepsy has been shown in certain cases, and its etiology and mechanism have not been satisfactorily demonstrated. Neuralgic headaches may also occur, but here also we must distinguish the true neuralgias. Functional headaches not infrequently lead to the habit of taking headache powders which in the course of time when gradually increased as they usually are in such cases lead to acetanilid poisoning and the resulting toxic headache, superimposed upon the pre-existing functional one, constitutes a perfect vicious circle. If the cause of the headache, a high degree of mental stress, is borne in mind, it is usually not difficult to differentiate this type from other forms.

Headache and *backache* not infrequently go together or appear at different times in the same patient. They may be continuous, "running from the base of the spine right up into the brain." Backache is more common in women than in men. Perhaps on account of the habit of wearing corsets their backs are more used to support and the musculature being relatively underdeveloped, they are weaker and therefore more subject to pain. Here another important point must be taken into consideration, the relation between backache, neurasthenia, and gynecology. It is a relation which is frequently terribly abused, but one which in certain cases should be carefully investigated. The time has passed when all forms of nervous instability were classed as hysteria which etymologically referred them to disturbances of the uterus. Reflex irritation from uterine malpositions or cervical erosions should be considered in all cases of chronic lumbosacral backache with neurasthenic symptoms which cannot otherwise be accounted for. The postural work of the orthopedists is becoming more and more important in cases having from the general point of view a similar symptomatology, but without gynecological trouble. This orthopedic aspect must be carefully taken into account for as I have already said the neurasthenic is apt to have a general muscular relaxation, both skeletal and visceral, resulting in bad positions of standing and sitting, bad habits of respiration and partly consequent, partly coincident, bad, metabolic facilities, poor peristalsis, sluggish digestion and constipation. It is in such cases that autointoxication may fairly be said to play a part, if ever, in the production of symptoms.

Asthenopia, usually interpreted as being due to eyestrain, may be the presenting symptom in a case, but more frequently occurs secondary to some other neurasthenic manifestation. The vision is good but tires quickly and there is a feeling of irritation in the eyes, which may even become slightly bloodshot. It must not be confused with hysterical amaurosis, in which there is an actual diminution or absence of vision, symbolizing the patient's unwillingness to recognize certain facts in life. Asthenopia is primarily due to poor concentration. The patient has been in the habit of thinking of something else while reading. He then by an effort of will tries to keep his attention fixed on the printed page. The simplest way seems to be by an effort of the eyes. This voluntary effort throws the automatic mechanism of accommodation out of balance with a resultant blurring of vision and sense of distress in the eyes. The patient who is more interested in himself than in what he is reading will naturally find it more of an effort to read than to think, and when he begins to worry about his eyesight, as it fails to improve with properly adjusted lenses, he feels that it is really injuring his eyes to keep on reading. A simple explanation and reëducation in the use of his eyes will quickly start such a patient on the road to recovery.

Insomnia, often a very distressing symptom, becomes all the more so to the patient who worries about his lack of sleep, feeling that it is the cause of all the rest of his trouble. The more he worries the less he sleeps, and the less he sleeps the more he worries. He feels that a certain amount of sleep is necessary to his physical health and integrity of mind. The thought of going to bed starts him worrying for fear he will not sleep, and by the time he has got to bed, what between his fear that he won't and his determination that he will sleep, he has worked himself into such a state of mental activity that sleep is impossible, and the longer he stays awake the worse he gets. According to the definition that sleep is the "reaction of disinterestedness," it is clear that he cannot sleep. The simple explanation to some such persons that sleep is comparatively unnecessary so long as rest and relaxation are obtained, will stop their worry and the first thing they know they are sleeping perfectly well.

Digestive disorders, so frequent among neurasthenics, must be carefully differentiated from those of organic origin which they closely simulate, and there is no doubt that in this realm, the patient is often treated for all sorts of conditions he has never had. There is no need of describing all the functional disturbances that may arise. Suffice it to say that their number is limited only by the number of functions present to be disturbed. Pavlov in his dog experiments demonstrated the effect of mental states on many of the digestive functions. With the present appreciation of states of mind as the determining factors in functional nervous diseases the relation between the dog experiments and the patient becomes clear. An important therapeutic criterion lies in the fact that such cases do not recover under the accepted forms of treatment for the organic condition simulated, but do clear up under treatment appropriate to the patient's condition as a whole.

Masturbation must be mentioned in connection with this subject on account of the frequency of its occurrence in a certain type of boy in whom the harm is done mostly if not entirely by his distorted or exaggerated ideas on the subject. The same may be said in regard to "wet dreams." I have seen a number of young men, some of rather notable ability, who apparently on account of one or the other of these conditions were on the verge of losing all that made life worth living. They couldn't eat or sleep or work. They were literally making themselves sick with worry. They thought they were losing their manhood. This idea is instilled and cultivated by quacks and their literature.

Such ideas, provided one is dealing with intelligent people and not mental defectives, respond almost at once to explanation and encouragement. The worry as to effect being dropped, the thought becomes less insistent and the habit is usually easily broken.

Treatment.—In the treatment of neurasthenia the mechanism of its production must always be borne in mind. In all civilized beings there are two great groups of forces at work; one which unites us to the rest of the animal kingdom, the other which we feel differentiates us from it. To the first group belong our emotional activities, all those instincts which lead to the preservation of the individual and of the race, teaching us to avoid danger and pain, and to seek pleasure and comfort, like all other animals. To the second group belong our intellectual activities, all those forces which have built up civilization, and made it what it is to-day. It is clear that in many ways these two groups of forces must be in direct opposition to each other, the first representing the sensuous, the second the intellectual elements of one's character.

When two opposing forces meet something must happen. If one is much stronger than the other, the solution is simple. If an individual is comparatively little bothered by intellectual ideals, and is satisfied and able to live a purely sensuous existence, the result is comparative happiness, so long as his ease and comfort are not disturbed. On the other hand, if one is of a high intellectual type, able to follow his ideals, and but little upset by emotional considerations, he also is able to live his life comparatively satisfactorily. But if the forces are so balanced that a constant indecisive conflict is being waged there is nothing but destruction of energy with its resulting unhappiness and inefficiency for other forms of activity. The man who can appreciate both the intellectual and the emotional aspects in his make up, who can correlate them giving each its place in his life without allowing them to come into conflict represents the highest type of civilized product. It is through his intellect that he is able to use his emotions to advantage without allowing himself to be governed by them. The man who has no emotions is as undesirable as the man who has no intellect. Neither can he be trusted. Unfortunately, the lack of appreciation of this fact may be the starting-point of trouble.

Take the sensitive child, for instance, brought up in austere surroundings. In the course of time, he inevitably begins to have instincts and impulses which he does not understand. What he learns comes by way of other children. He gets the impression that many things are intrinsically right or wrong, instead of being shown that most things are right or wrong only in relation to their environment, only in so far as they will directly or indirectly, immediately or in the long run result in benefit or harm to some one. As a result of this feeling of the essential rightness or wrongness of things he will do one of two things. He will either indulge, on the sly, in what he considers to be wrong, or he will try to repress his feelings. Generally the repression follows the indulgence, which may have been no more wicked than to allow his curiosity and imagination to dwell on subjects which to him had been forbidden. What child if told not to open the door of a room which is constantly kept closed will not take a chance some day to peep in? It is only human nature. Doing things on the sly naturally leads to fear of consequences. Here we have the primitive conflict: desire *vs.* fear. In adult life the mechanism generally becomes more elaborate, the desires and fears more subtle and complex so that they may not appear at all on the surface, but the general principles remain the same.

With this in mind it is easy to develop a rational line of treatment, which like all other forms of treatment to-day must aim at removing the cause and building up the resistance of the patient.

There is no other line of work in which more painstaking patience is required than in the handling of neurasthenics. Only too often they have been to physician after physician, who after going through a routine physical examination has told them that there was nothing the matter, or that it was all imagination. This is not only untrue, but most discouraging. There is something very much the matter and it is not imagination but because it was not objectively demonstrable by the ordinary methods of inspection, palpation, percussion, and auscultation, he has not been able to find it. A physician who is not better equipped to treat functional disturbances than that should at least have it borne in on him that it is his duty to send such patients to someone who can treat them, for a certain proportion of such cases can be cured, and still more of them greatly helped and enabled to live lives which though perhaps not ideal, will at least be happier and more useful in the community than before.

I have spoken of fatigability and irritability as the two cardinal symptoms of neurasthenia. There is another consideration of the greatest importance when it comes to treatment, and that is the fact that the neurasthenic is depressed. It is as if he was lost in a great forest. No matter how far he goes, he doesn't seem to be any nearer the open. No wonder he is discouraged. And then if a physician in whom he feels that he should have confidence tells him that all he has to do is to walk out, but refuses to show him the way, he feels as if he might just as well give up entirely, might just as well lie down and die, but as a rule he knows he can't do that for in some way food and drink will be supplied to keep him alive.

The first indication for treatment then is to revive the patient's courage and get his confidence, not only that you know the way out of the woods, but that you are going to show him. The next thing is to rectify as far as possible, defects in metabolism, through diet, excretions, hygiene, exercises, if necessary, and a careful supervision over the details of his life to see wherein he is putting forth his efforts to advantage and where they are most going to waste. In cases where the fatigue is most prominent, carefully regulated rest and exercise must be planned and systematized according to the needs and abilities of each patient individually. The "rest cure" so wonderfully developed by Dr. S. Weir Mitchell was just such a regulated system of rest and exercise coupled with the personality of the man himself to help the patients over the rough places in the road. Unfortunately, a great many physicians having heard of the rest cure but knowing nothing about it except the name, have given their patients rest and nothing else, when perhaps what they most needed was work. The result, of course, is a foregone conclusion. A rest too long continued leaves the patient worse off than he started. Exercise, first passive perhaps, in the form of massage and passive movements of the extremities, then active, starting with small amounts and gradually increasing, should be begun early in the treatment and supervised to see

that it is being carried out. The patient cannot do it all himself. He not only has to be told what to do and shown how to do it, but he has to be watched and encouraged while he is doing it. At first his symptoms may not improve, but he must be assured that with courage and perseverance they will improve, and they always do. This is a point too often overlooked. If the physician will not have courage and perseverance how can he expect his patient to have them? As he gets to know his patient he will gradually be able to find out what kinds of things have been upsetting him, and on tracing them back will perhaps be able to see how they started. Gradually he will be able to reassure him and explain the relative significance of his symptoms, so that by understanding them, the patient will in time be in a position to control them to a large extent himself.

As an adjunct to treatment, hydrotherapy is often of great value. If properly graded, it makes a patient feel better and improves metabolism. A great deal is being claimed for high frequency electricity in the form of autocondensation. It is undoubtedly of use in some cases of hypertension, but in simple neurasthenia, aside from the psychic or suggestive effect, its value is still to be demonstrated.

In regard to drugs there is little to say. Iron is of value only in those cases in which there is anemia. Strychnine in the form of nux vomica is probably of more use in atonic conditions than any other drug, but it should not be abused. The feeling that a tired irritable patient needs bromides to quiet him is very prevalent, but except in extreme restlessness a tonic is generally better than a sedative. Sometimes they can be combined to advantage, but the tendency is apt to be toward too much bromide which in the long run inhibits recuperative powers instead of helping them. If symptoms arise from fatigue of inhibitory impulses, the nervous system should be strengthened rather than weakened.

The symptoms that arise in the course of the condition must be treated according to their nature, but the fundamental principle must never be forgotten that neurasthenia being a functional disturbance dependent upon emotional conflicts is amenable not to the methods of organic medicine, but to a rational individualized system of psychotherapy.

How detailed an analysis of the development of symptoms should be made must be determined in each case. Some patients can be put on their feet after a very superficial explanation, leaving the rest for them to work out themselves. In other patients although temporary improvement may be got by superficial methods, no permanent results can be attained without searching analysis tracing the effect back to its cause. GEORGE CLYMER.

Neurenteric Canal.—The neurenteric canal is a short passage leading from the archenteron, or primitive gut, to the posterior end of the medullary canal. It is a wholly embryonic structure, appearing at an early stage and disappearing soon after. It is formed in connection with the closure of the blastopore (see article *Blastopore*) and the earliest stages in the development of the central nervous system. Its interest lies in its occurrence at a certain stage in the embryos of almost all vertebrates and their allies, the lower chordata.

The central nervous system of all chordata is at first an area of ectodermal cells, the *medullary plate*, deeper than the general ectoderm and extending anteriorly from the blastopore or the primitive streak along the dorsal surface of the embryo. It is converted into a groove by the elevation of the *medullary folds* at its margin, and these folds by uniting in the midline change the groove into a tube, the *medullary canal*, the lumen of which is the *neurocœle*. In the lower chordata (the Ascidians and Amphioxus) the medullary folds close over the blastopore, which then opens into the neurocœle and becomes the neurenteric canal. At this stage the neurocœle still has at its anterior end an opening to the exterior, the *neuropore*. This condition persists in Amphioxus until the formation of the mouth. So for a considerable period the only passage from the alimentary cavity to the exterior is by way of the neurenteric canal, the neurocœle, and the neuropore. The neurocœle is lined by ciliated cells.

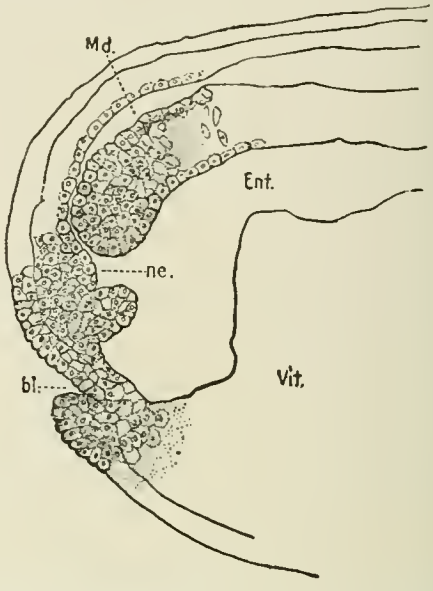


FIG. 4135.—Longitudinal Section of a Frog's Ovum shortly after the Closure of the Medullary Groove. The blastoporic canal, *bl.*, is only partially cut, but was found open in neighboring sections. (After Durham.) *Md*, Medullary canal; *bl.*, anal plate; *Vit.*, yolk forming the floor of the endodermic cavity, *Ent.*; *ne.*, neurenteric canal.

In the more primitive fishes (Elasmobranchs and Ganoids) there is a well-marked neurenteric canal formed by the closure of the medullary folds over the blastopore, or at least over the dorsal part of this opening. In the teleost fishes the neurenteric canal is represented by a string of cells connecting the notochord and the medullary plate behind Kupffer's vesicle.

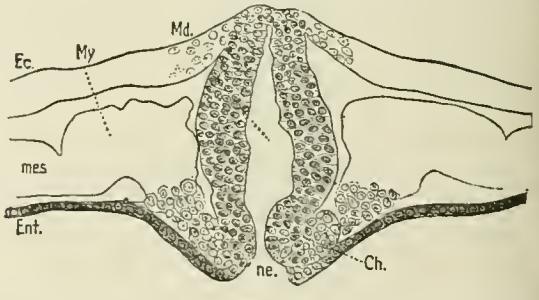


FIG. 4136.—Transverse Section of an Embryo Paroquet (Melopsittacus) to show the Anterior or True Neurenteric Canal. *Ec.*, Ectoderm; *My*, myotome; *Md.*, medullary canal; *Ch.*, notochord pierced by the short neurenteric canal, *ne.*; *Ent.*, endoderm; *mes.*, mesoderm. (After Max Braun.)

The blastopore of Amphibia when closing becomes at first a narrow slit, and then the lateral margins fuse so as to leave two openings, one at each end. The dorsal one is the neurenteric canal. The ventral one may either become the anus directly (in Urodeles)

or it may close (in the Frog) and form the anal plate (see article *Blastopore*, Fig. 675). Later the neurenteric canal is covered by the medullary folds (Fig. 4135).

Reptiles have a neurenteric canal which before the closure of the medullary folds opens to the exterior at the boundary between the medullary plate and the

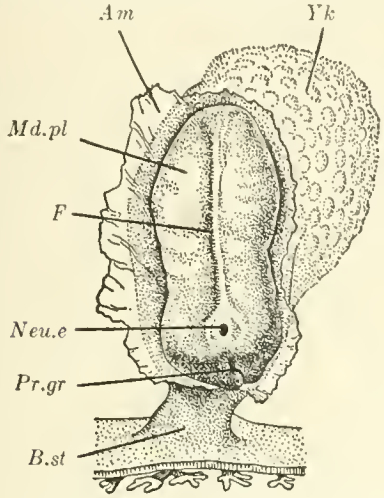


Fig. 4137.—Reconstruction of a Human Embryo 1.54 mm. long. The amnion has been opened to show the dorsal surface of the embryo. *Yk*, Yolk sac; *Am*, amnion: *Md.pl*, medullary plate; *F*, dorsal furrow; *Neu.c*, neurenteric canal; *Pr.gr*, primitive groove; *B.st*, body stalk. (After Count Spee.) (From Minot's "Embryology," Blakiston, Phila., 1903.)

primitive streak. From this point it extends anteriorly and obliquely inward through the rudiment of the notochord.

A neurenteric canal is present in some birds, as the duck, the goose, and the paroquet (Fig. 4136), but in

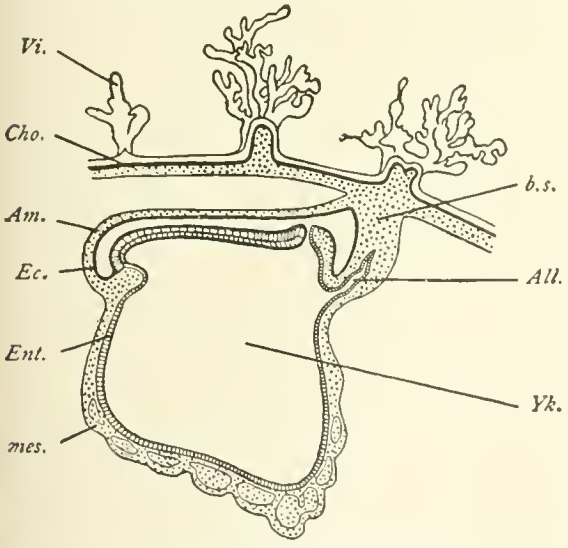


Fig. 4138.—Reconstructed Sagittal Section of the Embryo shown in Fig. 4137. *All*, allantois; *am*, amnion; *Ec*, ectoderm; *Ent*, endoderm; *mes*, mesoderm; *yk*, yolk-sac. The opening between the amniotic cavity and the yolk-sac is the neurenteric canal. (After Spee, from Minot.)

the chick it is represented only by a slight depression known as the *primitive pit* in the anterior end of the primitive streak (see article *Area Embryonalis*, Fig. 292).

The notochord of mammals at a very early stage is hollow, the lumen being known as the *notochordal canal*. In many mammals the neurenteric canal opens into the notochordal canal. This occurs in the rabbit, sheep, guinea-pig, etc. In others it is a simple perforation of the blastoderm, as in the hedgehog and man. In a human embryo of 1.54 millimeters the neurenteric canal has been seen opening to the exterior (Figs. 4137 and 4138).

The occurrence of the neurenteric canal in young embryos of all classes of vertebrates seems to indicate that this structure has been of importance in the evolution of the phylum. A true explanation of its significance probably would carry us a long way toward an understanding of the structure and mode of life of that primitive creature which was the common ancestor of the earliest chordata.

Robert Payne Bigelow.

References.

Balfour, F. M.: On the Early Development of the Lacertilia, etc. Quart. Journ. Microsc. Sci., xix. (1879); also in his Works, i., p. 644, with Plate 29.

Balfour: Comparative Embryology, vol. ii., pp. 267–269.

Braun, M.: Die Entwickelung des Wellenpapageis: ii. Theil, Semper's Arbeiten, v., 205–341, Taf. x.–xiv. (a valuable but excessively diffuse article. The most important passages on the neurenteric canals are on pp. 296, 301, and 308).

Durham, Herbert E.: Note on the Presence of a Neurenteric Canal in Rana. Quart. Journ. Microsc. Science, xxvi., 509–510, Plate xxvii.

Götte: Entwickelungsgeschichte der Unke.

Hertwig, W., 1903: Die Lehre von den Keimblättern. Handb. d. Entw. d. Wirbeltiere., Bd. i., Tiel 1, pp. 699–966.

Kellicott, W. E., 1913: Outlines of Chordate Development, New York, 1913.

Kowalevsky, A., 1870: Entwickelungsgeschichte der Störe. Bull. Acad., St. Petersburg, vol. xiv.

Kowalevsky, A., 1877: Weitere Studien über die Entwickelungsgeschichte des Amphioxus. Arch. mik. Anat., Bd. xiii.

Neuridine, $C_5H_{14}N_2$, is a non-poisonous diamine formed in the putrefaction of meat and gelatin. Under physiological conditions it may also be found in the brain and in the yolk of the egg. F. P. U.

Neurine, $CN_2 = CH - N - (CH_3)_3 - OH$, is a highly poisonous base formed in putrefaction and constituting one of the so-called ptomaines. See *Ptomaines*. F. P. U.

Neuritis.—Neuritis is inflammation of a nerve trunk or its branches. As a localized affection involving a single nerve it generally attacks certain nerves, such as the branches of the brachial plexus in the upper extremities or of the lumbar or sacral plexus in the lower extremities. The cranial nerves may also be attacked by neuritis. When only one nerve trunk is affected, the condition is usually spoken of as "isolated" or "localized" neuritis or "mononeuritis." When many of the peripheral nerves are involved at the same time, it is characterized as multiple neuritis, or polyneuritis, a condition meriting special description, and which will be discussed later. Neuritis may be either acute or chronic, or the symptoms of acute neuritis may persist for a long time and then become chronic.

The causes of neuritis are numerous. It may be due to traumatism such as direct wounding or contusion of the nerve, or to compression of the nerve by sudden and forcible muscular contraction; to dislocation of joints; to injury of the nerve from fragments of bone resulting from fracture; to compression of the nerve from the formation of callus; to pressure of growths; or, finally, to pressure upon the nerve trunks in the axilla during the use of crutches. Neuritis may also be caused by chemical agents such as ether, osmic acid, or alcohol, coming in direct contact with the nerve through subcutaneous injection. It may also develop from

refrigeration through exposure to cold, and as a complication or sequel of various infectious diseases. It may also arise by extension from adjacent inflammation.

Patients who are addicted to the excessive use of alcohol, or those suffering from chronic toxic disorders such as gout, rheumatism, diabetes, chronic nephritis, or syphilis, are more predisposed to the development of localized neuritis after slight traumatism or exposure to cold. Arteritis obliterans and arteriosclerosis may also be considered to be predisposing causes.

Pathologically, there are various types and degrees of neuritis. We thus have: 1. Perineuritis, in which the inflammation originates in the perineurium to which it may be limited. 2. Interstitial neuritis, in which the inflammatory process is located principally in the interstitial structure of the nerve. 3. Parenchymatous neuritis, in which the nerve fibers undergo inflammation and degeneration. The first two forms represent a true inflammatory process. In the third form, the same changes often occur which usually arise as a consequence of complete division of the nerve. As these different processes vary in degree and are frequently found in combination, their clinical differentiation cannot always be accomplished.

Isolated neuritis is generally a perineuritis or interstitial neuritis. There are redness and swelling of the connective tissue enveloping the nerve, the blood-vessels of the nerve sheath are distended with blood, and there may be minute hemorrhages. Serofibrinous exudation and migration of leucocytes follow the hyperemia. These changes may be limited to the sheath (perineuritis), or may extend into the substance of the nerve (interstitial neuritis). When the process is severe or of long standing, the nerve fibers may also become involved. In the parenchymatous form the inflammation begins in the nerve fibers, resulting in their degeneration and atrophy.

Symptoms.—Pain in the course and distribution of the nerve is the principal symptom. Its degree varies with the extent and intensity of the inflammatory process. The nerve trunk is sometimes swollen and extremely sensitive to pressure, the pain often radiating to the ultimate distribution of the nerve. The pain sometimes affects the entire extremity, which may become extremely hyperesthetic. It is variously described by patients as darting, boring, burning, and occasionally shooting through the course of the nerve. It is increased by movement and is usually worse at night. Numbness and tingling may also be present. This may be attended by some constitutional disturbance as increased pulse rate and rise of temperature. Should the nerve fibers become involved, objective sensory disturbances may arise, such as varying degrees of anesthesia in the area of the distribution of the affected nerve, with weakness or muscular paralysis. Herpetic eruption or glossy skin may also be present. In severe cases anesthesia, paralysis, and atrophy usually take place. The faradic irritability of the nerve and muscles is at first increased, but gradually it diminishes, and is finally lost when the nerve fibers undergo degeneration.

The neuritis may ascend a nerve ("ascending neuritis"), reaching the plexus from which the nerve arises, and thus extend to several or all of the nerves of the limb. The inflammation has also been known in rare instances to extend to the spinal cord, causing subacute or chronic myelitis.

Prognosis.—Acute neuritis may disappear in a few weeks if the cause can be successfully removed. The most favorable cases are those due to slight traumatism. More commonly the affection persists in a chronic stage for many weeks or even months. The most protracted forms arise in patients with gout or rheumatism, or in such toxic cases in which the toxin cannot be removed at once. When the axis-cylinder processes are involved, as in degenerative neuritis, the condition may last for many months, paralysis and atrophy becoming permanent if the nerve fibers do not undergo regeneration. An opinion as to the prognosis often depends upon the changes in the electrical irritability of the nerves and muscles.

Treatment.—When a nerve is divided by a wound, the separated edges should at once be approximated and sutured. In compression or injuries of nerves from luxation, fracture, callus, tumors, inflammation of soft parts, abscesses, etc., it is the first duty of the physician to insist upon immediate surgical measures to free the injured nerve if possible.

A cure is not always accomplished by this method alone, inasmuch as any accompanying muscular paralysis calls for subsequent treatment. Under such circumstances surgical intervention must be the first step, otherwise all other treatment will prove futile. The general constitutional condition of the patient must not be overlooked. In acute cases absolute rest of the affected limb is essential, either by keeping the patient in bed, or by immobilization of the limb by a suitable supporting bandage. The relief of pain is an important feature. In acute traumatic cases a Chapman's ice bag applied along the course of the nerve, or cold compresses often prove valuable. The application of hot-water cloths ameliorates the pain in many cases. When anesthetic areas are present, extreme care should be observed when hot-water cloths are applied, in order to avoid burning the skin. Blistering or superficial linear cauterization over the affected nerve trunk often effectually relieves the pain. The application of the high frequency current, or the use of the hot-air or baking apparatus often prove serviceable.

At times it is necessary to administer some of the coal-tar derivatives such as phenacetin, acetanilid, or salipyrin. When the pain is persistent and severe, and is not relieved by other means, we must resort to the use of opium, morphine, or codeine. Local injection of a solution of novocaine at the seat of the greatest pain often gives relief. The continuous galvanic current is also of great value in diminishing the pain. The anode should be placed over the affected nerve, the current strength being from six to eight milliamperes, the application lasting five or six minutes daily. For the paralysis accompanying degenerative neuritis after the acute symptoms have subsided, the application of the labile or interrupted galvanic current to the affected muscles seems to hasten the recovery of motility by improving the nutrition of the muscles and accelerating the regeneration of the nerve. Massage is generally contraindicated during the early period of the inflammation, but it can be favorably utilized later. Small doses of mercury have been recommended by Gowers for the purpose of influencing the neuritic process.

Multiple Neuritis or Polyneuritis.—This is a disease in which many nerves are inflamed simultaneously or in rapid succession. It usually affects symmetrically the nerve trunks in the extremities, particularly in their peripheral distribution. In this form of neuritis, the pathological process originates in the nerve fiber, the adventitial structure generally being involved secondarily. In mononeuritis the nerve sheaths and the connective tissue, as a rule, are primarily affected. As early as 1828 Graves described the condition as "a form of generalized paralysis probably depending upon disease of the peripheral nerves." The first authentic case with postmortem verification was published by Dumesnil, of Rouen, in 1864, but it was not until further observations were reported by Lancereaux in 1871, Eichhorst in 1875, Joffroy in 1879, Leyden in 1880, and Grainger Stewart in 1881 that the doctrine of multiple neuritis was placed upon a sound pathological basis. Many observations and monographs relating to this subject have been published, the literature now being quite abundant.

Etiology.—Multiple neuritis is invariably the result of some toxic substance circulating in the blood. A very large number of different causes are active in its production.

(*a*) *Poisonous substances introduced into the system* (these being mentioned in the order of their importance): Alcohol, lead, arsenic, copper, silver, phosphorus, mercury, carbonic-oxide gas, bisulphide of carbon, and nitrobenzol.

(*b*) *Poisons originating within the body* (autotoxic): Dyscrasic conditions such as gout, diabetes, tuberculosis, carcinomatosis, syphilis.

(*c*) *As a sequel or complication of various infectious diseases*: Diphtheria, influenza, typhoid fever, smallpox, scarlet fever, measles, pneumonia, whooping-cough, epidemic cerebrospinal meningitis, erysipelas, gonorrhea, malarial toxemia, acute articular rheumatism, leprosy, and all forms of septicemia.

The majority of cases of multiple neuritis are traceable to alcoholic excesses. It is hardly necessary to mention that the vulnerability of the peripheral nerves to the effect of alcohol varies in different individuals. One person may indulge in large quantities daily for years without developing neuritis, while many others who probably possess less resistance in the peripheral neurons are attacked by the disease after the continued daily use of a comparatively small amount of alcohol. The writer has seen several cases resulting from the daily use of about two ounces of whiskey continued for three or four months. Multiple neuritis as a sequel of acute alcoholic intoxication is almost unknown.

According to the preponderance of one set of symptoms over another, multiple neuritis has been classified into various clinical types, such as:

1. *A motor or paralytic type* (alcohol, arsenic, diphtheria, Landry's paralysis).

2. *A sensory type*, an ataxic form which is often described as "pseudotabes" or "neurotabes peripherica," and is most commonly due to arsenic or alcohol.

3. *A vasomotor type* (erythromelalgia, Raynaud's disease).

4. *An endemic form* (beriberi or kakké, particularly prevalent in Japan and the Dutch East Indies).

Multiple neuritis occurs most frequently, however, in transitional forms, and may then be characterized as a common or mixed type in which motor, sensory, and vasomotor phenomena arise in various combinations.

Polyneuritis usually occurs between the ages of twenty-five and fifty years. Aside from the form due to diphtheria, it is rare in children, although it has been occasionally observed between two and six years of age. A number of cases of multiple neuritis in children as a result of alcoholic poisoning are now on record. In one of the writer's cases the child, who was five years old, had been given whiskey and beer daily for several months by its ignorant mother, for the purpose of strengthening it after an attack of diarrhea. The disease rarely occurs after the sixtieth year.

Symptoms.—It is now well established that in multiple neuritis no set of symptoms is exclusively related to a single cause. A description of the symptomatology of the alcoholic form will convey a knowledge of the general features of the affection.

Multiple neuritis may be either acute or subacute in its onset, and may follow or accompany an attack of delirium tremens. The temperature may be slightly elevated in the beginning, and some fever may continue throughout the acute period of the disease. Normal temperature is not unusual. At first there is often tingling, or a sensation of "pins and needles" or numbness in the extremities, with vague sharp pains or aches, which gradually become more acute. The paresthesia and pain are soon followed by muscular weakness, or paralysis, or incoordination. Either the upper or lower limbs or both may be involved, first and chiefly the hands or the feet. The feet are affected more frequently than the hands; motor symptoms may exist in the legs, and only sensory symptoms in the hands. This is accompanied by tenderness along the nerve trunks and in the muscles, the muscular tenderness usually increasing to an extreme degree. The coordinating power may be affected at the same time. Tremor is often conspicuous. Most frequently the knee-jerks are absent, this depending directly on the involvement of the anterior crural nerves. The knee-jerk is present or even exaggerated in some cases of slight degree, and this invariably indicates that the anterior crural nerves are intact.

In the lower extremities the nerves most commonly affected are the peroneal and the posterior tibial and their branches. Occasionally the anterior crural nerves are also involved. Thus, the paralysis usually affects symmetrically the corresponding tibial group of muscles producing "foot-drop." In severe cases nearly all of the nerves of the extremities may gradually become involved, and a more or less complete paraplegia develops.

The upper extremities may escape entirely, or the paralysis is almost always of lesser degree and extent than in the lower extremities. The musculospiral nerve and its branches are most commonly affected, thus producing paralysis of the extensors of the wrist and hand and "wrist-drop." It often happens that other nerves are also involved. A peculiar feature in these cases is the implication of the nerves in their peripheral distribution, the paralysis usually being more pronounced in the distal portions of the extremity. This is also indicated by the fact that at times when the supinators and the long abductor of the thumb in the upper extremity and the tibialis anticus in the lower extremity remain intact, there may be paralysis of the other muscles which receive their supply through the same nerve trunks. Sometimes the muscles above the knees and elbows are also affected. In the more severe cases the diaphragm and the muscles of the abdomen also become involved. In rare instances several of the cranial nerves may be implicated, the facial muscles, those of the tongue, or the ocular muscles thus becoming affected. The paretic or paralyzed muscles soon become flaccid and undergo atrophy and present the reaction of degeneration. Sensory disturbances are often associated with the loss of motor power. They may be altogether absent or exist alone. In addition to the subjective sensations already mentioned, extreme hyperesthesia may exist over the affected parts, or tactile, pain, or muscular senses may be affected in various degrees. In the ataxic form incoordination is the chief symptom. It is usually accompanied by muscular tenderness, and exists with or without the affection of cutaneous sensibility just described. The incoordination in these cases resembles closely that of tabes, hence the form in which this symptom is predominant has been called "pseudo-tabes." Its most frequent cause is alcohol, but it has also resulted from arsenical poisoning and from infectious processes.

Trophic changes occur in prolonged cases in the nails, skin, and hairs, and are similar to those of ordinary neuritis. In uncomplicated cases the sphincters of the bladder and rectum are not involved.

In some severe cases in which the neuritis is widely distributed, the pneumogastric nerve or some of its branches may become affected, causing interference with the action of the heart, the muscles of respiration, and the vocal cords.

All of the symptoms vary according to the acuteness and intensity of the disease, and they also differ according to the cause. In lead poisoning the paralysis is usually confined to the upper extremities. In alcoholism all four extremities are often affected, the arms escaping more often than the legs.

Mental Symptoms.—A somewhat characteristic disturbance of memory often takes place. In general,

it may be described as a peculiar form of forgetfulness with delusions of recollection. The memory for recent events is generally confused but not always entirely lost. Occurrences of some days, weeks, or months previously are misinterpreted by the patient as of quite recent occurrence, or as having just taken place. Although he may be confined to bed and unable to move, he may assert that he has just returned from a long journey, or has been out for a ride, or has just visited friends, etc. These manifestations have been described as "Korsakoff's Syndrome." In some cases there are insomnia, delirium, talkativeness, or incoherence, or other more pronounced manifestations of acute alcoholic insanity or confusional insanity. All of these mental symptoms are essentially due to toxemia, and bear no direct relation to the degree or form of the neuritis. Although more commonly observed in alcoholic subjects, they are known to occur in the course of multiple neuritis due to other poisons and also from infection.

Diagnosis.—In acute cases, when all of the characteristic symptoms are present, and the patient is unable to move from the bed, the diagnosis is very simple. It is the subacute forms that often present some difficulty in their diagnosis. On account of the presence of incoordination, pains in the legs, and loss of knee-jerks, and some objective disturbances of sensibility, it has sometimes been mistaken for tabes. It is easily differentiated from tabes, however, on account of the presence (in multiple neuritis) of tenderness of the muscles and nerves, the neural character of the pains, the symmetrical diminution or loss of muscular power, the absence of bladder symptoms, and the presence of the pupillary light reflex.

Multiple neuritis has also at times been confounded with atypical cases of poliomyelitis, but poliomyelitis is most frequent in children; its onset is abrupt, the paralysis is rarely symmetrical in its distribution, and there is generally an absence of all sensory symptoms.

The history of some form of toxemia known to cause polyneuritis is a potent element in the differential diagnosis.

The Diagnosis of the Toxic Cause, and the Differentiation of the Various Types.—It is not always easy to determine from the clinical symptoms alone whether a certain case of multiple neuritis is caused by alcohol, arsenic, lead, or some infectious process. However, there are certain elements in the history, a peculiarity in the distribution of the paralysis, and well-defined indications associated with some special forms of toxemia or infection, which often conclusively prove the cause of the neuritis.

For instance, the somatic and psychical symptoms may present a classical picture of chronic alcoholism. Thus, in addition to the polyneuritis, there may be tremor in the lips, tongue, and hands, toxic amblyopia, chronic morning vomiting, cirrhotic liver, albuminuria, delirium tremens, or alcoholic dementia. *Arsenical neuritis* is often accompanied by vomiting, a general brown pigmentation of the skin, and the presence of arsenic in the urine. In some cases the ataxia is more pronounced than are the motor symptoms. The arsenic has usually entered the system as a result of acute poisoning after an ineffectual attempt at suicide. Occasionally the neuritis is produced by the prolonged administration of medicinal doses of Fowler's solution as used in the treatment of chorea in children, or from the inhalation of arsenical dust given off from wall paper and other articles containing arsenic. A large number of cases of arsenical polyneuritis occurred in England from the use of beer in which arsenical glucose had been used in its manufacture.*

Multiple neuritis from *lead poisoning* is most frequently found among those whose occupation requires frequent or continuous contact with lead. The accidental causes are numerous, such as the contamination of drinking-water by leaden pipes, the cooking of food in vessels containing lead in their manufacture, the use of various cosmetics, hair dyes, etc. It has also been traced to snuff, which was found to contain lead. As a rule, the lead enters the system through the alimentary canal as a result of uncleanliness, and the pollution of food by hands that have been in contact with lead. It may also enter the system through inhalation, and by absorption through the skin. As in other forms of toxemia individual susceptibility to the effects of lead has much to do with the development of neuritis. People in general ill health, and those addicted to alcoholics, or more predisposed to the toxic action of lead. The upper extremities are more commonly affected, a blue line is often seen on the gums, and lead may be found in the urine.

Polyneuritis from *diphtheria* may be attended with wasting and anesthesia; but the weakness in the limbs usually succeeds paralysis of the palate and ciliary muscle, which are never seen in other forms of polyneuritis.

Course and Prognosis.—Multiple neuritis usually takes an acute or subacute course and reaches its height in a few weeks or a few months. It then remains stationary for about the same period, and gradually recovery takes place. Some cases are very severe and are accompanied by high fever, and may terminate fatally in a week or two from paralysis of the heart or diaphragm, or from pulmonary edema. It sometimes assumes a course similar to that of Landry's paralysis. The condition is always serious when the patient's general health is poor in consequence of a recent infectious disease, or in severe types of chronic alcoholism, etc. When the vagus or phrenic nerves become involved, the life of the patient may be in constant danger, although recovery has occurred even under such circumstances. When the paralysis is confined to the distal portions of the extremities, the prognosis is more favorable. In exceptional instances the course may become chronic and progressive. In the majority of cases, however, in the absence of complications the disease terminates in complete recovery. Even in favorable cases the affection may last from several months to two years or more, depending upon the underlying cause, the extent and intensity of the nerve degeneration, and the recuperative powers of the patient. The prognosis is always materially influenced by the course and virulence of the toxemia. When the sphincter of the bladder is involved, it is usually indicative of extension of the inflammatory process to the spinal cord, thus rendering the prognosis as to recovery more doubtful.

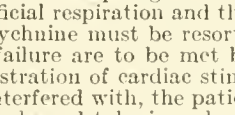
Treatment.—The treatment of polyneuritis is essentially symptomatic. Aside from the cause of the toxemia the various forms receive practically the same treatment. It is essential to discover, if possible, the cause of the neuritis, and to remove it or discontinue its further action. This should be the first consideration, particularly in cases due to alcohol. The sudden withdrawal of the customary stimulant is not always advisable, particularly when cardiac weakness is present. This can usually be successfully accomplished, however, by the administration of suitable heart tonics. Rest in bed, with general supporting treatment, is desirable or absolutely necessary in the majority of cases. A local or general warm wet pack for the purpose of producing diaphoresis, if the patient's strength admits, is often followed by excellent results in the early stage, or, if the patient is strong enough to bear the necessary procedures, a warm bath for fifteen or twenty minutes daily often proves beneficial. General constitutional treatment applicable to the special condition constituting the toxemic process should never be forgotten. In order to prevent deformities, faulty positions of the extremities should be corrected by giving the necessary support to paralyzed muscles. Thus when there is

* Glucose is made by the action of sulphuric acid on various kinds of starch. The origin of the arsenic was found in the sulphuric acid which is commonly made from arsenical pyrites.

"foot-drop" the feet should be kept at right angles with the leg by means of sand-bags, pillows, etc. For the purpose of relieving the pain anodynes should be administered when necessary in the same manner as mentioned in the description of the treatment of mononeuritis. When the diaphragm becomes paretic or paralyzed, artificial respiration and the hypodermatic injection of strychnine must be resorted to. Indications of heart failure are to be met by absolute rest and the administration of cardiac stimulants. When deglutition is interfered with, the patient should be fed through the esophageal tube in order to prevent the entrance of food into the larynx or bronchi.

Fortunately such emergencies arise only in exceptionally severe cases. After all of the acute symptoms have subsided, massage and electricity will prove useful. William M. Leszynsky.

Neurodin, acetyl-para-hydroxy-phenyl-urethane,



is a white, odorless, crystalline substance, soluble in 1,400 parts of cold water and readily in boiling water. It is said to be antipyretic and analgesic in dose of five to fifteen grains (0.3 to 1.0 gm.); but cyanosis and profuse sweating are apt to follow its use as an antipyretic. R. J. E. Scott.

Neurofibroma.—See *Fibroma.*

Neurofibromatosis, Multiple.—See *Recklinghausen's Disease.*

Neurokeratin.—See *Keratin.*

Neuroma.—See *Fibroma.*

Neuromimesis.—See *Joints, Chronic Diseases.*

Neurone.—See *Nerves, Histology of.*

Neurocytes.—*N. hydrophobiæ*, name given by Calkins to the cell inclusions found in connection with hydrophobia. These are more commonly known as Negri bodies. See *Protozoa.* A. S. P.

Neuroses, Cardiovascular.—See *Heart, Functional Disorders of.*

Neuroses, Nasal.—Neuroses of Olfaction.—The olfactory nerve consists of about twenty fibers given off from the under surface of the olfactory bulb. These fibers pass down through the cribriform plate, dividing into two groups as they enter the nose—an inner group distributed over the upper third of the septum, and an outer group distributed over the superior turbinate bone and the upper half of the middle turbinate bone. In structure it differs from other nerves in being composed of non-medullated fibers. The olfactory center in the cortex is not definitely known, but is generally associated with the temporal lobe (Gray).

The nerve is liable to disorders in connection with both its point of origin and its distribution.

Parosmia is a perversion of the sense of smell. While the sense of smell may or may not be perfect for ordinary odors, there are in addition certain imaginary odors. This condition is comparatively common among the insane, and is found in epilepsy, hysteria, and syphilis. It has occurred in connection with the epidemic disease—the grippe, cases having been reported in which the patient was annoyed for days by unpleasant odors and tastes. The writer has observed this condition in connection with atrophic rhinitis when the ordinary sense of smell was destroyed. Here the condition is one of considerable annoyance to the individual. The affection is comparatively rare.

Hyperosmia is an exaggeration or hyperesthesia of olfaction. In this affection odors which are not ordinarily noticeable to the healthy nose are present as exaggerations, causing great annoyance. The odor of an offending substance is often retained for several hours after the removal of the offending material. Like parosmia, it is comparatively rare. There seems to be some connection between it and certain disorders of the sympathetic nerve. Both parosmia and hyperosmia seem to be dependent more on some general nervous disorder or some neurotic predisposition than upon any disorder of the olfactory nerve within the nose itself.

The *treatment* of both the foregoing affections should be directed to the cause so far as it is possible to ascertain it, as direct treatment of the nerve is not likely to do much good.

Anosmia.—Loss of smell is by far the most common of the affections of the olfactory nerve, and may have its point of origin within the cranial cavity or within the nose.

Anosmia Intracranialis.—This may be caused by injuries, tumors, degeneration, as in locomotor ataxia, general paralysis, senile decay, intracranial syphilis, congenital absence of the olfactory nerve, hemorrhage, meningitis, and abscess. Compared with the total number of cases of anosmia, those of central origin must be considered to be rather rare.

Anosmia Nasalis.—This form of anosmia, in which the pathological condition is of nasal origin, is by far the most common. It may be the result of either acute or chronic processes. For the function of the sense of smell to be properly performed, air, with odoriferous particles, must freely reach the terminal filaments of the nerve, and these are stimulated to activity only when in a moist medium; hence anything that interferes with the free access of air or with the moisture of the part will cause partial or complete loss of the sense of smell. Acute anosmia is usually due to acute processes, like colds in the head, the grippe, acute ethmoiditis, hay fever, or to any condition that temporarily blocks the nose. With the subsidence of the acute condition the sense of smell usually returns.

Owing to the close relationship between the sense of smell and the sense of taste, anosmia is usually accompanied by very pronounced loss of taste, especially of flavors. If the sense of taste is unchanged, the loss of the function of olfaction is only partial.

The chronic forms of anosmia occur in connection with anatomical changes in the nose, such as spurs, pronounced deviation of the septum, or any changes which close the nostril, especially hypertrophic conditions of the middle turbinate. They also accompany the degenerative conditions of the mucous membrane, such as atrophic rhinitis, in which the nasal cavity is abnormally widened, its walls covered with crusts, and the mucous membrane dry to such an extent that the sensitiveness of the terminal nerve filaments is lost.

The *symptomatology* and *diagnosis* offer no particular difficulty. In testing for loss of smell, acrid, sharp, or pungent substances must not be used, as they produce irritation of the sensitive nerve filaments rather than stimulation of the olfactory nerve.

In the acute affections the *prognosis* is usually good. In the chronic forms, when the disease has lasted for any length of time, degeneration has probably taken place, and the prognosis is not as good. White[1]

reports two cases which were entirely cured by treatment of the nasal disease, one after twenty years and another after ten years of complete anosmia. The author has had several cases in which the sense of smell returned after the removal of nasal polypi. In one instance the sense of smell had been lacking for a period of several years. But cases like the one just referred to must be regarded as comparatively rare, as it is the rule that when the sense of smell has been deficient fo a long period of time, the probability of its recovery must generally be considered doubtful; and the correction of the apparent cause in the nose is not always followed by as gratifying results as could be desired.

The *treatment* consists in the adoption of measures which improve the general nervous system and bring the nose and throat into the best possible condition, so that all parts of the olfactory nerve distribution will be accessible to the air. The area of distribution of the nerve should be stimulated by such agents as friction, the use of iodoglycerin, solutions of the various stimulating oils, as camphor, menthol, eucalyptol; and an attempt made to increase the blood supply and secretion of the part. While the improvement secured will frequently be satisfactory, the writer has many times been disappointed as to results of treatment, and more often than otherwise in those cases of anosmia in which examination of the nose does not show any apparent physical cause for the condition. Several of these have followed attacks of the grippe, and have been only partially relieved, and occasionally not at all, by treatment; nor have all the cases resulted satisfactorily even when intranasal conditions such as polypi, etc., have been found which were apparently sufficient to account for the condition.

Reflex Nasal Neuroses.—The connection between some irritation of the nose and sneezing has been known and considered from the time of Hippocrates; while the writings of the early physicians, as Aurelianus, Avicenna, Pechlinus, Salmuth, and Van Helmont, show that they were familiar with various reflexes of probable nasal origin, such as rose cold, cough, headache, and difficult breathing. The influence of powerful and disagreeable odors on the organism was noted by many authors.

In the eighteenth century Gumprecht advanced the theory that irritation of the trigeminus in the nose was transferred to the pneumogastric, producing reflex phenomena in the throat, stomach, heart, and lungs. Rega carried this theory still further, and demonstrated or suggested the relationship between the genital tract and the upper air tract; while Wepfer described a large number of cases in which headache, cough, vomiting, vertigo, disturbances of vision, and other nervous symptoms were dependent upon nasal disorders.

One of the first attempts to define this connection between distant organs as a distinct reflex was made by Müller, in his physiology of 1843, when he wrote that irritation of any mucous membrane in the body could give rise to a respiratory reflex. The credit of first calling attention to the nose as a definite point of origin of various reflexes, with practical observations as to the treatment and cure of the same, probably belongs to Voltolini,[2] who advanced the proposition that nasal polyps cause asthma reflexly, or else by hindering respiration they change the chemistry of breathing and alter the structure of the lungs. His publication in 1871 was soon followed by a host of observations, confirmatory and otherwise, by different authors. Among these was Haenisch,[3] who observed that asthmatic paroxysms disappeared after removal of polypi, and reappeared only upon the return of these growths, and B. Fraenkel,[4] who regarded the asthma from polypi as a reflex cramp of the bronchi produced by irritation of the sensitive nerve fibers, and, in agreement with Schaeffer,[5] also stated that this irritation could depend upon or be brought about by catarrhal changes in the nasal mucous membrane.

Asthma was the first disease to be regarded as a reflex neurosis, but various other affections were soon placed in the same category, especially various colds in the head—the so-called nervous head colds.

Next came the observations of Hack,[6] who widened very much the range of reflex nasal neuroses, until there were included migraine, supraorbital and ciliary neuralgias, nightmare, various coughs, vasomotor disturbances of the vessels of the skin, epilepsy, and secretory neuroses. These were later followed by reports still farther extending the field of reflex nasal trouble. Among these were cases of exophthalmic goiter, diabetes, affections of the larynx, heart and stomach, chorea, dysmenorrhea, enuresis, and so forth, until a large part of the pathology was said to be dependent upon disorders of the nose.

In order to produce a reflex, a sensitive or sensory nerve in connection with a ganglion, and a motor or vasomotor nerve fiber are necessary. The chain, of which the ganglion is the center, being present, the point of origin of the reflex can be at either extremity. All the conditions necessary for the production of reflexes are found in their highest development in the nose; since the nerves supplying the nasal mucous membrane are sensitive nerves, originating near the floor of the fourth ventricle and having connections with many ganglia, as the otic, sphenopalatine, Gasserian, ophthalmic, and others, which in turn connect with motor and vasomotor fibers and with many sensitive areas in the respiratory tract by means of the pneumogastric and spinal accessory nerves. Connected with these is the sensory nerve of the nose, the olfactory, which supplies the upper portion of the nasal cavity over both the septal and turbinal areas.

Pathology.—The nose through its normal physiology is particularly liable to reflex influences; as its whole function of warming, moistening, and filtering the inspired air is controlled by a highly complex nervous mechanism, which anatomically adjusts itself under normal conditions to the varying atmospheric changes. Its power as a protective organ, through the information which it gives of the presence of various odors and poisonous gases, and by alarms such as sneezing, cough and glottis spasm, is also dependent upon a reflex action.

In proportion to the number of cases of nasal trouble, the number of pathological nasal reflexes is probably comparatively small. Their presence in the individual case depends largely upon the nervous make-up of the individual; and they are more apt to be present to a pathological extent whenever there is increased sensitiveness of the general nervous and reflex mechanism of the entire body.

An attempt has been made to find certain so-called reflex points or specially sensitive areas in the nasal mucous membrane, and such have been described by various authors. J. N. Mackenzie[7] thinks that the posterior portion of the inferior turbinate is the most sensitive area, though he does not claim that this is the only one. That this area is sensitive, and that its irritation will frequently bring about a severe paroxysmal cough is easily determinable in some individuals by passing a Eustachian catheter without previous cocainization; in many persons quite a paroxysm of coughing will be set up. The author has met with several instances in which it was impossible even under cocaine so to abolish this reflex that the catheter could be used satisfactorily. In one case vomiting was invariably brought about whenever the catheter was used. Other authors have regarded the middle turbinate area as the sensitive one, while the so-called genital spots are in the anterior ends of the inferior turbinates, and in the

tubercle of the septum. A survey of the literature, however, will soon convince one that there is no certain reflex point, but that the entire nasal mucous membrane can be the subject of reflexes in every point of its entire extent, the septum as well as the turbinate area.

Hack theorized that the condition was due to swelling of the erectile tissue through the nervi erigentes, a theory not accepted by others, as the presence of nervi erigentes in the nasal mucous membrane has not been proven.

Anatomically, the nasal mucous membrane is supplied by the first and second branches of the trigeminus as to ordinary sensation, and as to special sense by the olfactory; and impressions are taken not only directly to the brain, but also indirectly, by means of the branches of communication with the various ganglia and the brain, to the entire nervous system—sensitive, motor, sympathetic, and special sense. The nasal or ethmoidal nerve comes from the first branch of the trigeminus, and covers in its distribution the anterior portion of the nose, the septum, the anterior ethmoidal cells, and the frontal sinus. The second branch, the superior maxillary or dental nerve, supplies the floor of the nose and the maxillary antrum; while the posterior part of the nose, the septum, the posterior ethmoidal cells and the sphenoid sinus are supplied from branches of the sphenopalatine ganglion.

Irritation can be carried to the brain through the motor, the vasomotor, the secretory, or the sensory tracts. Through the brain the olfactory is brought into contact with the entire system, while the trigeminus is in connection with the sphenopalatine, otic, and ciliary ganglia, and the point of origin of the latter in the medulla is in communication with all of the motor fibers coming therefrom. It is therefore clear that, under favorable conditions, sensory or sensitive irritation of the nasal nervous elements can be referred to far-removed parts of the body, and the most various symptoms produced.

Etiology.—The method of origin of all of the nasal reflexes is the same. The first act is an irritation of the afferent nerve fibers, sensory or sensitive. This is followed by the transmission of this irritation to the ganglion and its appearance as an action, motor or otherwise. The exact way in which all this is brought about is still imperfectly understood. The nerves of the nose have a close relationship to the respiratory center, aside from the fact that inflammation beginning in the nose frequently passes by direct continuity to the lower respiratory region. Irritation begun in the nose has experimentally brought about closure of the glottis, expiratory tetanus, and stoppage of respiration. The same phenomena are caused by irritation of the vagus. The origin of a number of reflex neuroses of the respiratory organs can be explained on the theory that nasal irritations are carried by way of the ganglia to the respiratory center, and then pass along fibers of the spinal accessory and vagus or along the spinal nerves. This is seen in the case of glottis cramp, paroxysmal cough, and bronchial asthma.

Many eye affections, such as blepharospasm, strabismus, anomalies of accommodation, asthenopia, and pupil changes, seem sometimes to be dependent upon nose affections. The reflex tract is by way of the motor root of the facial and oculomotor nerves, and irritation along this tract can cause clonic or tonic action of the muscles. The tear function is affected directly through the lacrymal nerves, branches of which supply the mucous membrane of the nose. On the other hand, Ziem[9] thinks that the relationship of eye diseases to nose affections is brought about chiefly through the blood and lymph tracts, and only seldom through the nerves.

According to Jurasz, these reflexes can be advantageously divided as to their causative significance into three groups:

First, those reflex neuroses in which the sensible irritation originates in the nose and the resultant reflex appears in an organ outside of the nose; in this class are asthma, cough, bronchitis, epilepsy, eye and general nervous and neuralgic disorders.

Second, reflex neuroses in which the sensible irritation is in the nose, and asserts itself as a reflex within the nose itself; under this head are embraced the various forms of nervous catarrh, vasomotor rhinitis, hay fever, hydrorrhea, rose colds, and others.

Third, reflex neuroses that have their sensible irritation in some other organ and are carried reflexly to the nose, producing nervous colds, hyperemia, swelling of the mucous membrane, nose-bleed, erythema, edema, and other anomalies of the outer nose; contained in this last group are those dependent upon digestive disturbances and the class of affections caused by disorders of the sexual apparatus, to which latter the researches of J. N. Mackenzie, Grayson, and others have called attention.

Pathologically, the theory of origin of the first group is one of irritation of the afferent nerves of the nose, which pass over through the ganglion to the efferent vasomotor nerves; and the final effect is produced by changes in the volume of the blood-vessels.

In the second group we have only to do with vasomotor and secretory disturbances in the nose itself, the pathway of communication probably passing through one of the near-by ganglia. The primary irritation comes from the trigeminus or olfactory nerve endings, to be transferred to those nerves which effect changes in the volume of the vessels and in the quantity of the secretions. In these cases the brain and spinal centers are not necessarily concerned, but the circle is made complete with the help of the peripheral ganglia, and the reflex curve is often short.

In the third group the theory of origin is not yet satisfactory. The phenomena appear as the result of the sensible irritation of organs far removed, as the skin in case of colds, the alimentary canal, and the genital apparatus, and consist in changes in circulation and secretion in the nose. The sympathetic system is probably the principal medium of communication between the parts involved.

In such a highly complex mechanism as the nervous apparatus, the localization of the irritation is frequently difficult, especially so as the irritation can be at either end of the chain. In the main, those reflexes which have their point of origin in the nose itself, and which are the most common, are due to direct irritation of the parts, which may be produced in a variety of ways—by simple changes in volume, by touching, rubbing, or pressing them, by active hyperemia, by the direct effect of cold, or by the odor and pollen of flowers. When there is complete closure of the nostril, the reflex is less manifest than when there is variation of volume, irritation being caused at one time and not at another.

The severity of the reflex explosion does not necessarily bear much relation to the degree of apparent irritation, as slight irritants frequently cause considerable reflex irritation; in fact, the most marked reflexes seem to be associated with the least manifest pathological changes. Slight ulceration in the nose has been known to cause considerable cough, scraping of the throat, and inability to sing, and has been entirely relieved by cauterizing the spot with nitrate of silver. Such a case has been reported by M. Schmidt, and somewhat similar ones by others. These cases are more likely to occur in those of highly nervous make-up. The excessive irritability of any single portion of the reflex tract may be due to a local disturbance or may be a partial manifestation of some general neurosis, such as neurasthenia or hysteria.

Heredity does not seem to play any particular part. These cases are more common among the better classes than among the poor, and occur in those of highly nervous organization.

The arthritic diathesis has been regarded by French writers as an important factor, and there are many who regard hay fever as dependent upon this diathesis. While, as regards nasal neuroses in general, the arthritic diathesis may be a predisposing factor, it is certainly not the only one.

These neuroses are rare in children, and are most common between the ages of fifteen and forty. Race has but little influence.

Climate and the season of the year are important factors, and one class of nasal neuroses—hay fever, the term being used here generically—is especially frequent in the summer and autumn seasons. The climatic vagaries of asthma are well known; nearly every asthmatic has his private climate, one asthmatic doing well in a climate in which another does badly, and *vice versa*. The writer has known asthmatic members of the same family, one of whom was relieved by removal to a certain place while another was invariably made worse.

As regards the etiology of asthma, it is probable that many cases are dependent upon a nasal reflex condition, but not all. The pathology and etiology of asthma have not yet been satisfactorily worked out. It seems evident that both local and general factors are concerned in its causation. Asthma is a vasomotor bronchitis, with—in many cases—a cause or an exciting factor in the nose. Certain it is that the correction of nasal pathological conditions relieves and not infrequently cures the disease.

The nervous area of the interior of the nose is extremely sensitive; and any abnormal nasal condition can set up reflexes. The most common of these are hypertrophy of the inferior or middle turbinate, new growths, deviations and spurs of the septum, synechiæ, cicatrices, foreign bodies—that is, any condition which causes increased volume and pressure in some part of the nasal mucous membrane; while in atrophic conditions the nervous sensibility is so far diminished that the reflexes themselves are also greatly diminished and reflex neuroses are rare.

Operative procedures frequently bring about reflex disturbances, such as sneezing and cough, and may even be followed by vertigo, laryngeal spasm, or more serious conditions. The use of the galvanocautery snare has been succeeded by exophthalmos and rapid pulse; such a case has been reported by Semon. F. R. Packard[10] has reported a case of transient monocular blindness of the left side following removal of the anterior end of the left middle turbinate with the cold wire snare. The writer has seen acute insanity follow operation on the nasal septum in a boy of ten. It was evidently due to the pressure of the retaining plugs, and on their removal recovery was prompt.

There seems to be some sympathetic relationship between the erectile portions of the generative tract and the other erectile structures of the body. Ungratified sexual excitement, as well as excesses in coitus or unnatural sexual habits have brought about coryza of reflex origin. In type this closely resembles that of hay fever, and in the absence of a history might be mistaken for it.

Grayson[11] has reported a case in which turbinal engorgement in an engaged young woman was due to excessive demonstration on the part of the young man to whom she was engaged. This brought about ungratified sexual excitation, which was the cause of the nasal engorgement. He cites another case, the patient being a male, in which excessive sexual indulgence had caused nasal obstruction accompanied by marked hypersecretion, sneezing, and headache. All kinds of treatment, local and general, had been tried, the cause not having been suspected. When this was acertained and the habits corrected, the nasal condition promptly got well without further treatment.

Mackenzie[12] gives an account of a somewhat similar case, the patient being a woman, and the cause excessive sexual indulgence on the part of herself and husband. Here the complaint was of asthmatic breathing, with stoppage of the nostrils. Moderation in their marital relations soon brought about a cure.

That there is a physiological connection between the sexual apparatus and the nose is shown by various reciprocal relations between engorgement of the turbinate tissues and menstruation, such engorgement occurring in some women regularly during menstruation. Occasionally in those whose menstruation is irregular there is an engorgement of the nasal erectile tissue corresponding to the regular time of the menstrual epoch. Fliess[13] made investigations, the results of which seemed to show that painful, profuse, or irregular menstruation may in some instances depend upon an intranasal cause. He cites a number of cases to show that the pain of certain forms of dysmenorrhea may be temporarily dissipated by the application of cocaine to the nasal mucous membrane, or permanently controlled by cauterization. The inferior turbinate and the tuberculum septi are the portions of the nose which have a special relation to dysmenorrheic pains. Vicarious menstruation sometimes occurs in the nose. In boys around the age of puberty nose-bleed of apparently sexual origin has not infrequently occurred.

A case of sneezing following tooth extraction in a fifteen-year-old girl has been recorded.

Hypertrophic rhinitis in connection with digestive disturbances is one of the most common of observations; and many catarrhal cases of this class, even with considerable hypertrophy, frequently get well on the correction of the digestive disturbance. It sometimes happens that complete nasal stenosis will follow a full meal. Whether these cases dependent upon digestive disturbances are true reflex neuroses or only parts of a general congestion which is circulatory in origin, may perhaps be a question; since all of the hypertrophic conditions of sudden onset that are dependent upon digestive disturbances might be brought about through a passive congestion or a loss of the normal vasomotor tone.

Nasal Cough.—This can be very severe and paroxysmal. The source of the irritation should be found, and faradism used, vibratory massage, cautery, and such intranasal surgery as may be indicated. It is only from a comprehensive knowledge of all its pathological connections that a reliable differentiation can be made, and the patient is often in extreme anxiety because of consumption. The sound of the cough and a close interrogation of the nasal passages may aid in a diagnosis. If no specific organism can be found in the lungs, and the cough be of a spasmodic character, accompanied or not, by temporary alteration of the voice or the function of respiration, it may be of nasal origin. The different portions of the upper air-tract because of their ultimate connection with the vagi and sympathetic nerves are often the cause of extra pulmonary cough.

Nasal Headache.—Etiology. Diseased middle turbinates, vasomotor rhinitis, polyps, deflectiones, catarrh of the ethmoidal, frontal and maxillary sinuses, bony spurs pressing into the turbinates, deflections pressing into the turbinates, deflections plus spurs and hypertrophies and thickened mucous membranes. Neuralgia of the ethmoidal and frontal nerves—due to pressure on branches of the fifth. Empyema of the frontal or ethmoidal sinuses, closure of these sinuses or mucocele of the same.

The veins passing through the lamina cribrosa give off one large branch to the duramater, turn and again enter the nasal cavities, these becoming engorged, press against the brain substance, and occasion severe pain. Again it is plain that the hindered

flow of lymph and venous blood from the brain is a factor. Vasomotor disturbances of this region or compression of the small nerves in the bony canal of the cribriform plate by the artery or vein will cause these headaches.

Common Symptoms.—Unilateral pain, insomnia, touching of the turbinate causes increased pain in the head, dyspepsia and nausea, patient does not attribute the headache to the nose, acute coryza, nasal catarrh, stooping, coughing, running, etc., aggravates the pain which is often worse in the morning.

Symptomatology.—Patients usually complain of the particular condition that troubles them and not of the disease of the nose which is the cause. Asthma, neuralgia, migraine, nervous disturbances of the eye, voice, and heart, epilepsy, muscle cramp, goiter, spasmodic cough, and the like, can appear without any manifest signs of affection in the nose and yet be of nasal origin. Again, complaints of the nose, as narrowing, anomalies of secretion, itching, pressure or pain, may be so mild as hardly to be noticed, or the patient may not complain of the nose at all. Frequently cases of this sort are not correctly diagnosed until they have lasted a long time, and the diagnosis may then be reached only by the method of exclusion.

In the first group the rhinoscopic findings are swelling, hypertrophy, ulceration, new growths, foreign bodies, septal deviations, abnormal adhesions. These are also the principal objective causative factors in the second group, as these two classes are dependent upon the same general reflex mechanism, and differentiate themselves only through symptoms varying in causation and quality.

The neuroses of the second group have been given an enormous number of names. They can all be described under one head, to which Jurasz has given the simple designation of "nervous head colds." The general term "hay fever" includes them all.

The symptoms of hay fever come on in paroxysms, and in persons apparently well, lasting hours, days, or even weeks, with occasional intermissions. While most frequent in summer or autumn hay fever also occur at other seasons of the year. Here there is a direct irritation affecting the sensory or sensitive nerves of the nose. This irritation may be due to an emanation from plants, as in pollen hay cold, hay fever and hay asthma; to the odor of flowers, such as roses, violets, and others; to the cooking of certain foods; to the odor of various aromatic substances; or to the emanations from various living animals. It is well known that now and then attacks of asthma are brought about by riding behind a horse. These are usually personal idiosynerasies. In 1893 Bishop advanced the theory that the real cause of hay fever was an excess of uric acid in the blood, favored by profuse sweating, and common at the hay-fever period of the year. For the development of the disease specially sensitive nerve centers, hyperesthesia of the sensitive nerves of the nasal mucous membrane, and the presence of irritating agents are necessary. His theories have been accepted by many.

The condition begins by irritation or itching in the nose, followed by sneezing and the discharge of a copious, clear, serous fluid. These symptoms are of all degrees from mild to severe, and the sneezing may be terrific. Bobone has reported a case of unconsciousness and cyanosis as a result of cramp-like sneezing. Fink[14] thinks the large amount of secretion comes from the accessory cavities, the antrum principally, and that the secretory fibers of the trigeminus are the ones affected. The secretion is usually thin, but may be thick; frequently large numbers of handkerchiefs are required. On the other hand, sneezing may be present and the condition be one of hydrorrhea only; or with occasional attacks of sneezing the patient may complain of hindered respiration, stopped-up nose, reddened eyes, swollen conjunctivæ, abundant tears, intolerance to light, itching in neck, cough of an irritating character, pain in head, migraine, trigeminal neuralgia.

In addition to the above there is frequently a laryngitis and a pharyngitis, with cough and sense of oppression in the chest, difficult respiration, and more or less distinctive asthmatic symptoms. Fever is rare.

On inspection the nose conditions are frequently found to be not in accord with the severity of the symptoms. While marked pathological conditions are sometimes present, there may be only redness and swelling; on the other hand, the mucous membrane often appears pale or even anemic.

This group of cases appears most frequently in the summer and autumn seasons; and the principal exciting cause seems to be the presence of the pollen of certain plants, as roses, hay, golden rod, ragweed, and others. There has to be an individual susceptibility, but the pollen is apparently the exciting cause. From June to September is, in the United States, the most susceptible period, and from the 10th to the 31st of August the worst time, as the ragweed, the pollen of which is then in bloom, is the most irritating of all the pollens. Hay fever is apt to continue until the first severe frost at which time the symptoms spontaneously disappear.

In the third group, originating outside of the nose, the symptoms are those of a nervous head cold—swelling of the mucous membrane, stopped-up nose, sneezing, irritation, increased mucous secretion. Vicarious menstruation, abnormal dryness of the mucous membrane of the nose, anosmia, hallucinations of odor, changes of the skin of the nose, redness—all these may be of genital origin. Indigestion may also cause many of the same symptoms.

Diagnosis is not usually difficult in the group in which the whole process is in the nose, but is difficult when the origin is in the nose and the apparent seat of the symptoms is in other organs.

Whenever we have a reflex neurosis which is not clear in its origin, or there is the remotest suspicion of one, the nose should be carefully examined, since doubtless many pathological conditions do come from changes in this organ; but, on finding some trouble in the nose, one cannot be absolutely certain that the cause of the neurosis is found, as the nasal condition may be only an accompaniment and not a cause. Many people have extreme pathological changes in the nose without any accompanying reflex phenomena. The mere presence of a nose affection in the course of a disorder known to be a reflex neurosis will neither prove nor disprove that the nose is the cause of the reflex neurosis. An attempt should be made experimentally to bring about a reflex irritation of the supposed zone of origin. While this is probably accurate as a diagnostic measure, it is not absolutely certain.

Cocaine is one of the most valuable diagnostic remedies, since if under its influence the reflex disappears it is probable that it is of nasal origin. Weak solutions of adrenalin chloride will act in the same manner.

In doubtful cases treat the nasal condition and await results. If a cure is effected, the probability of the diagnosis being correct is very great.

In neurasthenic patients the moral effect of doing something in the nose may bring about relief and cure, even when the real cause is not in the nose at all; hence it will not do to label every neurosis that improves under intranasal treatment as a reflex nasal neurosis, though of course this is probable.

In the third group it is difficult to make the diagnosis, since it is not easy to demonstrate with exactness that a nose affection is the result of a remote pathological process. Here therapy has only slight diagnostic value.

The *prognosis* of all types of nasal neuroses is good after the removal of the cause, but there are apt

to be many relapses. If the affection has lasted a long time, as in asthma, secondary trouble, as emphysema, may be the result.

Therapeutics.—The treatment of the nose must be directed to the condition present. In the first group of cases, correct whatever is abnormal in the nose so far as possible, but do not promise too much. While the results are often brilliant, they may not be. In cases in which pressure is the cause of the reflex, leave the nose as roomy as it is possible to make it. The details of treatment will depend entirely upon the condition present. The moral effect of intranasal surgery is often considerable.

The treatment of hay fever must depend somewhat on the conditions found. Whether the uric-acid theory be correct or not, it is certain that remedies which favor general elimination are of great value. The writer is in the habit of getting the nasal mucous membrane into as good condition as possible before the attack; and during the attack he allows the patient a spray of adrenalin chloride (1 to 16,000) to be used as needed at home, and gives internally a tablet of: Quin. sulph. gr. ss., ammon. chlorid. gr. ss., camphor. gr. ss., opii pulv. gr. $\frac{1}{10}$, ext. acon. gr. $\frac{1}{10}$, ext. bellad. gr. $\frac{1}{10}$; one of these tablets to be taken every two to four hours until dryness of the throat, and then at longer intervals, with such remedies for the general elimination as seem demanded. While this does not cure, it greatly relieves.

For the itching of the eyes ten per cent. solution of argyrol is instilled into the eyes, a drop or two every one or two hours, and from ten to twenty-five per cent. solution applied to the mucous membrane of the nose. The nose is also previously thoroughly sprayed with a weak alkaline solution so as to remove all the irritating pollen. During the attack intranasal surgery or irritative applications to the nose are contraindicated.

Adrenalin chloride has not justified the claims first put out for it as a remedy for hay fever, since following its use in any but the weakest solutions reaction occurs. In very weak solutions, as stated, the author has found it to be of some value.

Dunbar of Hamburg, in 1903, acting on the theory that the pollen dust of certain grasses was the cause of hay fever, succeeded in isolating the poisonous component of the pollens: with this he was able to set up an artificial hay fever. From this pollen he produced through horses an antitoxin which he named pollantin. This is obtainable in liquid and dry form, and also in the form of an ointment. The results from the use of this remedy as compiled from reports given out by manufacturers are—effectual relief 45 to 52 per cent., partial relief 26 to 30 per cent., no relief 8 to 29 per cent., the percentage varying in different years. The serum is introduced into the eyes and nose by means of a pipette once a day, in the morning. The patient is directed to sleep with the windows closed. The powder is introduced by snuffing, the ointment by introducing within the nose, and then massaging the outer nose. The powder and ointment are preferred as being more stable. The liquid is to be used when eye symptoms prevail. It is preferable to begin a few days before the time of the expected attack.

Attempts have also been made[17] to produce immunity by subcutaneous injections of pollen extract, with the results that seem to show that the sensibility of hay-fever patients may be decreased by properly directed dosage, while excessive or too frequent inoculations may increase the sensibility. (See article *Hay Fever.*)

In all conditions of nasal neurosis, in addition to the local measures, treatment should be directed to the general system so as to lessen the nervous irritability.

The bibliography of this subject is so extensive that space cannot be given to it here. The reader desiring to study the subject in detail is referred to the extensive bibliography given in the article by J. N. Mackenzie on the same subject in the first edition of this Handbook; to the article by Dr. Mackenzie on the relations between the nose and sexual apparatus, already referred to; to the article on nasal neuroses in Burnett's "System of the Diseases of the Nose and Throat," by Joseph A. White; and to the very extensive and comprehensive bibliography in the article on nasal neuroses in Heymann's "Handbuch der Laryngologie," by Jurasz, to which article the author desires to express his special obligations in the preparation of the foregoing. GEORGE L. RICHARDS.

REFERENCES.

1. Article Nasal Neuroses, Burnett's System Dis. Nose and Throat.
2. Die Anwendung d. Galvanokaustik u. s. w., Wien, 1871.
3. Zur Aet. u. Ther. d. Asthma bronch. Berl. klin. Wochenschrift, 1874, No. 40.
4. Article in Ziemssen's Cyclopedia, vol. iv.
5. Asthma, etc. Deutsche med. Wochenschrift, 1879.
6. For complete list see Bibliographie nasaler Reflexneurosen, by Jurasz in Heymann's Handbuch d. Laryngologie, Wien, 1900.
7. First edition Reference Handbook, vol. v., p. 224.
8. Etiologie einiger nasaler Reflexneurosen. Archiv für Laryngologie, Bd. vii., p. 303; also Zuckerkandl: Anatomie der Nasenhöhle, Bd. i., p. 101, Pl. x., Fig. 4.
9. Beziehungen zwischen Augen- u. Nasenkrankheiten. Monatsheft für Ohrenheilk., 1893.
10. Phila. Med. Journ., July 16, 1898.
11. Trans. Amer. Med. Asso., 1897, section on Laryngology.
12. Johns Hopkins Bulletin, January, 1893.
13. Quotation from Mackenzie, *l. c.*
14. Deutsche med. Woch., November 14, 1901.
15. Medical News, July 7, 1900.
16. Intranasal Treatment of Dysmenorrhea. Emil Mayer.
17. Medical Annual, 1913, p. 413; 1914, p. 384.

Neuroses, Pharyngeal.—Neuroses of the pharynx consist of disturbances of sensibility, secretion, and motion.

ANESTHESIA OF THE PHARYNX.—This appears as a complete loss of the sensibility of the pharyngeal mucous membrane, or as a diminution of the same, and can be of either central or peripheral origin, lateral or bilateral, complete or partial. When of central origin it is due to hemorrhage, tumors of the brain which cause compression of the vagus and glossopharyngeus nerves, inflammation of the brain, bulbar paralysis, tabes, or lateral sclerosis. It is seen in connection with epilepsy, after influenza, in anemia, hysteria, insanity, and is one of the sequelæ of severe general diseases, as pneumonia and especially diphtheria. Cocaine, eucaine, morphine, chloral, bromide of potassium, carbolic acid, and menthol, when used locally and internally, bring about anesthesia of the pharynx. The reflexes usually fail, and there is occasionally a feeling of general pain, even in the presence of local anesthesia.

The *diagnosis* is made by direct examination. In the case of anesthesia of one side only, one-half will have the natural sensibility, while the affected portion will be insensitive to mechanical, thermal, or chemical irritations. When the anesthesia is complete, the mucous membrane is everywhere affected. When the result of diphtheria, anesthesia is often accompanied with paralysis of the muscles of the larynx and pharynx.

The *prognosis* depends entirely upon the cause, and is sometimes good and sometimes bad.

The *treatment* is based on the cause. Associated with diphtheria, the treatment is that of the general paralysis of diphtheria, and consists of measures to keep up the nutrition of the parts; careful feeding to prevent the introduction of particles of food into the larynx; the use of the constant and induced electrical

current; and internally, general tonics, such as iron, quinine, strychnine, etc.

Hyperesthesia of the Pharynx.—By this term is understood an increased sensibility due to central or peripheral irritations, such as accompany a large proportion of all cases of acute and chronic pharyngeal inflammation. An extreme sensitiveness of the pharyngeal mucous membrane is brought about, which is described as pain, or is evident in the form of coughing, choking, retching, vomiting, and explosive belching of gases from the stomach.

Hyperesthesia of the pharynx is a common manifestation, frequently seen when an attempt is made at a laryngoscopic or rhinoscopic examination. It is often extreme, many persons retching, gagging, and almost vomiting whenever any instrument is brought near to the pharynx. Even the opening of the mouth and the drawing out of the tongue may elicit the strongest reflexes before the instrument has touched any part of the pharyngeal wall. It is usually bilateral, is common in persons apparently absolutely sound, but more so in those who are very fat, in drinkers, smokers, and nervous persons. Local diseases, hyperemia, acute or chronic catarrh, general hyperesthesia, and increased general nervous sensibility intensify all the manifestations.

While it is a condition difficult to cure by any method of treatment, most persons after a while become used to manipulations in this region, and the treatment of the pathological condition present usually diminishes the sensibility.

Treatment consists in the local use of ice, menthol, chloral, bromide of potassium, various gargles, tannin, alum, and adrenalin, and in the avoidance of alcohol and tobacco.

Paresthesia.—Under this term are included various abnormal sensations, which are described as burning, pressure, itching, dryness, abrasions, lumps, or a sensation as of the presence of a foreign body in the pharynx. Among the foreign bodies complained of are pieces of bone, hairs, toothbrush bristles, needles, pieces of bread, cotton, portions of feathers—in fact, any substance that could possibly stick in the throat. Originally something may have lodged there, but as a rule it has been removed by retching or coughing before the physician was called. Hysterical and nervous persons of both sexes frequently complain of a lump in the throat (globus hystericus), of a burning pain, or of a feeling of icy coldness during the breathing. One must always be certain before making a diagnosis of paresthesia, that no foreign body is present.

Another one of the common forms of paresthesia is the belief that there is a carcinoma in the throat, the circumvallate papillæ having been felt by the finger; and it is often extremely difficult to rid the mind of the individual of the idea that a new growth is present.

A feeling of extreme dryness, without material objective change, is frequent in mouth-breathers; in chlorosis, anemia, and diabetes; and in users of morphine, atropine, or belladonna.

Paresthesia is a more or less constant accompaniment of the chronic pharyngeal catarrhs. It is found in connection with tonsillar affections and with the various pathological changes of the nose and nasopharynx. Inflammations of the interarytenoid region, neuralgia of the superior laryngeal nerve, and affections of the central nervous system are also causative. It can occur as a reflex condition accompanying anemia, chlorosis, hysteria, uterine and ovarian diseases, early phthisis, and hypochondriasis in the male and the climacteric in the female.

The *diagnosis* is dependent upon a careful examination of the entire pharynx, which must include the nasopharynx, tonsils and larynx as well, so that no possible source of irritation, direct or remote, shall be overlooked. The patient will usually tell whenever a painful area is touched with the probe. Sometimes there are several of these points, which disappear upon painting the area with ten per cent. cocaine. The course is very chronic.

Treatment must depend entirely upon the cause. So far as anything local can be found, appropriate treatment is to be given; while for general nervousness and hysteria the treatment appropriate to this condition must be applied; such as tonics, iron, quinine and strychnine, cod-liver oil, and sedatives. In neurotics as little attention should be paid to the local treatment as possible to avoid attention to the pharynx.

Secretory Neurosis.—Hypersecretion of the pharynx is a condition which not infrequently occurs, especially in singers. Individuals with apparently completely normal mucous membranes complain of an increased secretion of slimy mucus in the pharynx, nasopharynx, or larynx, making it necessary to swallow very often, and to spit a great deal when talking, the swallowed secretion being frequently vomited early in the morning. Examination shows more or less of this mucus on the back of the pharyngeal wall and around the velum palati. This condition is sometimes observed in old people. Its cause seems to be some disturbance in the nervous control of the secretory glands.

Treatment is only partially successful. The condition sometimes disappears of itself, but is liable to return. Belladonna is the most efficient simple remedy. The dosage must be carefully guarded. Only enough is given to bring about a sensation of dryness in the throat. It is then discontinued. Small doses of iodide of potassium or the syrup of hydriodic acid frequently do good by increasing somewhat the secretion of the glands, so that the slimy mucus is less thick and therefore less complained of.

There is also a condition of nervous lessening of secretion, with a feeling of great dryness, seen in connection with hysteria or the use of morphine or belladonna, and found in sufferers from diabetes.

Neuroses of Mobility.—Cramp-like spasm of the constrictors occurs occasionally, most frequently in persons suffering from dyspepsia or some stomach affection; in general functional neurosis; occasionally in granular pharyngitis, hypertrophy of the side walls, and in connection with inflammatory processes at the base of the tongue. Cramp-like constriction of the muscles, interfering with swallowing, is found in connection with diseases of the brain, and is an accompaniment of tabes. It is most commonly seen as a tonic cramp in hysterical dysphagia. The muscles of the esophagus are affected at the same time. In cramp of the muscles of swallowing, the passage downward of the mass of food is more or less interfered with. In hysterical dysphagia the swallowed mass is temporarily arrested at some point, usually with a sense of pressure and pain in the neck and around the sternum, then without further hindrance it passes into the stomach, or else with a feeling of suffocation, choking, and explosion of gases from the stomach it is vomited. The swallowing of solid substances may be impossible for days or weeks.

Cramp of the muscles of the soft palate occurs comparatively seldom. When of a tonic nature the velum is in close contact with the posterior pharyngeal wall resulting in an altered tone and impossibility of breathing through the nose. The cramp may be of a clonic nature, affecting only single muscles of the velum, as the levator or tensor or the azygos uvulæ. The causes are very various, consisting of true alterations in the nerve supply, central and peripheral irritations, and pathological processes in the immediate neighborhood.

The *diagnosis* of the various forms of cramp-like action of the muscles is not always easy, since hysterical dysphagia can simulate many affections. It can be differentiated from true paralysis of the muscles of the pharynx by its intermittence, as the phenomenon is not constant. The use of the probe, careful observation of the patient, and the study of all the possible causes will usually enable one to make a diagnosis.

Prognosis depends entirely upon the pathology, as does also the *treatment;* change of location, rest, diet, and faradic current to the back of the neck have seemed to be of some benefit.

Paralyses of the Pharynx.—These are mostly of central origin. Acute and chronic inflammation of the brain; tumors; hemorrhages which bring about compression of the vagus, accessorius, and glossopharyngeus nerves and their branches; as well as degenerative processes of the brain and medulla, such as bulbar paralysis, tabes, progressive muscular atrophy, and facial paralysis; lead intoxication; phthisis; grippe; pressure of carcinomatous glands upon the vagus and its branches—all these may have muscular disturbances of the pharynx as their sequelæ. Of the peripheral causes diphtheria and scarlet fever, and streptococcic infection are the most frequent. Syphilis and general neuritis are also causative.

Paralyses of sensation and of motion often occur together. Paralysis of the soft palate is the most frequent, and may be one-sided or double-sided, complete or incomplete. When it is one-sided, the palate is drawn sometimes toward the sound and sometimes toward the diseased side. The arch of the paralyzed side is deeper, while on the sound side the arch is higher and narrower. During phonation the velum comes toward the sound side. When the uvula alone is paralyzed, which is a frequent condition in pharynx or larynx catarrh and in paralysis of the vocal cords, it goes toward the sound side. In double paralysis of the velum, it hangs with the uvula straight down and shows no sign of active movement except in respiration, when the uvula moves slightly backward and forward; during phonation there is a slight attempt for it to reach the posterior wall. The voice has a very nasal tone. There is seldom difficulty in swallowing.

Paralysis of the constrictors of the pharynx, with or without accompanying paralysis of the velum and of the esophagus, is most frequent in connection with diphtheria, scarlet fever, the other infections diseases and in bulbar paralysis. When the paralysis is limited to the constrictors, particles of food lodge at the base of the tongue and in the adjacent sinuses, and fluids pass easily into the larynx, producing intense cough and suffocation. If the superior constrictor alone is paralyzed, the particles of food may be thrown into the nose.

The *diagnosis* of paralysis of the muscles of the pharynx is very easy, but the condition is often overlooked, especially when the paralysis is incomplete. The incomplete paralysis often suggests adenoid vegetations or polypi in the nose. When brought about through inflammatory or mechanical causes there are redness, swelling, edema, ulcers, and cicatrices. The cause of the paralysis is often difficult to find.

In central paralysis the electromotor excitability is normal and can remain so. In complete peripheral paralysis the electromotor excitability very rapidly diminishes and can be lost by the third week.

Hysterical paralysis begins suddenly, disappears suddenly, and comes again without apparent cause.

The *prognosis* and the treatment must depend entirely upon the cause. Prognosis is not good when the condition is of central origin, but good when of diphtheritic, rheumatic, infectious, or of local inflammatory origin.

Treatment.—Electricity is the best remedy. The faradic current can be used to advantage, although the galvanic current is preferable. When the paralysis has lasted any length of time both are indicated, as the faradic current helps maintain the nutrition of the muscle while the galvanic directly stimulates the nerve. When electricity is used one electrode should be placed on the cervical vertebræ or the anterior surface of the neck, the other on the pharyngeal wall against the paralyzed muscle. The pharyngeal electrode should be one in which the current can be turned off and on. General tonics internally, and remedies which promote the general nutrition both of the local part and of the general constitution are to be used in addition to the electricity. If the etiology can be traced to specific causes potassium iodide is valuable. The patient should be advised to consult a neurologist, as this condition is often a symptom of general paralysis.

George L. Richards.

Neuroses, Occupational and Professional.—Definition.—This title includes a large group of neuromuscular disorders having origin in protracted overuse, strain, or repeated shock of nerves and muscles, due to special occupations. These occupations, for the most part, require skill and intelligence and imply concentration of energy and attention, although they sometimes concern unskilled labor. Typical among them are such neuroses as writer's cramp, telegrapher's cramp, etc., but the increasing use of complicated machinery as well as the stress under which much modern work is done has developed many varieties. Thus typewriters, stenographers, pianists, violinists, drummers, auctioneers, machinists, lathers, carpenters, cigarmakers, tailors, pressers and ironers, stone and floor polishers, cobblers, masons, sewing-machine workers, milkers, and a great variety of other employees may acquire neuroses. In short an occupational or professional neurosis may arise at any time from repeated contractions of particular groups of muscles, repeated pressure upon them, as in grasping and pushing a tool, ironing, etc., repeated shock and vibrations, as in hammering, repeated pulling and stretching motions as those made by cobblers or seamstresses in sewing with coarse threads, repeated and limited finer movements of coordination such as are made in violin playing, stenography, etc., repeated grasping and pulling, as in milking, etc.

Etiology.—The neuroses manifest themselves through pains in the overused nerves, cramps in the muscles concerned, neuritis, muscular atrophy, and acroparesthesia. These symptoms may be combined in varying degree. The pains and cramps may be experienced not only during exercise of the affected groups of muscles but subsequently during periods of rest, and may become so severe as to compel permanent abandonment of the particular work which caused them. About ninety per cent. of all cases involve the nerves and muscles of the hand and arm. Neuroses may arise, however, in other nerves, as for example, the musculospiral, circumflex, and long thoracic from carrying heavy weights on the shoulders, or spasm may occur in muscles of the face, as in players on wind instruments. Working the pedals of machines, gongs, etc., may occasion neuroses in the legs, as also may "squatting" positions as assumed by tailors, mosaic layers, or gardeners in weeding. In the latter group of cases the perineal nerve may be compressed against the head of the fibula. Dr. Latta has reported a number of cases of sciatic pain in the right leg, occurring in locomotive engineers who sat sidewise upon a bench, the weight of the body resting upon the right hip while constantly jarred by the vibrations of the engine.

Symptoms.—Usually the symptoms of an occupational neurosis begin with increasing fatigue after

use of the group of muscles involved. Soon neuralgic pain ensues which is at first relieved by rest and then becomes constant, or is excited by such short periods of work that the employee is forced to abandon it. Tender points appear along the course of the nerve involved and there may be sensations as of numbness or prickling. In many cases severe muscle cramp appears, for example, whenever a tool or instrument is grasped, making it impossible to guide it. In some cases cramp and paresthesia may be more complained of than pain. Vasomotor disturbances such as redness and swelling may develop. In protracted cases there is considerable weakness with atrophy of the muscles affected. In such cases also such further symptoms may arise as dyspepsia, a rapid pulse, insomnia, and irritability. The various occupational muscular cramps are usually of central origin, but symptomatic cramps may occur with neuralgias or neuritis.

Special Neuroses.—"*Writer's cramp*" or "scrivener's palsy," untrue to its name, is not a true cramp, being frequently painless, nor a palsy, being without complete loss of muscular power. It is, however, a spasmodic disorder of the groups of muscles employed in writing, induced by long-continued overwork of the muscles, especially where the same words or figures are often repeated, as in signing a long series of documents. It is therefore excited by volition, and is favored by a cramped position in writing or in holding the pen, and by using a hard fine pen which requires pressure and minute guidance. Contributing factors are general strain or worry, but the condition is not uncommon in perfectly healthy persons. C. L. Dana states that "it is a neurosis having no appreciable anatomical basis," and argues that in this type of spasm the spinal group of cells concerned become exhausted and "the impulse which naturally would innervate them, strikes cells which respond unequally, or it overflows to other cell groups, hence the spasmodic irregular movements." The cortical centers or basal ganglia are doubtless similarly exhausted at times.

The symptoms vary in intensity and grouping. They comprise incoordination, and tonic spasm on attempting to write, or even to hold the pen. Anesthesia and vasomotor disorders may be present and there is always an exaggerated sense of fatigue after using the muscles. The pronator and supinator muscles of the wrist are sometimes involved. On grasping the pen the fingers tend to separate in rigid spasm. Paresis of the muscles is rare. The fingers may become hyperemic and slightly swollen. Tremor is sometimes present and pain may extend up the arm.

To relieve the symptoms the patient sometimes changes the fingers used to hold the pen, or may learn to write with the opposite hand. Prevention involves using a soft broad-nibbed pen, and a cork or rubber-tipped holder or one of the large bulbous holders especially designed. Correct posture and good light in writing with frequent intervals of rest are most desirable.

Telegrapher's and typewriter's cramps originate in the same manner with writer's cramp. The telegrapher's cramp is more liable to involve the extensors than the flexors of the fingers, but the flexors of the wrist are affected, and sometimes the forearm muscles. Fulton estimates that a rapid operator may make 30,000 to 40,000 muscular movements per hour. The spasm begins slowly at first interfering only with certain code letters, but the spasm finally draws the fingers from the keys and the wrists from the table. Pain is usually absent in telegrapher's cramp, but in typewriters pain and spasm occur in the fore and middle fingers of both hands.

Milker's spasm may involve the flexors of both hands and fingers. One of the writer's patients was a farmer who had been milking fifteen or eighteen cows before breakfast on cold mornings. He was obliged to abandon the work altogether.

An unusual case of spasm was reported to the writer by Dr. Thro. A woman employed in fastening bands inside of hats acquired the habit of rotating the head to follow turning of the hats until she acquired a fatigue spasm of the muscles used in rotating the head. A similar case with torticollis, reported by Annandale, was in a girl weaver who rotated the head to follow the motion of the shuttle.

Prophylaxis.—The neuroses of occupation may be avoided by such measures as changing the position of the body, changing the balance of pressure exerted, from one muscle group to another, by brief periods of rest from the particular work in which the muscles are employed, and by massage, douching with hot and cold water, etc.

Treatment.—Rest is the first criterion. This at first should be complete as regards the particular group of muscles involved, which in serious cases should be supported and protected by a splint and bandage. If there is much pain in the following anodyne liniment is effective.

℞. Chloral and menthol . . . . . ää ʒi.
Alcohol and aquæ camphoræ. . . . . ää ʒii.

The linimentum saponis, belladonnæ, or camphoræ is also serviceable. The act of rubbing in the liniment serves as a mild massage, which is helpful. Later more vigorous massage, douching with alternate hot and cold water, and galvanism may be employed to stimulate the local circulation. There is nothing to be gained from drug treatment, but the patient's general health should be built up if need be, and the psychic element in the case should receive attention as the patient is liable to become discouraged and a neurosis may become a psychosis.

W. Gilman Thompson.

Neuroses, Sexual.—Masturbation.—Masturbation or onanism is the production of the sexual orgasm by manipulation of the genitals by the hand, by friction of the thighs, by the use of various implements, or by the imagination.

Etiology.—Any local pathological condition of the genitals may be the starting point of masturbation. Among the more common conditions may be mentioned intertriginous processes; retained smegma; long, tight or adherent prepuce; worms; vaginitis; highly acid urine, etc. In older children, gymnastic exercises in which the legs are frequently rubbed together; spanking; too warm feather beds; the reading of erotic literature and the seeing of suggestive plays are often the etiological factors. Unscrupulous nurses may employ masturbation to quiet noisy infants, and older children often are taught the habit from school companions. Married women often employ masturbation, when they are left sexually unsatisfied on account of impotence or withdrawal on the part of the husband.

Pathology.—In infants and young children, as a rule, there is simply the local condition of irritation present, and if this is removed the habit may be easily stopped. There are some very precocious cases, however, that develop so rapidly as to cause, even at this early age, the same local and central irritation which will be presently described as found in the confirmed adult masturbator.

In the adult male, the pathology is as follows: At the beginning, the child manipulates his penis (due to any one of the etiological causes); this act sends an impulse to his brain, which sends another impulse to his muscles of erection, and also causes a hyperemia

of his prostatic urethra. So far the condition is like normal coitus. But this act frequently repeated leads to a congestion and hyperesthesia of the prostatic urethra, so that impulses are constantly sent from thence to the brain, which again in response sends impulses to the prostatic urethra, still further increasing its hyperesthesia. A vicious circle is thus formed. In other words, there is in time formed such an irritation in the prostatic urethra that the patient is compelled to masturbate, just as he would be compelled to scratch an irritation on the skin.

In the adult female, the pathology is similar, except that the irritation is in the external genitals. If the habit has been persisted in for a long time, from the purely mechanical effects of the continued manipulation of the parts, they remain hypersensitive even after the original cause has been removed. In fact, they become more sensitive than the mucous membrane of the vagina; and so, if these patients marry, the stimulation of the latter organ by ordinary coitus is not sufficient to excite the sexual centers sufficiently and orgasm does not occur without the aid of masturbation.

In married women, the pathology is somewhat different. To understand it thoroughly, it will be necessary to describe briefly the physiology of normal coitus in the female. At the commencement and during coitus, there is a general hyperemia of all the pelvic organs. In a normal coitus with fully developed orgasm, and the expulsion of the secretions from the genital glands, a deplethorization occurs, and the pelvic organs are left in their natural condition.

If, however, the act is interrupted by withdrawal or rapid ejaculation on the part of the husband, the orgasm in the female either does not occur at all, or takes place incompletely. The sexual glands do not completely empty themselves, the pelvic organs remain hyperemic, the woman remains in a state of unsatisfied sexual excitement, and easily gets into the habit of masturbating to complete the orgasm.

In psychic masturbation, the pathology is as follows: Either as a result of previous or recent experience, an impulse is sent from the higher parts of the brain to the sexual centers. These in turn send impulses to the genitals just as in normal coitus or ordinary masturbation. If this is frequently repeated, the sexual centers themselves become hyperirritated, because they have not had a chance to return to physiological rest. Following this hyperirritability, we get more or less exhaustion of the centers, and it takes stronger and stronger mental images to arouse them into activity. The nervous drain upon the higher centers can easily be imagined.

Symptoms.—The *local symptoms* in children consist simply of redness and sometimes a slight swelling of the prepuce in the male, and of the vulva in the female. Sometimes a slight vaginitis is present. In the adult female, a marked hypertrophy of the labia minora is almost pathognomonic of masturbation. They are dark-colored, often pigmented and parchment like, while their base may be red and swollen. There is often intense redness and spots of excoriation near the vaginal entrance, and sometimes we find a mucopurulent secretion bathing the external genitals. If the urethra has been used for purposes of masturbation, we will find signs of irritation within the meatus. As a general rule, in the unmarried, the hymen will be found intact. In the adult male, we find a marked hyperesthesia of the entire urethra, but especially of the prostatic portion. The prostate is often enlarged but always hypersensitive.

The *general symptoms* in very young children are sometimes hard to recognize. In older children, however, they are quite characteristic. These children are generally more bashful, more retired, more dreamy and more easily embarrassed than normal children. They do not play with other children and frequently avoid their society. They complain of headaches, are easily fatigued, and are generally anemic and run down. Some pediatricians claim to have noticed cases of functional heart disease due to masturbation. In the confirmed adult male masturbator, the general symptoms are at times very severe. They are often those of cerebral exhaustion, to wit, delayed or at times incoherent associations, difficulty in recalling names of things, inability to express themselves as well as before, frequent loss of the thread of thought, and incapability of continued effort. Loss of memory is often complained of, but upon careful examination it will be found not to exist. Among the other more common symptoms complained of may be mentioned pain or weakness in the muscles of the thigh and legs, pains in the eyes, headache and dizziness. Psychic masturbation is very common. In the adult female, the general symptoms are similar though not nearly as severe as in the adult male. Indeed, it is not uncommon for females to have practiced masturbation for years without any ill effect whatsoever. Morbid blushing is a very common symptom, and backache is frequently complained of. If a female had practiced masturbation for many years before marriage, she often gets little pleasure from coitus and prefers masturbation to it. The reason for this has been given above.

Diagnosis.—The main point is to think of the possibility of the habit, in the presence of otherwise inexplicable nervous symptoms. Mothers and teachers should be instructed to watch out for it. In young children the local conditions very often tell the tale. It must be remembered that in the female the sexual sense is more highly developed in the urethra than in any other portion of the genitals, and this portion of the anatomy should be scrutinized carefully especially in married women where gynecological examination is justifiable. In practically every case where a foreign body has been introduced into the female bladder from without, masturbation was the cause.

Course and Prognosis.—In children, as well as in adults, the earlier the habit is discovered and attended to, the easier it is to cure. This is especially true in children, before the pathological congestion and vicious circle found in the adult has been formed. In many cases the children themselves notice the evil consequences of the habit, and stop it voluntarily without any special treatment whatsoever. But even cases of very long duration can be cured. While under its baneful influence, the entire psychic and physical condition of the child suffers. He can attend to his lessons, but does so under a greater amount of nervous tension and energy.

The confirmed adult male masturbator cannot generally stop the habit without treatment. He continues in the habit year after year. The number of times he masturbates varies greatly, and it is sometimes astonishing to hear how many times a day and for how long a period he can keep it up. But after a while he comes to that stage (if untreated) where he masturbates, not because he likes to, but because he *has* to. He has that awful irritation in his deep urethra, and he simply *must* masturbate. The periods of previous excitement (pleasure) become less and less, as does also the amount of fluid ejaculated. Then there comes a time when he *cannot* masturbate. He has the irritation, he has the impulse to masturbate, but no matter how he manipulates his penis or how he excites his brain, he can obtain neither an erection nor an ejaculation. He is indeed in a most wretched condition. The results of treatment, even in these severe cases, however, are excellent. Between the first and second treatments, he may experience the desire to masturbate, but is able to resist the desire. Already after the second treatment, he does not even experience the desire for masturbating. The psychic

form continues somewhat longer, but also finally yields to treatment. But of even more importance than the genital effect of the treatment is the effect on the character of the patient himself. His whole character changes. He now finds delight in the society of women. From a morose, underfed, ill-natured man, he is often transformed into a jolly, good-natured fellow, full of the spirit of life.

In the adult female, the course of the disease is generally not so severe (even if untreated) as in the male. This is especially true in the case of married women, who start the habit some time after marriage, after several years of normal coitus, as a result of either withdrawal or impotence of the husband. In these cases, there is often no bad result from the habit.

Treatment.—The first thing to do is to remove any of the conditions mentioned under etiology. The patients should also avoid tea, coffee, eggs, and alcoholics. In young children this alone may cure the habit. Spanking is especially to be avoided, as in some children it arouses erotic impressions. Older children should be spoken to in very plain but tactful language and their sense of manhood be appealed to. The object of treatment is to direct the child's interest into other and more natural channels.

Constant watching, as a method of treatment, is not only useless but harmful. In the first place, the methods employed by the masturbator are so numerous, and the opportunities for committing the act so easy, that no matter how careful the watching, it will be of no avail. In the second place, the method keeps the boy's mind continually reminded of his genitals.

Except in very unusual cases, I do not recommend restraining apparatus. In the first place, it also concentrates the child's mind on his genitals, and in the second place, it often stimulates the child's inventive genius to substitute one form of masturbation for another. Thus children who have used their hands for masturbating, and have them tied, will often discover methods in which the hands can be dispensed with, such as pillow masturbation, thigh friction, etc. It may even be the starting point for psychic masturbation.

In the confirmed adult male masturbator, the most important thing to be done, besides the general treatment just outlined, is to treat the congested condition in the urethra so as to break up the vicious circle. This is accomplished by *gently* massaging his prostate and making deep urethral instillations of silver nitrate solution with the Bangs sound syringe. The treatments are at first given every fifth day, and later at longer intervals depending upon the sensitiveness of the urethra and the reaction to the treatment. We start with a small sized sound and a 1–3000 silver nitrate solution, and gradually use larger sounds and stronger solutions, but not stronger than 1–500.

In the adult female, besides removing the underlying cause, and improving the general health, we must try to substitute any out-door hobby, or even hard work, so as to keep the mind engaged, and directed in other channels. We must especially try to develop her will power, and talk to her, not in vain hints, but in plain tactful language. Long marriage engagements should be discouraged. Marriage should never be advised merely as a cure for masturbation. Operations on the genitals are also inadvisable, unless some other distinct indication, aside from the masturbation, presents itself. In bad cases we may administer bromides, but for a short while only.

Where impotence of the husband or withdrawal has been the cause, the treatment of the husband and his instruction in sexual matters should be employed.

Impotence in the Male.—*Definition.*—Impotence in the male is that condition in which the man is unable to perform the sexual act. It must be strictly differentiated from sterility, in which condition there is impossibility of impregnating the female. The sterile man is not necessarily impotent, while it is possible for a partially impotent man to impregnate his wife. Impotence may be classified as organic, functional, or psychic.

Organic impotence is that condition in which the impotence is due to some anatomical defect in the sexual organs.

Etiology and Pathology.—Any condition which causes a lack of development or atrophy or destruction of any portion of the sexual apparatus may cause impotence. Among such conditions may be mentioned atrophy or destruction of both testicles before puberty due to mumps or traumatism; lack of development or destruction of the penis; spinal syphilis, tabes, or injuries to the spinal cord or cerebrum; injuries to the urethra and cicatricial contractions of the penile tissues as well as plastic exudates in the penile tissues and shortness of the frenum. Among rarer conditions may be mentioned horny growths, elephantiasis, ossification and fracture of penis. In some cases, however, it is remarkable how much of the penis may be destroyed, and also how rudimentary this organ may be without causing impotence. Enormous hydrocele, large scrotal hernia, and elephantiasis of the scrotum sometimes interfere with intromission. Excessive horseback riding may also cause impotence.

The chief *symptom* is the impotence itself. In many cases partial erection can take place, and in some cases erection can occur but is accompanied by severe pain. The same nervous and psychic symptoms may accompany organic impotence as will be later described as common to functional impotence.

Treatment.—This consists in removal of the impediment. A rudimentary penis may sometimes be developed by giving the patient artificial apparatus with which he may accomplish coitus. Later he can cohabit without its use.

Functional impotence is that form in which there exists no *gross* pathological change in the structure of the sexual apparatus, but in which the mechanism of copulation is disturbed through an interference with the function of the sexual centers or the nerves and peripheral end-organs.

Etiology and Pathology.—The normal act of coitus consists in the harmonious relationship of the libido, erection, ejaculation and orgasm. The absence or disturbed relationship of any of these factors constitutes impotence, either partial or complete. Moreover, not only must the normal sequence of events occur, but also the relative time for each factor must be observed for normal coitus. Thus, if ejaculation comes before complete erection, or long after erection has subsided, or if the erection does not last long enough, or if the whole process of coitus goes too quickly, impotence may be said to exist.

For a clear understanding of the pathology of impotence, it will be necessary to give a brief description of the physiology of normal coitus. This will be considered under two heads, first, the mechanism and sequence of events as they take place in the end-organs, and secondly, the sequence of events in the sexual centers and nerves.

1. Mechanism of Coitus in the End-organs.—As soon as the libido is aroused, an impulse is sent to the erection center in the cord. This center, now aroused, sends impulses to the penis which cause a dilatation of its arteries, and a relaxation of its musculature, thus forming large trabecular spaces, which become engorged with blood. The muscles surrounding the penis are thrown into contraction, thus compressing the veins, and so adding to the engorgement of the penis. As soon as the organ becomes rigid, the action of its suspensory ligament aided by the erector penis and the accelerator urinæ muscles causes it to become elevated. Finally all the perineal muscles

come into play to complete the erection, and now the organ is hard and tense. The mucous glands of the urethra pour into the urethra an alkaline secretion to neutralize any acid urine which may have been left therein, and which would be inimical to the vitality of the spermatozoa.

As coitus proceeds, the contents of the seminal vesicles are squeezed by muscular action into the ejaculatory ducts, the muscles of the prostate squeeze out its secretions, and at the height of the orgasm, the contents of the seminal vesicles mixed with the spermatozoa which have just been extruded from the testicles are pushed through the ejaculatory ducts into the posterior urethra, where they mix with the prostatic secretion, and the entire product, the semen, is driven from the bulbous urethra through the penis by the contraction of the entire perineal group of muscles.

2. Nervous Mechanism of Coitus.—In the following description, I have closely followed that of Groag[1] as being of especial clearness.

We may represent the various conditions diagrammatically as follows (Fig. 4139). From *C* (cerebrum, *i.e.* libido) impulses are sent to *R* (erection center) which sends them to the dilator nerves until complete erection results. Now *R* receives from *P* (glans penis during friction) continuous new impulses which serve to strengthen and keep up the erection. Besides sending the receiving impulses to the dilator nerves, *R* has also the function of keeping back a part of the impulses it receives until its cells are filled to their utmost tension, and then only to send them to the ejaculation centers E_1 and E_2. As soon as *R* is so filled up with impulses from *C*, *P* and *V* that they overflow to E_1 and E_2, ejaculation occurs.

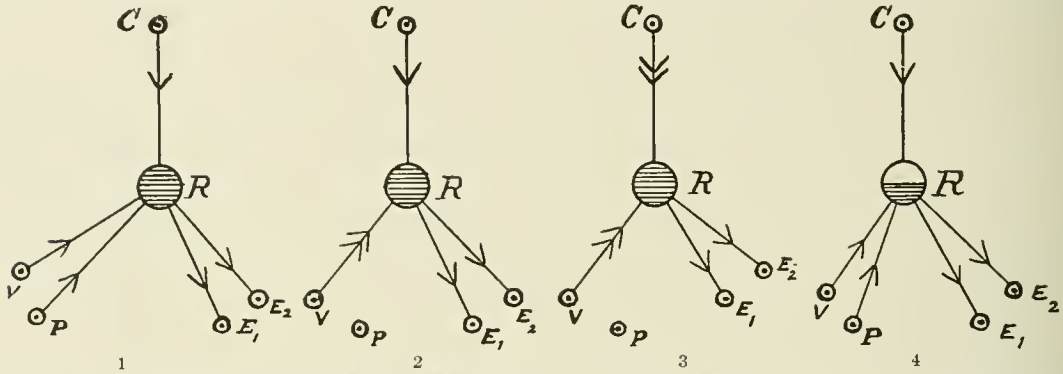


Fig. 4139.—Diagrammatic Scheme of the Nervous Mechanism of Coitus, Impotence and Pollutions. (After Groag.)—*C*, cerebrum; *R*, erection center; E_1, sympathetic ejaculation center (which causes the expulsion of the secretions of the sexual glands); E_2, spinal ejaculation center (which controls the striated muscular fibers); *P*, glans penis; *V*, seminal vesicles. The single arrow indicates an ordinary impulse; the double arrow, a very strong impulse. The transverse lines in *R*, in 1, 2 and 3, indicate that *R* sends out impulses to E_1 and E_2 only after having been completely filled up with impulses, while in 4 we see that *R* sends them out before it is completely filled up.

We may now briefly describe the nervous mechanism of normal coitus as well as the pathology of impotence according to the above scheme. The seat of the libido is in the cerebrum and it may be aroused in various ways. Once aroused, an impulse is sent from the cerebrum (*C*) to the erection center (*R*) in the lumbar enlargement of the spinal cord. This center sends impulses through the dilator nerves to the penis, which causes engorgement and erection as previously described. As the penis enters the vagina, the friction of the glans penis (*P*) sends additional impulses to the erection center. The erection center is also getting impulses from the distended seminal vesicles (*V*). The erection center has two functions, first, to receive impulses from the cerebrum, penis, and seminal vesicles and, secondly, to hold back these impulses till the proper time and then send them to the ejaculation centers, so that ejaculation should come at the proper time and not too soon. We will now take up some of the etiological factors and show how they cause impotence. We will discuss withdrawal, masturbation, gonorrhea, and ungratified sexual excitement.

Pathology of Withdrawal.—During normal coitus there occurs a normal working hyperemia of the erection center (*R*) as well as in the end-organs. With ejaculation the hyperemia of the erection center as well as in the end-organs disappears. There now ensues a period of rest for several days, and the sexual centers as well as the end-organs have plenty of time to recuperate.

If the act of coitus is interrupted by withdrawal, however, ejaculation is incomplete, and therefore the erection center is not thoroughly deplethorized, and remains more or less hyperemic. The same holds good in the end-organs until finally a condition of chronic congestion of these parts (mainly the prostatic urethra) occurs. The seminal vesicles do not empty themselves as well as in normal coitus, and therefore become earlier distended, and the desire for coitus is sooner experienced. As a result of the more frequent indulgence in coitus due to the increased desire, the sexual centers do not obtain the necessary rest for recuperation. Moreover, the chronic congestion in the end-organs, as well as the more frequent condition of distention of the seminal vesicles has the effect of continuously bombarding the erection center with impulses even in the absence of coitus. The erection center thus becomes at first hyperirritable and later exhausted. While in a state of hyperirritability, the slightest impulse it receives from any of its sources, at the very commencement of coitus, causes it to respond so rapidly that it *at once* sends the impulse to the ejaculation centers, and ejaculation takes place at once, just as the penis has entered the vagina (rapid ejaculation) and later on even before the penis has entered (premature ejaculation). In other words, the center has lost its power to hold back its receiving impulses till the proper time as in normal coitus (see Fig. 4139, 4). Finally the center becomes completely exhausted, and refuses to send out any impulses at all (it cannot respond to any stimulation) and we thus get, as a final stage of impotence, not only no ejaculation but also no erection.

Pathology of Impotence Following Masturbation.—A confirmed untreated masturbator sometimes marries with the idea of curing his masturbation, and finds himself impotent. The pathology is similar to withdrawal, except there are lacking the impulses from distended seminal vesicles, for the masturbator does not give his vesicles a chance to become distended. The chief cause of the exhaustion of the erection center comes from the extreme congestion of the prostatic

urethra which has been bombarding the center with impulses for years. In the psychic form the sexual centers have been so dulled, that it is only the most vivid pictures which the imagination can conjure up that can arouse them to action, and the ordinary acts of coitus are not sufficiently powerful to arouse either the desire or the ability for coitus.

Pathology of Impotence following Gonorrhea.—After severe, and especially ill-treated gonorrhea, there often remain pathological conditions in the posterior urethra, especially in the region of the verumontanum, such as erosions, ulcerations, granulations, vegetations and areas of congestion. The prostate and seminal vesicles may be filled with purulent material. Irritability and exhaustion of the erection center results from the reflex irritation caused by these local conditions.

Pathology of Impotence following Ungratified Sexual Excitement.—This is the temporary impotence of long marriage engagements, in which the man spoons with his girl for hours at a time several nights a week, and keeps this up for months or years. We finally get a chronic congestion of the prostatic urethra just as in masturbation, but in addition there is present an almost constant condition of distended seminal vesicles unless relieved by an occasional pollution. The center becomes exhausted just as in the previous conditions. See Fig. 4139.

In addition to the above we must mention a group of cases in which the pathology is obscure. To this belong impotence following diabetes mellitus, acute febrile conditions, various forms of acute and chronic poisoning, and, according to some, obesity and chronic nephritis.

Local Symptoms.—Disturbance of the libido will be discussed under psychic impotence.

Disturbance of Erection and Ejaculation.—The patient first notices that the time consumed in coitus is not as long as it previously was. Gradually the length of ejaculation becomes shorter, at the same time the period at which ejaculation commences after intromission also becomes markedly diminished; so that, at this stage, although the penis is erect, and enters the vagina, ejaculation takes place immediately after, or at the moment of, intromission (rapid ejaculation). Later, not only is ejaculation rapid but the erection itself does not last as long as usual. Still later, while the penis becomes erect, ejaculation and decline of the erection takes place so rapidly that the penis has not had time to enter the vagina (premature ejaculation). Later still the penis becomes only partially erect or goes down at once without any ejaculation at all. Finally, although libido may still be present, there is neither erection, ejaculation or orgasm.

Disturbance in the Orgasm.—The orgasm is believed to be due to the squeezing of the fluid through the ejaculatory ducts into the posterior urethra. In rapid ejaculation it is either diminished or entirely absent for the following reasons: When the erection center sends its impulses too rapidly to the ejaculation centers, the impulses which are sent out by these centers are also weaker than normal. Therefore, the squeezing out of the fluid through the ejaculatory ducts becomes less intense and the orgasm is either diminished or absent.

Besides the symptoms mentioned above, there is an important group of cases, whose symptoms cannot be consistently classified with any of the preceding groups, cases where there is an entire diminution of the whole process of coitus. To this class belong men in whom the sexual functions appear very late, and last only for a short time. They rarely masturbate, rarely have pollutions, have very slight libido and easily remain continent. They sometimes marry for economic or other reasons, and are impotent, but do not worry much about their condition.

Besides the local symptoms just mentioned, there is in addition a series of local symptoms which often accompany impotence and are due to the same conditions in the posterior urethra, prostate and seminal vesicles, which are also the cause of the impotence. Among these may be mentioned frequency, burning and pain at the end of urination, vesical tenesmus, incontinence of urine, dribbling after urination, as well as difficulty of starting the stream of urine, pollutions, etc.

General Symptoms.—There is a long train of symptoms, too numerous for description, which often accompany impotence from whatever cause, and which may be described under the general term of sexual neurasthenia. Of this character are pains in the legs, pains over the eyes, in fact, pains in any and every portion of the body. General weakness, headache, vertigo, and almost any kind or combination of symptoms is met with.

There is also a long list of *psychic* symptoms which has been very graphically and artistically described by German and French authors. I will not attempt to give here a graphic description of the miseries and psychic emotions of the impotent man, but will simply state that this condition is at times the cause of the most extreme unhappiness, and not infrequently leads to suicide.

Diagnosis.—We must diagnose whether it is the erection center, the ejaculation centers, the libido or a combination of all of them which is at fault. We must also exclude tabes or other nervous condition as a cause of impotence.

The *prognosis* varies considerably in the different conditions. It is generally good in men below forty-five who have been able to perform normal coitus before their present impotency. It is very poor in cases of congenital lack of sexual desire and vigor. Wherever a man has always been sexually weak from the very commencement of his sexual life, and has superimposed upon this congenital weakness the evil influences of withdrawal or excessive masturbation, the prognosis is poor. It is also not good in men past fifty, or in men with a neurasthenic history to which the evils of sexual neurasthenia have been added. The prognosis is very good in those acute forms of impotence due to overindulgence in coitus, as well as in impotence from ungratified sexual passion, and in the ordinary cases of impotence from withdrawal or excessive masturbation in which there is no underlying condition of general neurasthenia. The prognosis is naturally poor in the confirmed sexual invert.

Treatment.—What then is the condition of affairs in the ordinary case of functional impotence? There are hyperirritated or exhausted sexual centers depending upon the stage of the disease, and a chronically inflamed posterior urethra with congested or inflamed seminal vesicles and prostate. The first indication is absolute sexual rest in order to give the exhausted centers time to recuperate, and to remove every cause of irritation, which includes the treatment of the diseased posterior urethra and prostate and seminal vesicles.

The first indication is met by not only abstaining from coitus, but from every act which might excite the sexual passion. The length of time he should abstain from coitus varies in different cases. As a general rule it may be said that young and vigorous men should be kept continent for from three to six months, while men past forty-five should be allowed coitus much sooner, for fear of a complete dying out of the sexual passion.

Besides the abstinence from coitus, the patient should also abstain from all alcoholics, as well as from tea, coffee, eggs and oysters, for all these stimulate the sexual apparatus and centers.

At this time nothing is so useful as the internal administration of the bromides in large doses. At least fifteen grains should be given three times a day well diluted after meals. The object of this is to quiet the irritated centers, and at the same time to remove

all sexual desire for the time being. The large doses of the bromides should be kept up for at least two months in young persons and for one month in older patients, and then gradually reduced.

The treatment of the pathological conditions in the posterior urethra is the same as in masturbation. If the endoscope reveals any gross pathological condition such as cyst, vegetations, etc., these should be treated by the recognized intraurethral methods. After the very acute condition of congestion has been removed, a few direct applications of strong silver solution (ten to twenty per cent.) can be advantageously applied to the diseased areas.

This combined treatment, to wit, abstinence, restricted diet, bromides, intraurethral treatment, and prostatic massage should be kept up for several months depending upon the age of the patient, the stage of the disease, and also the reaction to the treatment. During this time, his general health should receive the closest attention. A liberal and easily digested diet, largely made up of cream and other fats, should be ordered. Constipation must be relieved as it tends toward interference with the return circulation in the pelvis and thus make for local congestion. Tonics and out-door exercises should be ordered where feasible. A very useful adjuvant is cold baths, or cold spinal douches. These are to be taken only in the morning and never at night. Hot baths are positively injurious.

When we have decided that the sexual centers have fully recuperated, and observed that the posterior urethra as well as the adnexa are normal, we stop the bromides and turn to stimulants. Of these the best are strychnine and yohimbin. I order one-twentieth grain of strychnine sulphate to be taken at 5 P.M., 7 P.M., 9 P.M., and 11 P.M. Yohimbin acts very well within certain limitations. Its chief application is after a long period of sexual continence, and when the erection center has been completely rested. The center will now react splendidly to this drug and the first and much feared coitus will be successful. It is not to be given continuously but only for one or two weeks in doses of one tablet three times a day.

The treatment of those cases in which there is a congenital lack of sexual vigor is very unsatisfactory and all we can do is to conserve whatever power they have, by warning them against excessive coitus and withdrawal.

Psychic impotence is that condition in which the impotence is caused by inhibitory influences from the higher centers.

Etiology.—Any act or factor which can influence the imagination may be the cause of the inhibition. Among these may be mentioned fear of venereal disease, fear of pregnancy, fear of being caught in the act, fright, disgust of the partner, fear of being impotent on account of youthful masturbation, etc.

Pathology.—The libido is normal, and even may be very powerful, but inhibitory impulses are sent from other cerebral centers to *C* (Fig. 4139) preventing it from sending impulses to the erection center (*R*). In those cases where erection has already commenced, the inhibition is transmitted further from *C* to *R* thus stopping the forming erection.

Symptoms.—Misdirected Libido.—(*a*) Sexual perverts. Normally the libido of a man is directed toward a woman. If, however, the libido is directed toward any other source, the person is a pervert. The seat of the trouble is probably in the cerebrum.

(*b*) Impotence of the Roué.—On account of too frequent coitus, these persons find no longer pleasure in normal coitus, and therefore seek for stronger and stronger methods of excitement in order to cause erection.

(*c*) Relative Impotence.—Under this heading may be mentioned those cases where the husband, after many years of married life, becomes impotent with his wife, though perfectly potent with other women. To this class also belong those curious cases where men are potent only with certain types of women, either blondes or brunettes or having other physical characteristics, and are impotent with all other types.

The three forms of impotence just mentioned are sometimes classed under functional rather than psychic impotence.

Inhibited Libido.—The person has normal or even intense libido, but just at the exciting moment either the erection fails to occur, or if it has started, suddenly ceases. At each further attempt the same thing occurs and may even be worse.

The *diagnosis* can only be made by a careful consideration of the patient's history together with a most careful genito-urinary examination, as well as a general examination. The most important points are the presence of normal libido, the absence of organic defects or diseases, the absence of a history of withdrawal or other unnatural sexual excitation and the presence of a definite psychic history.

The *prognosis* is generally excellent.

The *treatment* is entirely psychic. Endoscopic urethral examination as well as electricity are especially impressive. It is a grave mistake to tell the patient that there is nothing the matter with him. It is this form of impotence that can be cured by anything varying from a bread pill to Christian Science.

Pollutions in the Male.—Under this heading I include any involuntary semen-like discharge coming out of the penis and not connected with coitus.

I have purposely made this definition a very broad one in order to include all discharges which have been classified as spermatorrhea, involuntary seminal emissions, prostatorrhea, defecation spermatorrhea, urination spermatorrhea, and urethrorrhea ex libidine sexuale. I have done this in order to simplify the subject which has been unnecessarily complicated by distinctions and pathology which do not exist.

Pollutions may be either diurnal or nocturnal. Pollutions which accompany defecation and urination are called defecation spermatorrhea and urination spermatorrhea respectively. Prostatorrhea is a term which is applied to a discharge which is supposed to come from the prostate but without any inflammation of this organ. Urethrorrhea ex libidine sexuale is a secretion of Cowper's glands and those of the urethral follicles and glands, called into action by sexual excitement just as in normal coitus, but without coitus being indulged in.

Etiology.—Any factor which either causes a distention of the seminal vesicles or irritates them or the prostatic urethra or the glands of Cowper may cause pollutions. Among such may be mentioned ungratified sexual excitement, withdrawal, results of masturbation, prostatic massage, excessive horseback or bicycle riding or inflammations of the posterior urethra.

Nocturnal pollutions are perfectly normal if they occur with erect penis, and at not too frequent intervals, and are not accompanied by a feeling of marked depression. Diurnal pollutions, as well as defecation and urination spermatorrhea are practically always pathological.

Pathology.—We must revert to the same scheme of the modus operandi of erection and ejaculation which has been given in the section on Impotence. This is illustrated in Fig. 4139, 2. The diagrams show that 2 is the same as 1 except that the impulses from *P* are absent, while those from *V* are very strong.

We begin with an overdistention of the seminal vesicles. As a result of this, impulses are sent to the central nervous system and erotic dreams are formed. As a result of this dream, impulses are sent from *C* to *R* with about the same intensity as the normal coitus (Fig. 4139, 2). The impulses from *P* are absent. For this reason, in order to distend the erection center (*R*) thoroughly, the impulses that run from *V* to *R*

must be *very* strong in order to cause an overflow of impulses to E_1 and E_2 and allow ejaculation to take place.

So far this may be perfectly normal if it does not happen at too frequent intervals. If, however, as a result of any of the etiological factors mentioned, either the cells of the cerebrum or the erection or ejaculation centers become hyperirritable, the whole process takes place at the slightest provocation. Finally, just as in impotence, we may get an exhaustion of all the centers so that they will refuse to respond to any impulse. Pollutions become less and less frequent (without any treatment) and at length stop altogether. The patient considers himself improving but, as a matter of fact, is getting worse. Should such a patient at this stage attempt coitus he will find himself impotent.

The pathology of diurnal pollutions is similar, and is illustrated in Fig. 3. Sometimes in the waking state, in the presence of markedly distended seminal vesicles, strong long-continuing lascivious irritations may lead to strong erection and ejaculation. In Fig. 4139, 3 we notice the same condition as in 2 except that the impulses which come from the cerebrum (*C*) are exceedingly powerful.

The local pathology is similar to that found in withdrawal or masturbation. We must also state that the local conditions may be absolutely normal, the pollutions being due to a hyperirritable condition of the sexual centers.

The pathology of defecation and urination spermatorrhea is still in doubt. We are not certain whether the condition is due to a reflex action set up by the act of defecation or urination, or whether it is due to insufficiency of the musculature of the seminal vesicles or ejaculatory ducts, or due to mechanical pressure of hardened feces or to the mechanical action of the abdominal muscles incident to defecation and urination.

In urethrorrhea there is simply an overactivity of Cowper's glands and those of the urethra. Normally, these glands pour out their secretions into the urethra at the very commencement of coitus. In urethrorrhea there is an overactivity of these glands, so that the merest act of flirtation, or spooning, or even erotic thoughts, are sufficient to cause these glands to pour out their secretions, which then appear at the meatus. The condition is simply due to too great a response on the part of these glands to central stimulation.

Symptoms.—In normal cases, the patient experiences during the night an erotic dream, which is accompanied by an erection of the penis and ejaculation. He is generally awakened during the process of ejaculation. Sometimes, however, he continues in his sleep, and, upon awakening in the morning, discovers that he has had an emission. In some cases no dream accompanies the ejaculation, or at least is not remembered by the patient. *Normally* these emissions do not occur on the average more often than once in ten days, and always occur with erection. They are not accompanied by any marked feeling of depression, sometimes, indeed, quite the reverse, with a feeling of contentment.

In pathological cases the patients have pollutions two or three times a week, often without erection. After the pollutions, they complain of marked nervous symptoms and a feeling of depression to be described hereafter. The pollutions, if untreated may even increase in frequency, but after a while they diminish and finally cease altogether. This means that the sexual centers have become completely exhausted, and fail to respond to any stimuli.

Diurnal pollutions are most generally present in patients who also suffer from nocturnal pollutions. In these cases, the mere sight of a woman, or the rubbing up against one in a crowded car, is sufficient to cause an ejaculation of semen with very slight, if any, erection. Sometimes the patient sees fluid appearing at his meatus every time he looks at it. This represents a much more severe type of pollution.

In defecation spermatorrhea the patient notices that during the straining incident to defecation, a discharge runs out of his urethra. The quantity varies from a few drops to a dram. In mild cases, these losses accompany only severe straining efforts, or the passage of very hard fecal masses, whereas in the more severe cases, they appear with every defecation, even when the fecal contents have been artificially made soft and watery by mineral cathartics, and are unaccompanied by any straining whatsoever. As a matter of clinical experience, I have frequently noticed that these severe cases are the forerunners of impotence.

In urination spermatorrhea the patient notices the discharge after urination. Patients with urination spermatorrhea almost always suffer from nocturnal pollutions and frequently also from defecation spermatorrhea. This represents the severest type of pollutions. It makes no difference whether spermatozoa are found in the discharge or not.

The *general symptoms* of pathological pollutions vary greatly in intensity. They are especially severe in patients with an underlying neurasthenic tendency. One of the symptoms is a peculiar feeling of lassitude, of diminished energy after the occurrence of a pollution. The patient wakes up dead tired, without any ambition, with no inclination for work, and feels as if he has been up all night doing work. He is entirely exhausted and fit for sleep rather than for the duties of the day.

Among the other more common symptoms may be mentioned headache, burning of the eyes, discomfort in the inguinal regions, heaviness in the testicles, faintness, palpitation of the heart, excessive perspiration, pain down the spine and tremor of the hands. Loss of memory is frequently complained of, but does not exist, except it be due to idiosyncrasy to bromides. Exceptionally, we find patients, who come for other troubles, and whose history shows that they are subject to frequent pollutions, but apparently have no symptoms therefrom and do not bother about them.

In ordinary cases of pollutions, the sexual powers of the patients do not suffer much, if any; yet, from a careful observation of many cases, I am firmly convinced that finally there occurs a temporary impotence in quite a number of cases.

The urinary symptoms which often accompany pollutions are due to the pathological conditions in the posterior urethra and are the same as have been mentioned under impotence.

The list of symptoms just given are those which one hears complained of on going carefully into the history of *many* cases. I do not by any means mean to infer that any *one* patient complains of all these symptoms. We may find few or many in any particular case, as well as any combination of symptoms.

In urethrorrhea, the patient notices, after a prolonged act of spooning, some fluid just within, or coming out of the meatus. Generally a prolonged period of erection has preceded this event.

Diagnosis.—The main point is to distinguish between normal and pathological pollutions. Normal pollutions are always nocturnal, whereas pathological pollutions may be either nocturnal or diurnal, and may accompany defecation or urination. Normal pollutions occur on the average not oftener than once in ten days, whereas pathological pollutions occur much more frequently. Normal pollutions always occur with strong erection, whereas in pathological pollutions the erections are weak or absent. Normal pollutions are generally not followed by a marked period of depression, whereas pathological pollutions are generally followed by such a feeling. Only the most gross carelessness will confuse pollutions with gonorrhea, yet this mistake has been made.

The *prognosis* of normal pollutions is, of course, ex-

cellent. In pathological nocturnal pollutions, the prognosis is very good also. We can reduce them to normal limits. In urethrorrhea, the prognosis is likewise very good under proper treatment. Diurnal pollutions are much more obstinate but finally yield to persistent treatment. Defecation spermatorrhea is a much more serious condition, and urination spermatorrhea is the worst of all. Defecation spermatorrhea which is only present on severe straining or after the passing of hard fecal masses, is hardly more important than pathological nocturnal pollutions, but the variety which comes with every stool is very apt to be a forerunner of impotence.

The general prognosis is worse where there is an hereditary tendency to general neurasthenia. It is worse in cases coming on after fifty and accompanied by premature ejaculation or total impotence.

The more excuse there is for a pollution, the less serious it is. Thus, a man who has been continent for several weeks is entitled to a pollution, and a man who has been spooning with his girl for hours, has also a right to expect a pollution during the night. It is only those cases where pollutions occur with little or no sexual excitement, such as merely brushing up against a female in a crowded car, or merely thinking of one, which represent the more serious types.

In considering the seriousness in the prognosis of pollutions, I only refer to the possibility of impotence, and to the persistence of the general neurasthenic symptoms. Pollutions, no matter how severe, never endanger life, and there is not the slightest evidence that they ever lead to insanity or other serious nervous conditions.

Treatment.—The normal cases should be told in plain and definite language the significance of pollutions, and their harmlessness if not too frequent. Patients suffering from pathological pollutions should abstain from alcoholics, tea, coffee, and all kinds of sexual excitement. Cold bathing in the morning should be encouraged, hot baths should be taken as little as possible and especially not at night.

For the pollutions themselves, nothing succeeds so well as sodium bromide, fifteen grains three or four times a day well diluted after meals. For the relief of the congestion or other pathological condition in the posterior urethra we apply the same treatment as in masturbation. Very strong cauterization of the verumontanum, as recommended by some German authorities, I have found to be of no use in this condition. In the few cases in which I have tried thepsychophore, I have also not derived any benefit.

In defecation and urination spermatorrhea, the bromides do not act as quickly or as positively as in the other forms. The main treatment in these cases is to avoid constipation and the treatment of the prostatic urethra.

In urethrorrhea, it is necessary only to instruct the patients about the harmfulness of spooning, and a discontinuance of this will generally bring about a cure. If necessary a few silver nitrate instillations in both the anterior and posterior urethra will usually cure the patient.

Priapism.—This is persistent erection of the penis, unaccompanied by sexual desire, and usually very painful.

Etiology.—Priapism in children is due to vesical calculus, tight or adherent prepuce, or rectal worms. Priapism in adults is due to vesical or prostatic calculus, stricture, cystitis, retention of urine, gonorrhea, cantharides.

Essential priapism is due to disease of the brain or spinal cord, injuries of the perineal region, alcoholic or sexual excesses, leukemia.

Many authors limit the term priapism to what has just been described as essential priapism. Most modern authorities, however, understand by the term priapism any abnormal prolonged erection of the penis unaccompanied by voluptuous feelings, irrespective of the underlying cause, and it is under this latter interpretation that the subject will be discussed herein.

Pathology.—Under the head of causes which act by direct irritation of the erection center may be mentioned injury low down in the spinal cord, spinal syphilis, early tabes and alcoholism. Alcohol causes priapism either by local irritation and through the urine, removal of the inhibition of a normal cortex of the brain through psychic pathways, changes in the cortex, but mainly subcortex, due to the toxic effects of the alcohol, and its effects upon the peripheral nerves.

Under the heading of causes which act by reflex action of the erection center may be mentioned vesical or prostatic calculus, tight or adherent prepuce, rectal worms, stricture, cystitis, retention of urine, and cantharides poisoning.

To the causes which act by removal of the inhibition from the higher centers belong cases of injury high up in the spinal cord, cerebral or cerebellar hemorrhage, and alcoholism.

In the priapism of acute gonorrhea we may have an edematous infiltration of the corpus spongiosum which becomes less extensible than the corpora cavernosa (chordee) or a congested infiltrated mucous membrane and submucous connective tissue which is not able to stretch during erection, thus causing severe pain. In the priapism due to alcoholic and sexual debauch, intense swelling is found to be present not only in the structures of the penis but also in the perineal and cremasteric region. Priapism due to cantharides poisoning is due for the most part to the intense inflammation of the urethral mucous membrane caused by the poison.

Under the present heading belong also those cases due to direct traumatism of the penis and perineum. Here the extravasation of blood with its subsequent clotting acts mechanically so as to interfere with the normal distensibility of the parts, thus causing the erections to be painful. For the same reason purulent infiltrations of the mucous and submucous tissues cause priapism.

In cancerous infiltration of the penile tissues, the parts become stiff and rigid, and thus mechanically interfere with the normal distensibility of erection, thereby producing priapism.

In leukemia, the priapism is due to the interference with the return circulation, due to the pressure of the enlarged glands, and also to thrombosis of the corpora cavernosa. The organ thus remains more or less permanently engorged.

Symptoms.—In children and adults, priapism dependent upon reflex irritation from calculi, retention, etc., is very mild and transient in character. In cantharides poisoning the symptoms, while in some cases rather severe, are greatly overshadowed by the other more dangerous symptoms of the poison. In gonorrheal priapism the symptoms are very pronounced. The attacks come on at night, and the intense pain awakens the patient. The entire organ is congested and sensitive, while the pain is so severe at times that patients have tried to break the erection by direct force. The result is disastrous, as rupture of the urethra may result. If the attack subsides, and the patient goes to sleep again, he is generally promptly awakened by another attack.

Priapism dependent upon spinal or cerebral conditions is usually not painful. There is often no sexual desire, and the only inconvenience is that caused by the position of the organ. This, however, is the most persistent of all the forms. Cases of continuous priapism for four or five months at a stretch have been reported.

The most painful forms are those caused by alcoholic or sexual excesses. Here the onset may be in one of three ways: either after several mild and frequent attacks of erection, lasting but a few minutes at a

time, a condition of priapism finally sets in; or after coitus, the penis refuses to go down and remains in a condition of priapism; or again, the patient wakes up at night without any premonition, and finds his penis in a state of painful erection which persists for a long time. Often the sufferer tries to relieve himself by coitus, but this generally fails and makes matters worse. Even in those exceptional cases where orgasm and emission are possible, there is absolutely no pleasurable feeling whatever. Taylor[2] says: "In this pronounced condition the sufferings of the patient are very severe. The patients fear the least touch of their linen or of the bedclothes, and jarring of the bed or heavy steps in the room cause them agonizing suffering. They draw up their legs upon the abdomen in order to protect the penis from the slightest touch. This organ may lie rigid against the abdomen, or it may be more or less erect and at a right angle with the body in the horizontal position. Very soon these patients become much worried and apprehensive, and their faces give evidence of anxiety and suffering." Even when, after a long attack, relief comes at length, everything seems normal and the patient is happy, this relief in the vast majority of cases proves to be only an intermission, and the whole condition returns again in a short time.

In the priapism of leukemic origin, all grades of severity occur.

Diagnosis.—The main point is to find the underlying etiological cause. It must not be confused with satyriasis.

Course and Prognosis.—The prognosis must be guarded, as in some cases gangrene has resulted. Moreover, in a large number of cases impotence has been noted as a sequella. The prognosis must be particularly guarded in spinal and cerebral cases, being dependent upon the severity of the underlying injury. In leukemic cases, as well as in those of sexual perversion, the priapism is generally very persistent, and even if apparently cured is often followed by relapses. In gonorrheic cases, the prognosis is excellent unless the patient does some violence to his urethra. In reflex cases the disease vanishes with the removal of the cause. In traumatic cases, the priapism generally disappears after a while, but the trauma may have permanently injured the urethra. In tabes the priapism disappears as the disease progresses.

Treatment.—In priapism due to reflex local conditions, these conditions should receive appropriate treatment. Wherever there is a history of or suspicion of syphilis, antisyphilitic treatment should be given. In gonorrhea I have had the best results from suppositories containing opium and belladonna, and the local application of ice. In traumatic cases, ice to limit the hemorrhage, followed by incisions under absolute asepsis to remove blood clots and to allow free drainage of the exudate. Early incision is especially important in purulent infiltration.

For the priapism itself, especially for those severe cases following alcoholic or sexual excesses, morphine, chloral, or bromide of potassium may be used during the paroxysm. Either very hot or very cold applications may be employed locally, but chloroform narcosis is generally of no avail.

Clitorism.—This is a very infrequent condition, and the term has not even found its way into English text-books or other works on gynecology, nervous diseases, or sexual diseases. It cannot even be found in medical dictionaries.

It was first described by Rohleder, I believe, and is the exact counterpart of priapism. Indeed, it might be called priapism in the female. Rohleder describes it as a condition of long-continuous, painful, recurring erection of the clitoris. In some cases ejaculation takes place. It is the result of very intense masturbation or tribadism. Hysteria, nymphomania, and excessive coitus are also at times etiological factors. The treatment is that of sexual hyperesthesia, and the primary object is the cure of the onanism.

Clitoris Crises.—Köster[5] reported a very rare condition of crisis in the clitoris, occurring in locomotor ataxia, and similar to the other well known crises which occur in this disease. The few other reported cases come mostly from French and Italian writers, and up to the case reported by this writer, it was, I believe, unknown in Germany. The patient was forty-nine years of age, and had been suffering from tabes for a period of twenty-one years. Besides the condition presently to be described, she also suffered from laryngeal crises and presented also the classic symptoms of tabes dorsalis.

The crises came in attacks, which occurred every other day, starting about two days before the menstrual period, and lasting during the entire period and even a few days beyond. The nature of the attack was as follows: The patient experienced a peculiar involuntary access of sexual feeling, a sensation of pleasurable tickling, which began in the vagina, traveled down the clitoris and vulva and culminated in a true orgasm with spasm of the clitoris and ejaculation. Immediately thereafter sharp, darting, lancinating pains were experienced in the vagina, uterus, and back, lasting for several hours.

Like the other crises of tabes they are entirely independent of will, and appear only at night or when half asleep. All efforts on the part of the patient to suppress the erotic feeling are generally without avail. Sometimes, at the very commencement of the attack, however, the patient appeared to abort it by getting out of bed and walking about.

Care must be taken to differentiate these true crises from pseudo-crises. In the latter, owing to peripheral or radicular irritation, clitoris crises may occur especially during light sleep.

Satyriasis.—Satyriasis is defined[3] as excessive venereal impulse in the male. The excessive impulse must be pathological, in order to constitute satyriasis. In those afflicted, there exists an abnormal terrible desire or impulse to have sexual intercourse under any circumstances or conditions, irrespective of the age of the female or other considerations of decency or decorum.

Etiology.—The etiology is not at all clear, and various causes given by some authors are vigorously denied by others. This is mainly due to the different conceptions of the disease itself held by different authorities. Alcoholism, pulmonary phthisis, continence and masturbation are given as etiological factors.

Pathology.—Opinion is divided as to whether it is a disease per se or only a symptom of some form of psychosis. My own opinion is that in the present state of our knowledge it is best to consider satyriasis as a clinical entity just as we consider impotence or masturbation; that is, a condition which may be due to either local, cerebral or psychic causes. This conception does not conflict with the opinion that the disease is merely a symptom of some graver psychosis, nor with a case which has come under my own observation where the disease was due to the irritation of an exceedingly large and inflamed verumontanum. The view just expressed is merely tentative, as it appears to me the only one to harmonize all the clinical facts.

Symptoms.—The person afflicted with satyriasis strives to obtain coitus at any price. If he cannot obtain it in the ordinary way, he resorts to masturbation, sodomy, or rape. The case which came under my own observation was that of a poor laborer, who spent all his wages to obtain connection, and who told me that he would have had connection several times a day if he had had the price. Every time he saw a female, he would be seized with an inordinate desire, which he found it most difficult to restrain.

The psyche of these patients is made up of sexuality which covers their entire world. Everything they see or hear brings thoughts on sexual matters. In most cases of the disease, the genital organs are in a state of continual turgescence. Many of those afflicted eventually find their way into the criminal courts.

The *diagnosis* is to be made from a careful study of the history of each case. It is especially important to make the correct diagnosis and differential diagnosis in criminal cases, so as to fix the responsibility in cases of rape or other assaults.

Prognosis.—In the absence of a distinct pathological condition the prognosis as to cure is bad. Many of the milder cases, however, seem to be able to control themselves to a certain degree, often even to a very marked degree, and they may go through life without getting themselves into trouble.

Treatment.—In each and every case, it is well to investigate the condition of the posterior urethra. In the case reported by me above, I found a definite pathological condition, the removal of which cured the disease. The pathological condition in that particular case was an extremely enlarged and congested verumontanum, the largest I had ever seen, and the treatment consisted in direct application of very strong silver nitrate to the parts through the Wossidlo-Goldschmidt posterior urethroscope.

Even though we cannot get at the etiological factors or remove the underlying pathological condition we must not neglect treatment nevertheless. We must positively interdict alcoholics, as well as coffee and tea. We must also remove any local genital condition as well as anything that psychically stimulates the sexual centers. The reason for this treatment is as follows: There are very many mild cases of satyriasis, in which the patient under ordinary circumstances is quite able to control himself, but if drunk or under additional outside sexual stimulation, is entirely unable to do so, and gets himself into serious trouble. The more severe cases ought to be placed in an institution, for the protection of society, as well as for their own protection, and we ought not wait until some unfortunate, uncontrollable impulse brings them into the criminal courts.

Nymphomania.—This is defined as excessive venereal impulse in the female.

Etiology.—Much that has been said concerning the etiology of satyriasis also applies to nymphomania. Neither culture nor breeding seem at times to have any etiological influence. It is found in the most cultured, in the most modest, and in the most religious almost to the same degree as in those less carefully educated. The hereditary factor, however, stands out prominently in the etiology of these cases. In so many do we find an immediate history of insanity or other severe psychosis in one or other of the parents, or very near relatives, that we cannot help concluding that nymphomania, far more than satyriasis, is in the vast majority of cases really a psychopathy.

The *pathology* is not at all understood. We do know, however, that the disease is not dependent upon any local condition of the genitals.

Symptoms.—In nymphomania the sexual desire is purely physical in character, and centered upon the local pleasurable excitation of the genitals. The nymphomaniac tries, by all sorts of coquetry and exposure of her genitals if necessary, to attract men to her for purposes of coitus. In many cases, the mere sight of a man is enough to throw her into the most intense sexual excitement. One of the most prominent symptoms, especially in young girls, is the demand for gynecological examination, and especially for catheterization. Any excuse for examination is brought forward. The patients will voluntarily retain their urine in order to have to be catheterized. Many of these cases, in their despair, come begging for castration, in the hope of finding relief in this operation, and some have even attempted suicide. Prostitution is often the logical outcome of nymphomania. Rohleder[4] has called attention to the fact that nymphomaniacs are not infrequently sterile.

Diagnosis.—Whenever a single girl or woman seeks or enjoys gynecological examination, or without evident cause, desires catheterization, we must suspect nymphomania.

The *course* of the disease is generally from bad to worse. Many of these women end up as prostitutes, and quite a few become insane.

Treatment.—In the vast majority of cases, nothing can be done for them. According to Forel, Moll, von Schrenck-Notzing and Fuchs, hypnotism has cured mild cases, but has been found absolutely powerless in the severe form of the disease. Rohleder[4] states that Fränkel has been trying Röntgen treatment of the ovaries, with the idea of causing not only sterility but also a diminution of the libido, but he does not know if any good has resulted therefrom. The best that can be done for these unfortunates is to put them into an asylum where they can be of no harm either to themselves or to society in general.

Frigidity.—Frigidity is lack of sexual desire in the female. It may be total or partial, congenital or acquired. In total frigidity the patient has absolutely no desire, sometimes even a feeling of disgust for the sexual act. In partial frigidity there may still be some feeling left, but it is present to but a very slight degree, and only on infrequent occasions. While total frigidity is rare, partial frigidity is not at all uncommon. At least 10 per cent. of all married women suffer from partial frigidity, and some authorities have placed it as high as 40 per cent.

Etiology and Pathology.—Frigidity is normal before puberty and in old age. It may also be considered normal in modestly reared girls up to their marriage, and it is not abnormal to have it persist for some time after marriage. It may be acquired or congenital, and these will be considered separately.

Acquired Form.—Under this heading come a lack of relationship between the male and female genitals which may be due to a very large or roomy vagina, a markedly relaxed condition of the vaginal musculature, marked lacerations after childbirth, an undersized penis, etc. Impotence in the male or withdrawal, especially if started at the very commencement of married life, before the sexual sense has been developed in the female, is very apt to cause frigidity. Among other causes may be mentioned masturbation, castration before puberty, and various psychic conditions such as lack of affection, fear of pregnancy, and faulty methods of education in which the sexual element has been unduly repressed.

Congenital Form.—In these cases the female is born with little or no sexual desire. I have found that there is a large hereditary element about it. Thus, I have very often seen an entire family, all the members of which, both male and female, were very passionate sexually, and others again where the opposite condition prevailed.

Contrary to what one might expect, injuries and diseases of the clitoris rarely if ever lead to frigidity. On the other hand, injuries to the vaginæ bulbi, as well as injuries to the constrictor cunni, have caused frigidity.

Pathology.—The pathology of cases due to chronic masturbation has been given under that head. In inverts, who sometimes marry for economic or other reasons, frigidity is the rule. Here the pathology consists in the psychic make-up of the individual. In frigidity due to impotence in the male, the pathology must be sought in the sexual centers. These very often lie dormant in the unmarried female, and have to be aroused into action after marriage. Should the male be unable to arouse them, they continue in

their dormant condition, and frigidity finally results.

Frigidity is very often part of a symptom-complex, consisting of infantile uterus, scanty and delayed menstrual function, sterility and lack of sexual passion. In these cases there seems to be a lack of development of the entire sexual make-up, anatomical, physiological, and psychical.

Symptoms.—The frigid woman has little or no inclination for sexual intercourse and receives no pleasure from the act. Very often she submits as a sense of duty to her husband. Some of the more intelligent may even simulate sexual passion to please and deceive their husbands. Some women, on the other hand, seem proud of their frigidity and boast about what they consider their superior will and control of their desire. Although the majority of cases of frigidity cannot be recognized by any external sign, appearance, or mannerism, yet in some cases there is certainly a less feminine and a more masculine character about the person.

Diagnosis is made from the history, which we as a rule obtain from the husband.

Prognosis depends upon the possibility of the removal of the etiological cause. In total congenital frigidity, the prognosis is generally bad.

Treatment.—Any of the gynecological conditions mentioned in the etiology should be remedied if possible. Masturbation should receive its appropriate treatment.

Of great importance, because so much good can be done, is the management of those cases where the sexual centers have not been unduly aroused on account of the husband. He should be fully instructed in sexual matters and should be made aware of the fact that sexual excitement and orgasm is as important to his wife as to him. Before proceeding to intercourse, therefore, he should with all the artifices of love awaken in her the passion and desire for intercourse, and then, and not till then, should he proceed to the act. If, as is often the case, his orgasm should come before that of his wife, he should not remove his penis, but should allow it to remain in the vagina, at the same time, with kisses and caresses, fan his wife's excitement until she has had her orgasm.

For the congenital frigidity, Rohleder[4] suggests the internal administration of yohimbin, which is supposed to act by determining an increase of blood to the genitals, just as in the male, and this erection-like action may start or increase the sexual desire. He also recommends coitus during the menstrual period, as in even extreme cases of frigidity, there is some sexual excitement present at this time.

In the absolutely hopeless cases, it would be proper for the peace of the family, to instruct the wife to simulate sexual excitement including orgasm. There is certainly no harm in this fraud, if it answers the purpose, and it is certainly far better than the breaking up of a family by divorce, or the leading of the man into extramarital coitus, with all its dangerous consequences.

Vaginismus.—This is a violent, painful, involuntary spasm of the muscles surrounding the vaginal entrance.

Etiology.—Although in the vast majority of cases a definite pathological condition will be found, it is also important to remember that, as a general thing, there exists at the same time an underlying neurotic condition as a predisposition to the condition.

Pathology.—While we are wont to regard vaginismus as a neurosis, careful investigation will very often show some local or general condition present to account for the reflex spasm.

One of the most frequent underlying causes is the awkward attempt at coitus by the male at the very commencement of married life. These awkward attempts, often combined with a peculiar formation of the vulva and vagina, sometimes cause the penis to enter the extreme upper portion of the vagina, and to press the urethra against the symphisis pubis; the severe pain which results causes the woman to shrink from and fear every act of coitus, and is also the cause of the reflex spasms of the muscles of the vaginal outlet. Very often the first attempts at coitus cause unusually severe lacerations and fissures which provoke the spasm of the muscles at each succeeding attempt.

Among other pathological conditions present may be mentioned a very tough hymen, tender and inflamed carunculæ myrtiformes, urethral caruncle, neuroma of the fossa navicularis, varicose veins, or prolapse of the urethral mucous membrane, fissures of the fourchette, neck of the bladder or anus, hyperesthesia of the vaginal mucous membrane, masturbation, or any other cause likely to increase the irritability of the external genitals. A penis which is too large is often assigned by the wife as the cause, but this condition is really one of very great rarity, and we ought not to take much stock in such explanation.

Symptoms.—Vaginismus is most frequently met with in young women at the very commencement of their married life. At the first attempts at coitus, the musculature of the vaginal entrance is thrown into a violent involuntary painful spasm, which effectually prevents the entrance of the penis. Generally the spasm involves only the muscles of the vaginal entrance, but in severe cases the entire musculature of the perineum, anus, and bladder seem to participate. In rare cases the constitutional effects are so severe that general convulsions have followed. With each renewed attempt at coitus, the spasm seems to increase and after a while in some cases, the mere approach of the male, or even the mention or memory of the act, is enough to throw the parts into a spasm. As a result, such women dread the attempt at coitus, and shrink from the act, although, in some cases, they have borne this condition for a long time from a sense of duty. Often modesty restrains them from seeking medical aid, until finally a nervous breakdown ensues.

Although the penis is generally prevented from entering, it does enter in some cases, but with difficulty and with pain. As a general thing the spasm comes on with the first approach of the male organ, but in some cases it does not commence until the male organ has entered and then ensues the peculiar condition known as penis captivus, in which the penis is imprisoned within the vagina by muscular spasm, and cannot be withdrawn. In particularly severe cases it has been necessary to chloroform the woman in order to release the penis from the muscular spasm.

As already stated, a gynecological examination shows the parts to be extremely sensitive, so that it is sometimes impossible to insert the examining finger, and a general anesthetic is necessary to make an examination. This will usually reveal one of the pathological conditions mentioned above.

Although vaginismus is generally encountered in the recently married, cases have occurred where it first developed later on, sometimes even after childbirth. In some cases the spasm came on during labor, and interfered with the birth of the child. It has also been accidentally discovered upon gynecological examination in the virgin, the slightest touch causing a muscular spasm.

Diagnosis.—Vaginismus must be differentiated from dyspareunia, although frequently a cause of the latter. In dyspareunia there is only pain in intercourse, and no spasm of the muscles, while in vaginismus the pain is due to the spasmodic contractions of the muscles. In dyspareunia coitus is perfectly possible, while in vaginismus, as a general thing, it is impossible.

Kraurosis vulvæ, in its early stages, may have to be differentiated from vaginismus. Careful inspection, however, even at the commencement of the former disease will reveal the sensitive areas at the ostium vaginæ, as well as beginning shrinkage of the vulvar integument.

Course and Prognosis.—If not treated, the disease

goes from bad to worse, until the entire nervous system suffers, and the patients literally become nervous wrecks. Dyspareunia, frigidity, and sterility are the sequelæ. Masturbation may be the cause, but sometimes is the outcome of the disease. The prognosis depends upon the ability of the surgeon to discover and remove the underlying pathological condition.

The results of treatment, however, are almost invariably gratifying, though there is a small percentage of cases which resist all treatment. If pregnancy ensues, the condition almost always disappears after childbirth, although in rare instances such has not been the case.

Treatment.—As a matter of prophylaxis, it is necessary to instruct young men before marriage to avoid any brutal attempts at coitus on the wedding night. All attempts at coitus should be positively interdicted, until the condition has been cured. A thorough gynecological examination should be made, under an anesthetic if necessary, and any pathological condition found should be relieved.

After removal of the cause, we have next to treat the condition of spasm, which often remains as a pure neurosis, sometimes due to fear, even after the underlying cause has been eliminated.

In mild cases, before coitus is permitted, a pledget of cotton soaked in five per cent. cocaine solution, should be inserted in the vagina for a few minutes, and the vulvar region should likewise be painted with it. In other cases, the local hyperesthesia can be relieved by painting the affected parts twice a week with a four per cent. solution of silver nitrate.

In marked cases, however, we must resort to gradual dilatations of the vagina with vaginal dilators. These should be inserted in increasing sizes, and left in for an hour at a time. Later the patient herself may insert them several times a day.

Severe and obstinate cases require forcible dilatations or incisions. In either of these operations a general anesthetic is necessary, and it goes without saying that in any procedure undertaken, the hymen should be first thoroughly removed.

Withdrawal.—Coitus interruptus or withdrawal (by some called onanism) is the voluntary interruption of coitus by withdrawing the penis from the vagina before ejaculation takes place. The object of the procedure is to prevent pregnancy by having the ejaculation take place outside of the female genitals. Economic stress is the reason generally given, and it is indeed rare for the woman to avoid pregnancy on account of the pains of labor.

Pathology.—The physiology and pathology of coitus in the male has been given in the section on Impotence and in the female in that on Masturbation. It will therefore not be necessary to repeat them here.

Symptoms.—The symptoms may be divided into local and reflex. The local or sexual symptoms have been given in discussing the pathology of coitus in the section on Impotence.

When we come to the reflex symptoms, however, we find them to be of widely divergent character, and many of them do not in any way suggest their sexual origin. There is hardly an organ in the body whose workings may not be disturbed by reflexes coming from the abused sexual mechanism. Among these may be mentioned cardiac symptoms, symptoms suggesting sciatica, nervous exhaustibility, pain in the skin of the penis as well as general neurasthenia, gastrointestinal symptoms, etc.

The *diagnosis* can only be made by bearing in mind the possibility of such an etiological factor in conditions otherwise obscure. We must not neglect to suspect it, however, even if there has been a recent pregnancy, because the practice is not successful in many cases, and pregnancy may result in spite of it.

Course and Prognosis.—The general neurasthenic symptoms frequently disappear with remarkable and startling rapidity. Even when they disappear more slowly, the patient himself notices the improvement between each successive visit. In the sexual symptoms, the course is sometimes a direct reversal of the mode of onset. Thus, in cases which had gone on to complete impotence, the first attempts at coitus will be marked by premature or rapid ejaculation. Finally the lengths of coitus increase until the normal is reached. In those cases which were characterized at first by the presence of frequent pollutions, and later by their disappearance, there may be a reappearance of the pollutions while the patient is progressing toward recovery before the final normal stage is reached. The patient must be advised of this, else he may become discouraged, thinking that he is getting worse.

Treatment.—This consists in giving up the habit, and treating the impotence and pollutions as described under these headings.

Dyspareunia in the Male.—Under this heading a condition will be discussed which, I believe, has never been described as a clinical entity, although occasionally mentioned as a symptom. By dyspareunia in the male, I mean the exact counterpart of female dyspareunia, namely, pain during coitus. Under this heading I do *not* consider pain at coitus in the presence of acute inflammation of the urethra, for such is really irritation of an inflamed surface, and cannot be considered as a neurosis.

Etiology.—So far as my personal observation goes, I have seen dyspareunia in the male only as a sequela of either masturbation or withdrawal, and these two conditions must, therefore, be considered the most important if not the only etiological factors.

Pathology.—The pathological seat is to be sought for in the seminal vesicles and ejaculatory ducts. Inasmuch as none of these cases come to autopsy, we can judge the pathology only by analogy and by the result of rectal palpation of these parts. Inasmuch as the pleasurable feeling of the orgasm is the result of the squeezing of the seminal fluid through the ejaculatory ducts, we can readily understand how any inflammation of these ducts would be accompanied by a sensation of pain, especially where the inflammation is such as would cause a temporary narrowing of part of the lumen of the duct, and so cause a temporary resistance to the onward passage of the seminal fluid.

Symptoms.—The chief and only symptom complained of by the patient is a severe, acute, knife-like pain coming on just at the orgasm. It is generally felt in the perineum, although it may be referred to the anterior urethra, more especially at the meatus. The chief characteristic of the pain is its simultaneousness with the orgasm and its sharp, cutting, knife-like character. Upon examination, we always find the seminal vesicles enlarged and exquisitely tender. The same local conditions may also be found present in the urethra as are found in masturbation or withdrawal, although the symptom-complex may be present in the absence of every condition except the enlarged and tender seminal vesicles.

The *diagnosis* is to be made solely from the characteristics of the pain just described.

The *prognosis* is excellent, as every case treated by me so far has absolutely recovered. The cases are, however, rather infrequent.

The *treatment* is really the treatment of the underlying condition and consists briefly in abstinence from sexual intercourse, *gentle* massage of the prostate and seminal vesicles, the treatment of the accompanying congestion of the deep urethra by *weak* silver nitrate instillations, the avoidance of alcoholics as well as tea and coffee, and, in particularly bad cases, the temporary administration of bromides. For a detailed description of the underlying conditions, see the sections on Masturbation and Withdrawal.

Max Hühner.

References.

1. Groag, Paul: Uber nervöse Funktionsstörungen der männlichen Sexual Organe. Zeitschrift für Physikalische und Diäbetische Therapie, 1912.
2. Taylor, Robert W.: A Practical Treatise on Sexual Disorders of the Male and Female.
3. Dorland, W. A. Newman: The American Pocket Medical Dictionary, 1911.
4. Rohleder, Hermann: Die Zeugung beim Menschen.
5. Köster, Georg: Zur Kenntniss der Klitoriskrisen. München. med. Wchnschr., Jan. 29, 1911.

Neuroses, Traumatic.—It has long been known that, as a result of accidents, especially—but by no means exclusively—of those involving the head and back, there developes in certain cases a train of nervous symptoms in general resembling those of hysteria and neurasthenia. Sir Benjamin Brodie in 1837 first described local hysterical symptoms of this origin and certain observations on the subject were published from time to time, but to Erichsen, who in 1866 devoted the first serious study to the subject, we owe the foundation of most of our modern notions with regard to these troubles. Since his time a vast amount of literature has been devoted to the subject and the writings of Page in England, Charcot in France, Oppenheim in Germany, and Walton and Putnam in the United States, have been specially illuminating. With the vast increase in travel and the multiplication of industrial machinery, with a corresponding increase in the frequency of accidents among workmen, the matter has assumed a very great importance.

Naturally from the discussion of these neurotic symptoms, the results of gross trauma involving fracture of the skull or vertebræ and injury of the contents of the cranial cavity or of the vertebral canal are excluded. In practice, however, our chief task is often to determine whether or not a gross lesion of the nervous system has been produced.

In the production of the traumatic neuroses, something more than a mere trauma seems to be necessary, the elements of fright and shock playing an important part, while constant brooding over the probability of serious impairment of function and the hope of securing compensation, furnish abundant opportunities for autosuggestion. In no sort of happenings are these elements better combined than in railway accidents, hence the frequency of traumatic neuroses among the victims of such occurrences. A similar psychic effect is produced by contact with strong electric currents, though falls, blows on the head and traumata of the most varied sorts may be the starting-points for severe neuroses.

The increasing tendency of courts and juries to assess damages against railroads and other common carriers for injuries suffered by their patrons and the general adoption of measures providing for the compensation of workmen injured in industrial accidents, has greatly multiplied the number of claims and has undoubtedly furnished a powerful incentive to the simulation of neuroses, while even in those who intend no fraud the prospects of a money settlement held continuously before them and exaggerated by unscrupulous lawyers, stimulates the tendency to autosuggestion already present and so greatly exaggerates the intensity of the train of symptoms already set in motion by the accident.

As contributing factors, neurotic predisposition, alcoholism, chronic poisoning by lead and other metals, working in intense heat or amid surroundings causing a constant strain, and last but not least, a certain mental inferiority undoubtedly play a rôle.

As to the nature of the traumatic neuroses there has been much controversy. Starting from the original idea that they were due to actual, though molecular lesions of the central nervous system, opinion has gradually tended to the view that they are of mental origin differing from the ordinary psychoneuroses only in their exciting cause. Such was the view of Charcot and of his pupil Babinski, while Oppenheim, though admitting the similarity of their symptomatology to that of hysteria and neurasthenia, asserts that they are not identical with these neuroses but differ from them at many points.

Pathology.—In strictness a neurosis should have no pathological anatomy. However, it has not yet been definitely decided whether or not the traumatic neuroses depend upon fine changes in the brain and spinal cord. Few of these patients die as a result of their injuries and even in such autopsies as have been obtained, the findings have been mainly negative. However, Schmaus has shown that in animals, concussions of the spinal cord, though they did not produce any gross lesions, nevertheless led to degeneration of the axis cylinders of the nerves and to destruction of their medullary sheaths; while Bikeles, Kirchgässer, and Kazowsky found similar conditions in the medulla and spinal cord after blows on the head. Scagliosi and Luzenberger found changes in the ganglion cells, while it is well known that in death from strong electric currents there are congestion of vessels and minute hemorrhages into the central nervous system (Van Gieson and others). It requires no great stretch of the imagination to carry over these findings into human pathology.

Symptoms.—Probably the most marked feature in the traumatic neuroses is the mental state of the patient. In many cases the whole appearance denotes apprehension and dissatisfaction, with a certain tinge of distrust. The forehead is wrinkled, the eyebrows arched, the angle of the mouth drawn down, while the whole body is bent forward and movements, when they are made, are slow and hesitating. The patient is irritable and gives frequent expression to various hypochondriacal ideas dealing with the extent to which his nervous system has been shattered and the hopelessness of his recovery. Attempts at encouragement and explanation are apt to have little effect other than to convince the patient, either that the physician does not understand his case, or that the latter is really acting in the interest of those who wish to avoid paying the damages rightly due to him. These patients are apt to be emotional and perhaps weep for slight causes. They often complain of loss of memory, but in truth they are generally so absorbed in self-observation that they pay little attention to external affairs, so receive only very summary impressions of what is going on about them. They nearly all sleep badly, their rest being disturbed by dreams, and feel tired in the morning, but the complete insomnia often claimed is generally an exaggeration due, not so much to intentional falsehood, as to the feeling that they have not slept. When the injury has affected the head, complaints of headache and vertigo are very frequent. Particularly does the patient become dizzy and his face congested when he bends over. Epileptiform attacks have been occasionally observed even after trauma to an extremity, while localized spasm is not infrequent. General muscular weakness is nearly always complained of. The knee-jerks are nearly always exaggerated sometimes only on the side affected by the trauma.

Of all the objective symptoms, probably the most constant and striking are vasomotor phenomena. There is abnormal irritability of the heart, frequently increased rapidity of the pulse, and it is held that such disturbances long continued, may lead to the early development of arteriosclerosis. The skin often shows cyanotic areas, the patient flushes easily, factitious urticaria (dermographism) is quite common, while the so-called "hard edema" is sometimes observed. Alopecia and premature grayness are occasional symptoms. There is motor weakness, often with tremor, which increases with excitement and self-observation. The tendon reflexes are generally

increased while pareses and paralyses having the general characters of those found in hysteria are not infrequent. In injuries to the head the paralysis is apt to assume a hemiplegic, in those to the spine, a paraplegic type, though it may be a monoplegia. It is noteworthy that in monoplegia or hemiplegia, the paralysis is always on the side of the injury. The face always escapes. The paralysis is occasionally flaccid but it is more commonly spastic and contractures are apt to supervene. The paralysis is usually more complete than one of organic origin since it is dependent upon the loss of the motor memories necessary to carry out the desired movement. On the other hand associated movements, or those produced in a reflex way, may still be possible. There may be slight atrophy of the affected muscles but there is no reaction of degeneration.

Sensory anomalies are frequent, though not constant. They consist of anesthesia, pain, and paresthesias of various sorts, most commonly on the affected side. Hyperesthesia is usually limited to the skin area over the injured part, but anesthesia may affect the whole or the greater part of a limb. Sometimes, while there is anesthesia or hypoesthesia for pinpricks, touch is experienced as painful.

A very important symptom in the traumatic neuroses is concentric limitation of the visual field. This affects both eyes, but where there is hemianesthesia it is generally more marked on the anesthetic side.

Ear symptoms such as tinnitus and impaired hearing are common enough. When there is hypoesthesia or anesthesia, the skin reflexes are generally diminished or lost. Pain in the joints is often present. In many cases the locomotion of the patient is affected, and the most varied disturbances of gait are seen. Walking is often impaired through stiffness and pain in the back and the stiffness of the legs often simulates a spastic gait, but the toes do not scrape the floor in the same way as in spastic paralysis and when the patient is lying on his back, there is no true muscular rigidity. There may be a staggering gait, even a pseudoataxia, which, however, does not resemble either the ataxia of tabes or cerebellar ataxia at all closely.

Speech disturbances allied to stammering, sometimes occur, but stumbling speech is very exceptional if it occurs at all.

The pupils react to light and any failure on their part to do so is strongly suggestive of an organic lesion. Slight differences in size between the two pupils sometimes occur, however, while rapid dilatations and contractions without change in the light reaching the eyes—hippus—is not infrequent. Nystagmus almost never occurs.

Nutrition may become greatly impaired, though this is the exception rather than the rule. Disturbances in the urinary secretion and discharge are sometimes complained of and a traumatic diabetes has been described.

According to Mann, in cases in which there is a feeling of pressure in the head, vertigo, and tinnitus, the resistance to the passage of the galvanic current through the skin of the head is reduced. Friedmann has described what he calls the "vasomotor symptom-complex" as occurring after head injuries. This consists in headache, vertigo, congestions, nausea, intolerance to alcohol, occasional febrile attacks and pareses in the territory of the cranial nerves which last but a short time. This form "the congestion neurosis" he would distinguish from the psychogenic variety. In some cases with these symptoms, disease of the finer cerebral vessels has been found, while serous meningitis may also play a rôle according to Quincke and Weitz.

The symptoms above described, however, are those of the severe cases. In the great majority of instances there is rather a general complaint of weakness and pain with but few or no objective symptoms. It will be recognized that nearly all the symptoms enumerated occur in the psychoneuroses, hysteria, neurasthenia, and hypochondria. Many authors in fact consider them as manifestations of these neuroses and speak of traumatic hysteria and neurasthenia.

Diagnosis.—In a case of traumatic neurosis the history should be taken with the same care as in nervous diseases of other origin, since unless this is done, important etiological factors are apt to be missed. The discovery of the signs of constitutional inferiority of the nervous system is important as lending probability to the functional nature of the case. When a train of nervous symptoms presents itself in the victim of an accident, it is important to find out first—if possible—if any such symptoms were present before the accident. If there were not, are the symptoms present such as could well be the result of such a happening? Next the nature of the accident and the circumstances attending it, are to be considered and statements as to the patient's condition immediately after the accident, whether he lost consciousness, if he could walk or had to be carried, etc., should be obtained if possible from someone who was present and the sequence of events up to the time of the examination should be traced, special attention being paid to the status of any claim for damages which he may have. The direct examination of the individual may then be taken up. Above everything, questions likely to suggest symptoms are to be avoided, for the relationship between the traumatic neuroses and hysteria are of the closest, most authors holding that the suggestive effect of the accident, the attending circumstances and the subsequent proceedings are responsible for the whole clinical picture. The physician should, however, preserve an open mind as to the question of simulation, for while undoubtedly a great portion of the symptoms are of mental origin and due to suggestion either from without or within, most of these patients are not intentionally falsifying but honestly believe in the actuality of their injuries and their sufferings are real enough to them. However, the previous record of the individual is of importance here, for professional malingerers are unfortunately numerous enough. The objective symptoms are to be proved by comparing them with similar symptoms known to be of organic origin and also with those of hysteria. For example the gait may be spastic, spastic-paretic, or ataxic, but seldom agrees with that due to organic disease affecting the lateral or posterior columns and many curious variations are seen. For example, a patient recently examined had a peculiar mincing, somewhat spastic gait, in which the thighs were not flexed on the body at all, the legs being moved at the knee-joint only. While this pseudo-spastic paralysis is often accompanied by tremor, this tremor is increased on excitement and not in intended movements as in multiple sclerosis. In general the paralyses found in the traumatic neuroses, present similar characters to those seen in hysteria. In a man struck by a car, a paralysis of one leg came on a week later, the leg was dragged after him in its entirety and was anesthetic. A hemiplegia is apt to occur on the injured side and may be accompanied by hemianesthesia. It is to be remembered, however, that a blow on one side of the head may produce an injury on the opposite side of the brain. Tremor is present in a large number of cases of traumatic neurosis. It may resemble that of paralysis agitans or that of hysteria, but is apt to be lessened upon voluntary movement contrary to that of multiple sclerosis, which is increased.

While the tendon reflexes, especially the knee-jerk, are nearly always increased in the traumatic neuroses and both knee and ankle clonus are occasionally found, the presence of the Babinski or Oppenheim reflex should always suggest organic disease. Loss of knee-jerk is practically never found except in organic disease, but all the methods of reinforcing it should be tried and only on failure to obtain it by any of these

methods should it be reported as absent. The other tendon reflexes are of little value in the diagnosis between organic and functional conditions. The skin reflexes are of importance in that, if those arising from a given territory are normal on both sides, it would militate against the claim of the patient that one side was anesthetic, while inequality between the two sides would point to diminished sensation on the side of lessened reflexes. The pupillary reflexes are important, in that loss of contraction to light always suggests organic disease—generally tabes, general paresis, or cerebral syphilis. The bladder reflexes may be disturbed in traumatic neuroses, but there is seldom more than temporary inability to void urine. Trophic disorders may occur after trauma as mentioned above, but any marked muscular atrophy, especially if there is reaction of degeneration, is an indication of nerve or spinal-cord involvement.

The subjective symptoms are, of course, much more difficult to confirm and to estimate, since here, the question of simulation comes in particularly. Loss of sight or of hearing are not infrequent complaints. In the investigation of these the aid of the specialist is generally advisable. However, the general practitioner can carry out some simple tests like the following. Concentric limitation of the visual field is a very characteristic sign of hysteria and occurs also after trauma. This is best determined by the perimeter, but can be roughly tested by having the patient close one eye and fix the examiner's finger with the other; the other hand best holding some white object like a folded pocket handkerchief is then slowly brought around from back of the patient's ear and he is asked to indicate when he first sees it. Blindness in one eye can be tested by writing a short sentence having alternate words in red and in black ink, which the patient is asked to read, while a red glass is placed in front of his good eye. If he really is blind he will leave out the words in red, while the reading of the whole sentence proves that he can see with both eyes. Unilateral deafness can be tested by standing behind the patient and placing in his ears the ear pieces of a binaural stethoscope provided with rather long pieces of rubber tubing. The fingers are now placed on both pieces of tubing and the observer talks into the receiver while he from time to time compresses the tube leading to the sound ear. If now the patient does not experience a gap in the conversation he quite surely hears in the supposedly deaf ear also.

In testing common sensibility the patient should not be asked whether he feels or not, but his expression, the state of his reflexes and the protective movements carried out, should be carefully watched while the stimulus is applied. The distribution of the anesthesia when it is present is important as that of functional origin generally occurs in bands, in isolated areas or as hemianesthesia, while that from organic lesion is either segmental or corresponds to a definite nerve territory. The intensity of the stimulus should be varied from time to time and the reaction from different areas should be compared with what is known to be normal for these areas. To decide whether the patient actually suffers pain or not is difficult, often impossible. In general, slight pain increases, severe pain retards the heart's action. Especially does pressure over a painful point cause quickening of the pulse (Mannkopf's symptom). Oppenheim has noted that a painful position of the affected part has a similar effect, also that pain is apt to produce vasomotor phenomena, for instance flushing of the corresponding side of the face. In general, prolonged and careful observation of the patient is necessary for a correct estimation of his subjective complaints and this unfortunately is not always practicable. Damage suits are often decided by the testimony of someone who has been able to watch the claimant while off his guard.

Prognosis.—In the milder cases of traumatic neurosis recovery may be expected though the local symptoms may be very persistent. "The more the psyche is involved, the more unfavorable in general is the prognosis" (Oppenheim). If there are marked cardiovascular symptoms the development of organic heart disease and arteriosclerosis is favored. Injuries from strong electric currents are always to be considered as serious and a guarded prognosis made. In general, the outlook depends a good deal upon how promptly any claims are adjudicated, as the effect of long-continued litigation is most unfavorable. The sooner the matter can be closed up, the better for the patient, and it is usually wiser for him to accept a moderate settlement than to risk the deleterious effect of a long conflict in the hope of being awarded a large sum of money. Most of these long-continued cases do not recover even after they have been paid in full. The plan of paying a weekly or monthly sum during the time of disability has been found to be a bad one and in Germany where it has been longest in force, most physicians are advising the payment of a lump sum and making the claimant understand that he can expect no more, or that of making payments depend upon his going to work and doing what he can.

Treatment.—There is no doubt that the neurotic symptoms are increased by idleness and continued self-observation and are benefited by enough employment to occupy the patient's mind.

The usual measures appropriate to the psychoneuroses, such as change of scene—often to some suitable health resort—and the milder forms of hydrotherapy, electrotherapy, and massage, together with tonics, have the widest range of application. All violent measures are to be avoided. At times, a certain amount of judicious neglect may be advisable. Above everything the value of a well-regulated psychotherapy is to be kept constantly in view. Probably most of the physical measures of treatment act largely through their effect upon the mind of the individual. Galvanization of the head and the spine according to the methods described under electrotherapy may be of use in some cases; also galvanic and faradic applications to the muscle may benefit the functional paralyses. For anesthesia the faradic brush is sometimes of value.

Charles Lewis Allen.

Nevus.—*Synonyms:* Mother's mark, birth-mark, portwine mark.

Definition.—A nevus is a congenital alteration of the skin, confined to a limited area and characterized by an increase in the amount of pigment deposit, and by a certain amount of hypertrophy of one or more of the other elements of the skin, especially the vascular and connective tissues, as well as the hair, fat, nerves, and lymphatics. Unna aptly describes nevi as: "Circumscribed, small malformations of the skin, which have a hereditary basis, or have their foundations laid in embryonic life, become evident at different periods of life, develop very slowly, and are distinguishable by their color or the form of their surface."

The following varieties of nevi may be distinguished: *Nevus fibromatosus; N. lipomatodes; N. pigmentosus; N. pilaris* or *pilosus; N. unius lateris* (*N. linearis*); *N. vascularis; N. verrucosus.*

Nevus fibromatosus is marked by excessive connective-tissue development; it varies in size and involves the skin in different parts of the body. As subdivisions may be mentioned: N. foliaceus, in which the central portions are fibrous, while the circumference is vascular; N. mollusciformis, a protuberant pedunculated form and N. sarcomatodes, which at first is a simple congenital nevus, but afterward undergoes sarcomatous degeneration.

Nevus lipomatodes is a congenital fatty tumor (lipoma), usually more or less fibromatous.

Nevus pigmentosus, the commonest form of nevus, is characterized by an excessive deposit of pigment in a circumscribed area of the skin. The discoloration thus produced varies from pale yellow to purple or even black. The lesion, which is usually level with the skin, occurs especially on the face, hands, neck, arms, and back. This variety of nevus is often verrucose, or elevated; at times it is more or less covered with hair and is then designated as *Nevus pilosus* or *N. pilaris*.

Nevus vascularis, N. sanguineus—"mother's mark," includes a large number of forms, among which are now classed varieties of angiomata, which embrace tumors of embryonic rudimentary vessels.

The vascular nevus may involve the capillaries, the smaller veins, or the terminal arterial branches.

The capillary nevus is distinctly cutaneous and in size varies from a pin's head to the palm of the hand or

Fig. 4140.—Case of Angiofibroma of Congenital Origin. (Case of Dr. Isadore Dyer.)

even a larger area; at times it involves whole regions of the body. This is the form of nevus most commonly met with. It is usually only slightly elevated, or it may even be level with the surface of the skin. It is often seen as a tiny red spot with lines (dilated capillaries) radiating from a central point of vascular hypertrophy, and to it are applied the terms "spider nevus," or "spider cancer," or *nevus araneus*.

Vascular nevi often begin indistinctly and spread gradually until they cover large surfaces. On the other hand, nevi, present at birth, may within a few months entirely disappear spontaneously.

The venous nevus is apt to be more elevated than the capillary. It is smooth, stands at a higher level than the surrounding surface of the skin, is soft and compressible, and often is lobulated. The thin-walled veins of which it is composed communicate directly with one another and are bound together by delicate bands of connective tissue, thus constituting a network of intercommunicating venous sinuses. Such a formation should be called a nevus cavernosus or an angioma, for such in reality it is. These tumors are markedly irregular in form, reddish or bluish in color, and at times erectile (in women this is especially noticeable at the time of menstruation).

Although there have been reported many instances of congenital nevi which seem to confirm the belief that prenatal events, through the impressions which they make upon the mother, sometimes play a part in the causation of these tumors, the best modern authorities are opposed to this view.

Nevus Verrucosus.—A warty nevus, often having a hairy growth, and at times highly vascular and erectile.

Nevus unius lateris is excluded, by Unna, from the nevi, but only provisionally. I am disposed to believe that this type of growth may properly be classed among the nevi. It embraces a number of types of nevus, in which the essential feature is the arrangement in a linear way following the distribution of the superficial nerves. Some attempts have been made to show the association of this form of nevus with previous neurotic influence, injury, shock, etc. The terms N. neuroticus, N. linearis, papilloma neuropathicum (neuroticum), etc., have been applied to this type. That the term *unius lateris* is a misnomer is evident from the fact that the author has had two cases of bilateral distribution. To these he has given, by preference, the name "linear nevus."

It is certain that there is a distinct difference in the arrangement of the lesions between this variety and the ordinary nevi. The arrangement is in sprays and clusters of lesions, which vary in character, some of them having a pale yellow pigmentation, while others are black. Then again there are also differences in structure, some of the growths being clearly vascular nevi while others are mere papillomatous growths. In some cases there is even involvement of the lymph vessels (lymphangioma). The occurrence of linear nevus in subjects of disordered hypophysis, as related by Cushing, and the variations in growth due to the

Fig. 4141.—Vascular and Verrucose Linear Nevus of the Cheek. (Case of Dr. Isadore Dyer.)

general state of the patient, opens up a new idea of this form of congenital lesion. The association with the pituitary gland, if entirely established, makes the treatment debatable unless the controlling factor of the hypophysis is taken into consideration. Opera-

tive procedure on the hypophysis is known to affect these nevi; would it not be likely to effect a cure if the central operation were complete, without undertaking local interference at all?

The PATHOLOGY of nevi is of only indirect importance, as the condition is not difficult of diagnosis and the treatment is essentially radical.

Unna quite exhaustively reviews the histological evidence in regard to the different types of nevus, and discursively argues the embryonic origin and course of the several varieties classed by him under the term nevus. Soft nevi, or the warty, epithelial types, are recognized as embryonic deposits in the upper part of the cutis, while the hard nevi are either of prickle-cell layer origin or else are found chiefly in the horny layer. The more complicated nevi are also considered by him in their complex pathology.

TREATMENT.—The necessity for treatment of nevi must depend upon the character, the location, and the size of the lesion or lesions. Simple pigmentary moles are of little serious importance, and, on account of their harmless character, they need not be removed. In exceptional cases the melanotic mole calls for early operative interference. Even the simple moles, when there are several of them, often cause sufficient disfigurement to warrant their removal by surgical interference. Hairy moles are especially disfiguring. In the case of vascular nevi, on the other hand, the danger of accidental hemorrhage must also be taken into consideration.

There are not a few different ways in which nevi may be treated. For the simple pigmentary moles and also for those of a verrucose character the employment of escharotics will often suffice. Of these we might name carbolic acid, chromic acid, glacial acetic acid, picric acid, acid nitrate of mercury, corrosive sublimate, cantharides (in collodion or in ether), pyrozone, sodium ethylate, nitrate of silver, nitric acid, salicylic acid (alcoholic solution or in collodion), chrysarobin, chrysophanic acid, pyrogallic acid, liquor potassæ, etc. In simple, warty nevi, covering the lesion with carbonate of soda, overlaid with adhesive plaster, will often result in resolution and disappearance of the mass in a few days.

In the case of large lesions, or where the location forbids the use of caustic applications, the actual cautery—the Paquelin or the galvanic—should be used.

In small pigmentary nevi electrolysis is preferable. To the negative pole of a galvanic battery a small needle (steel, platinum, or gold) is attached. The positive pole carries the sponge, which is customarily held in the patient's hand. The needle is introduced beneath the pigmented mole and the current is gradually increased until the lesion blisters. To accomplish this a current of about eight or ten milliampères is required, or, if cells with switchboard are used, there should be as many as from twelve to twenty cells. Where the moles are hairy, a blunted broach or needle should be employed. The hairs are removed first by electrolysis, and then the mole itself is removed by the ordinary operative procedures. In removing the hairs the needle should be gently introduced into the hair follicle, the hair shaft serving as a guide and care being taken not to pierce the follicle. The current is gradually applied until there is frothing at the orifice of the follicle, when the hair is ready to come away. If there is resistance on the part of the hair, the operation is not complete. Not more than from three to five milliampères is needed in this operation; in fact, in some instances a single milliampère will be found sufficient. The negative pole of course must be used here.

In the treatment of vascular nevi, electrolysis is likewise of service, but more particularly in those in which the area of skin involved is small, and the vessels forming the growth are simply capillaries. The object of the treatment here is either to cause the absorption and atrophy of the blood-vessels or to effect their destruction. Various procedures, all of them more or less inefficient, have been suggested for the accomplishment of these objects, but as the space at our command is limited, we shall describe only those which have stood well the test of time.

There are two methods for using the ligature. First of all, it is a good plan in smaller nevi to circumscribe the growth with a single or double silk ligature, drawing tightly and tying on opposite sides of the growth, when the double ligature is used. In the case of the larger nevi, the ligature is applied at a point a little remote from the growth. An incision is made above the vein, or small artery, a catgut ligature is applied, and the wound closed. In either instance the growth begins to pale after several days. In superficial nevi the whole patch grows bluish in color. Here and there a spot grows white where the blood has been absorbed, and finally, in the successful cases, the whole patch grows whiter and whiter. When it is thought best to resort to excision, as in the case of deep-seated nevi, it will often be found advisable to ligate a few days or weeks before the excision. When the cautery is employed, several methods may be followed. A fine platinum needle may be attached to the galvanocautery, raised to a red heat, and then introduced into the growth several times in succession. Linear cauterization may equally well be carried out by means of the needle or with the small platinum knife. The Paquelin cautery will serve the same purpose.

Caustic pastes (Bougard, Felix, Marsden, etc.) act as the cautery does, by producing an eschar, and finally a slough. With caustics, however, the slough is apt to be more extensive than when the cautery is used. Hence the need for caution in using them.

Vaccination has been used in locations where an irregular scar is no objection. The slight bleeding need not be stopped, except by a temporary compress.

The injection of pure carbolic acid or the tincture of iodine is followed quite often by gratifying results. Little scarring remains, plugging of the vessels is rapidly obtained, and the operation is less painful and of shorter duration than when other methods are employed. The injection of a one-per-cent. solution of chloride of zinc is used for the same purpose. The perchloride of iron may be used by injection, or, as is frequently indicated in the more elevated growths, silk threads, saturated with the perchloride solution, should be passed in several directions through the nevus, and be allowed to remain until they are absorbed in the contraction, or else slough out.

Except in the case of small nevi, the treatment is never highly satisfactory, and the methods employed may have to be changed several times before the whole of the growth is removed. It is always well to impress upon the patient the necessity of perseverance in the matter.

Where the patient will submit, the use of repeated ignipuncture with the Paquelin cautery under a general anesthetic will effect good results; otherwise the electric needle is of most service. A number of cures have been reported after long use of electrolysis. For extensive nevi of the capillary variety, multiple needles (as many as a dozen) attached to the negative pole of the galvanic current may be employed. This does not answer so well as the single needle frequently introduced. The amount of current required varies with the patient and should be regulated accordingly, a mild current being used at the start.

The technique of this operation is as follows: The patient should hold the sponge electrode and should turn on the current when the needle is introduced and turn it off when the needle is withdrawn; or, if he does not mind the greater painfulness of the procedure, he should keep the sponge constantly applied. The needle may be pushed in to a depth of at least half an

inch below the surface of the skin and parallel with it, and it should be allowed to remain until a distinct eschar, in the form of shrivelled skin, shows itself along the line of the needle. This procedure is to be repeated at each sitting as often as the patient will permit. As this linear operation almost always leaves ridges as the ultimate result, it is probably better to introduce the needle simply at a right angle to the surface of the skin, leaving it in position until a small blister forms. Several such punctures should be made at each sitting, and they should be located as closely together as possible. At each sitting, for a few succeeding days, a new area should be selected, and then each area in turn, beginning with the one first selected, should be gone over a second or even a third time, until finally the region so treated presents the appearance of a white superficial scar.

For the cavernous variety of nevus the electrolytic method is not so well adapted. In the treatment of this condition by electricity the positive pole is supplied with a platinum and the negative pole with a gold needle, or *vice versa*, and both are introduced at once, deeply. The strength of the current is gradually increased to the limit of the patient's endurance, and is kept applied as long as possible.

In both varieties of nevus it requires months of treatment before any result is obtained, but usually the patient's endurance is finally rewarded. The most satisfactory treatment of all forms of nevus to-day is with carbon-dioxide snow. The ordinary tank of carbon dioxide is used, the gas allowed to escape into a chamois skin cloth pocket and then the solidified gas is packed in a cylinder of glass or other material so as to make a solid stick; in the absence of any other utensil, the ordinary solid silver ear speculum is excellent for the purpose. A cone of the snow is formed and with one end against the nevus pressure is used and the snow kept in contact from fifteen to thirty seconds. The thicker the nevus, or the more cavernous, the longer the application. The area blisters in a few hours; the blister dries and ultimately falls off, leaving little or no scar. Several applications may be needed, but the result is excellent. The high-frequency current is also employed in nevus flammeus with good results.

In pigmentary and flat nevus radium has also been used, but it would seem to have no advantage over the carbon dioxide; in vascular types it may also serve in small lesions. ISADORE DYER.

New Mexico.—The surface of the state of New Mexico forms a great plateau sloping in a general way from northwest to southeast. Santa Fe at the north, the highest town of importance, has an elevation of 6,947 feet, while Carlsbad in the southeast has an altitude of 3,100 feet. The inhabited portions of the surface may be said to vary in height from 7,000 to 3,000 feet. A feature which distinguishes New Mexico from the other portions of the Rocky Mountains plateau is the absence, except in the northern part of the State, of the continuous ranges of high mountains which divide the States to the north into eastern and western halves. The Rocky Mountain range proper ends near Santa Fe. To the south of this point the surface of the plateau is broken by numerous mountains, which form small chains of usually no considerable elevation above the plateau and are irregular in their course and distribution.

The divide between the waters of the Gulf of Mexico and those of the Gulf of California runs irregularly through the western portion of the state. The chief rivers are the Rio Grande, which arising in Colorado bisects New Mexico into two nearly equal halves, and the Pecos which arises in the mountains near Santa Fe, pursues a southerly course through the eastern portion of the State, and finally joins the Rio Grande in Texas.

The extreme northwestern part of the State, largely given up to Indian reservations, has but a small population, chiefly Mexicans, and is of little importance in the study of the climate from a medical point of view. The northeastern part shares to some extent in the climatic peculiarities of Colorado, having a somewhat harsher climate and more precipitation than the more southern portions of the State. The southeastern part of the State along the Pecos valley has the lowest elevation of any part of the New Mexican plateau. It is therefore hot in summer and it receives a share of the "northers" of Texas, hence sometimes storms and relatively severe cold in winter. From Santa Fe south, with the exception of the Pecos valley just referred to, the climate is remarkably uniform throughout the State. Differences that exist are dependent less upon latitude than upon altitude, or to some extent upon local conditions such as trend of valleys, proximity of mountains, etc. The climate, like that of all plateaus, is dry. The heat of the day is easily borne on account of the freedom of evaporation. The nights are relatively cool at all seasons, the air cool in the shade even in warm weather.

New Mexico enjoys a remarkable exemption from severe storms. As the Weather Bureau officials say, the State lies without the "normal stormtracks." Of 1,133 transcontinental storms observed during ten years but twenty-three, or only a little more than two per cent. passed through New Mexico. In August and September there were none. In October three passed across Arizona and New Mexico from southern California, four began in northeastern New Mexico or western Texas. In November five originated in Colorado or northeast New Mexico, none passed through the remainder of the State. There were no storms in January. The remaining eleven storms to be accounted for were distributed through the other months of the year. The rainfall of New Mexico occurs chiefly in the summer. The snowstorms of winter are scanty and infrequent and the snow rarely lies long on the ground. The spring is the driest season, entire absence of precipitation or showers which leave but the merest trace of moisture being the rule in the months of April, May, and June. The summer rains usually begin early in July. Thunderclouds roll up about noon and the rains occur largely in thunderstorms during the afternoon and evening. The result of this distribution of precipitation is to make for coolness in the summer afternoons. Hence, June, a dry month, is usually hotter than July and August. But these considerations apply chiefly to places of medium or high elevation in which the rainfall is fairly abundant. In years of relatively abundant precipitation the rains continue during the autumn. The heaviest precipitation, however, almost always takes place in July, August, and the early part of September.

The dryness of the spring is an unusual climatic feature which leads to misapprehension as to the aridity of the region in the mind of the newcomer at that season. It is not infrequently the case that the rainfall of spring is insufficient to start the growth of the grass. The trees put forth their leaves as usual, but herbaceous plants at the lower and medium elevations await the rains of summer. In July the country becomes transformed and the driest mountain slopes are covered with verdure and with flowers. The height of growth of the vegetation is reached about September first. At this time, if the rainfall has been normally abundant the country is covered with tall grass and the flowers are at their best.

The freedom from storms in winter is especially noteworthy. As has been stated the winter months are relatively dry. Practical experience shows that while dry cold is stimulating and easily borne, cold and dampness combined produce a chill out of proportion to the temperature. No one is more keenly con-

scious of this fact than the patient who leads the outdoor life at rest and no single factor is of more importance for his comfort than a dry air during the cooler portions of the year. At Saranac the requisite dryness is secured through the intense cold; in New Mexico, more agreeably for many, by the comparative absence of precipitation during the winter. The following table, compiled from reports of the Weather Bureau, gives the mean monthly precipitation for some of the more important towns of New Mexico as well as, for purposes of comparison, of some of the principal towns in Arizona and Southern California. The data given for Fort Bayard and Mesilla Park apply also to Silver City and Las Cruces respectively. Since the elevation bears an important relation to the amount of precipitation the altitudes of the places of observation are also given.

In studying this table we notice that Santa Fe and Las Vegas, the most northern of the New Mexico towns, are like Colorado in that there is a fair amount of rain in the months of April, May, and June. Cloudcroft with its much higher altitude has more than an inch of rainfall every month in the year except April and May. In the other New Mexico towns the precipitation is insignificant except in the months of July, August, and September. This is true also of Tucson and Phoenix. Prescott shows a double rainy season, a summer rainfall like that of New Mexico, but also a precipitation of more than an inch in the months of January, February, March, November, and December. Los Angeles and San Diego have almost their entire rainfall in the winter months. The rainfall as given in this table, taken in connection with the altitude, shows more distinctly than data as to temperature where the invalid can secure the greatest comfort in his outdoor life both in winter and summer. It is hardly necessary to point out that comparative freedom from driving rains and snows during the cold season is as important for comfort as the condition of the air with reference to dampness.

Mean Monthly Precipitation.

	Altitude.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Las Vegas	6,384 ft.	0.47	0.93	0.62	1.00	1.95	1.76	4.07	3.36	2.32	1.04	0.82	0.63	18.97
Santa Fe	6,947 ft.	0.61	0.89	0.72	0.85	1.05	1.14	2.65	2.58	1.65	1.04	0.79	0.75	14 72
Albuquerque	4,943 ft.	0.40	0.24	0.21	0.53	0.39	0.76	1.16	1.30	1.88	0.73	0.51	0.40	7.51
Alamogordo	4,338 ft.	0.62	0.56	0.45	0.49	0.16	0.66	1.73	2.37	1.20	0.71	0.76	0.63	10.34
Cloudcroft	8,650 ft.	1.95	1.76	1.20	0.90	0.62	1.46	3.21	4.25	2.86	1.48	1.81	1.42	22.92
Fort Bayard	6,140 ft.	0.89	0.97	0.70	0.32	0.32	0.67	3.18	3.28	2.06	1.18	0.77	0.80	15.20
Mesilla Park	3,863 ft.	0.32	0.46	0.29	0.17	0.24	0.53	1.86	1.67	1.36	0.70	0.58	0.44	8.62
Prescott	5,320 ft.	1.56	1.96	1.71	0.82	0.55	0.24	2.85	3.20	1.05	0.78	1.11	1.57	17.40
Tucson	2,390 ft.	0.77	0.94	0.76	0.32	0.12	0.20	2.44	2.63	1.14	0.53	0.73	1.08	11.66
Phoenix	1,108 ft.	0.85	0.87	0.61	0.33	0.11	0.08	0.89	0.94	0.69	0.37	0.67	0.86	7.27
Los Angeles	293 ft.	3.00	2.83	3.10	1.00	0.45	0.07	0.01	0.03	0.13	0.72	1.31	2.93	15.58
San Diego	93 ft.	1.77	1.93	1.52	0.63	0.33	0.06	0.06	0.11	0.08	0.34	0.95	1.84	9.62

Mean Relative Humidity.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Fort Stanton	58	54	45	34	33	39	55	58	59	54	59	61	51
Santa Fe	54	53	53	34	36	33	49	47	46	46	48	54	46
Roswell	63	57	49	50	45	50	62	67	66	65	68	66	59
Mesilla Park	52	52	46	42	40	42	54	58	59	56	55	53	51
Los Angeles	65	70	72	73	76	75	75	75	72	71	64	60	71
San Diego	71	74	74	75	77	79	80	80	78	76	71	67	75
Phoenix	50	45	38	31	26	22	35	39	38	38	44	44	38

The humidity of the air as shown by the wet bulb thermometer is also of importance in this connection. Unfortunately not many observations of this kind have been taken in New Mexico. The subjoined table gives the data for Santa Fe, Fort Stanton, Roswell, and Las Cruces (Mesilla Park). For comparison the figures that are available for California and southern Arizona are added.

It will be noticed that the percentages for Santa Fe, naturally higher in the cold season, are very low in summer notwithstanding the precipitation. The readings for Phoenix show a similar though lesser rise in winter, but are very low for all seasons, while the humidity of Los Angeles and San Diego on account of their proximity to the sea bears no relation to the precipitation but is higher during the summer months when the rainfall is least.

Few appreciate to its full extent the influence of humidity upon comfort in warm weather. The "sensible heat" or the readings of the wet-bulb thermometer are much more important physiologically than the actual temperatures. The Weather Bureau once instituted simultaneous thermometer readings throughout the United States in midsummer. The hour chosen was 8 P.M. Eastern time, which was equivalent to 6 P.M. Mountain time and 5 P.M. Pacific time. Naturally the Southwest was found the warmest part of the United States. But when the readings of the wet-bulb thermometer were considered the case was very different. Lines of equal sensible heat showed the arid region the coolest part of the United States. The line of 60° sensible temperature starting in northern New England skirted the northern boundary of the United States to the 110th meridian, then pursued a south-southeasterly course to southeast New Mexico, thence westerly to the neighborhood of Los Angeles. Southern New Mexico and Arizona were as cool as Denver, as Havre, Mont., near the British line, as Lake Superior, as Portland, Me., as Halifax!

Notwithstanding the great assistance afforded by evaporation in reducing temperature, the summer heat of the lower levels is severe at midday. In a general way it may be said that the altitude of 4,500 feet is the least at which the summer temperatures would be considered agreeable. A height of 5,000 to 7,000 feet is to be preferred for summer residence. Some of the charts of the Weather Bureau are apt to mislead as to the temperature of New Mexico, because they reduce the temperatures to sea-level temperatures. The isothermal lines upon these charts do not pass through places of really equal temperature. The temperatures given for towns of high altitude are not those actually recorded, but represent the readings which would theoretically have been made if the places of observation were at the level of the sea.

For one who leads the outdoor life, not only the temperature and the humidity are important conditions, but also the winds. Cyclones are unknown in New Mexico and violent winds are not common. "The average hourly wind movement" of the Weather Bureau does not mean much unless we are informed as to the height and location of the anemometer. As given, the annual average wind movement for Santa Fe, Fort Stanton, and Mesilla Park is seven miles per

hour as compared with fourteen miles per hour for Amarillo, Texas, and ten miles per hour for El Paso.

The prevailing direction of the winds is from the west. But on account of the hilly or mountainous surroundings of many of the towns, and the tendency of air currents to flow up and down the river valleys, there is a considerable divergence in the reports of individual weather observers as to the direction of the winds. The winds accompanying rain naturally vary according to the location of the storm center. In the local precipitations of the summer months there cannot be said to be any prevailing direction of the winds. The steadily blowing winds are the winds of the dry season. In the part of the state best known to the writer their prevailing direction is from the southwest. The mornings the air is comparatively still, but the wind rises toward noon, quickly reaches its maximum and gradually declines with the sun, generally ceasing at sunset. The force of these winds is usually not great. It is their persistence which becomes wearing upon the nerves, especially when combined with the glare of the afternoon sun. For these reasons in selecting a residence it is important to learn the direction of the prevailing winds and find or build a sleeping porch (which will serve at the same time for passing many of the waking hours of the invalid) on the leeward side of the house. As a rule, perhaps the east side is the place of choice for such a porch, the occupant of which will then be sheltered not only from the wind but from the sun during the hottest hours of the day.

Associated with the wind is more or less dust, the amount of inconvenience from which, of course, varies greatly with the local conditions. At Fort Bayard the dust which was formerly annoying during the dry season has been so diminished by the planting of grass and by permitting the natural grasses to grow by the exclusion of cattle that it is now hardly noticeable. The more drought-resisting grasses, such as Bermuda grass, can be cultivated without irrigation if started in the rainy season. Much more can be done than is commonly supposed to mitigate the inconvenience arising from the dust which is an inseparable feature of all dry climates.

It cannot be too much emphasized that the climate of New Mexico is essentially a cool climate. Though the heat be great at noon the nights will be cool. On the other hand in winter though, as rarely is the case, the mercury may have reached zero during the night, if the next day is clear the sun will be warm and extra wraps may be unnecessary for walking. The climate of New Mexico is relatively equable in that there is a freedom from the sudden and violent changes from heat to cold and *vice versa* which afflict more northern latitudes, and in that the extremes of cold and heat, especially sensible heat, are much less. It is not equable in the sense that there is litte difference between the temperature of day and night, and therein lies one of its greatest advantages. As pointed out by Weinzirl,* the benefit of altitude is largely due to its stimulating effect upon the bodily processes. In the northern mountains the air, bracing for the robust, is too keen for the invalid. In New Mexico the altitude is so to speak guarded by the latitude. The heat in summer is made tolerable by the cool dry air; the cold in winter is not intense and is mitigated by the heat of the sun, the freedom from precipitation not only making for unclouded skies but for dryness of the air. Hence the enfeebled body of the invalid experiences the stimulation of alternations of heat and cold at all seasons, but those alternations are restricted to relatively narrow limits—they are not so marked as to be in danger of overtaxing his powers of reaction. It is manifestly desirable that the invalid, especially the consumptive, shall be able to settle down for a protracted stay without feeling himself compelled to change his residence with the seasons. For such a patient the climate of New Mexico offers almost unrivalled attractions. At medium elevations he can remain out of doors, with rare exceptions, day and night throughout the year. Invalids dependent upon their own exertions for support have settled throughout New Mexico with little regard to the relative climatic advantages and disadvantages of the different parts of the state, from the plains south of Raton to Columbus on the border of Mexico. Some of these do well in spite of the exertions and privations involved in the work of clearing land and establishing new homes. But no one should go to New Mexico with the hope of benefiting tuberculous disease without sufficient means to enable him to live at least one year without work. That the physicians of the Rocky Mountains plateau are more impressed on the average than those of lower altitudes with the necessity of rest in the treatment of tuberculosis, which seems to the writer to be the case, is perhaps due to the fact that on account of the elevation deeper breathing during exercise is necessary than near sea-level. A given amount of work involves therefore a greater tax upon the lungs. Of course, no climatic advantages will compensate for overworking the diseased organ during the period when rest is the primary indication.

Considerations as to food and shelter will usually restrict the choice of a location for the invalid visitor to the larger towns. Those coming with their families can obtain suitable houses in such towns as Santa Fe, Las Vegas, Albuquerque, Deming, Silver City, and Las Cruces on the Atchison, Topeka & Santa Fe Railway, and Alamogordo on the El Paso & Southwestern (Rock Island route). The demand for such accommodations, especially for the winter, is sometimes in excess of the supply. The best hotels are the Harvey houses in the chief towns of the main line of the Santa Fe system. They are somewhat expensive and, being on the railroad, noisy. Very advanced cases may experience difficulty in securing admission to the hotels. There are hotels and boarding-houses in all towns of any importance. But even if the invalid succeeds in securing lodgings at such places they are not as a rule well adapted for his purpose and should be made use of only while seeking a more permanent abode. The choice for the invalid should lie between a house of his own and a sanatorium. The advice frequently given to go upon a ranch and "rough it" is especially unfortunate. The food is generally poor, the society uncultured, the temptation to overwork physically ever present. There has been considerable activity of late years in the establishment of sanatoria in New Mexico. The institutions now in operation vary greatly in charges and in completeness of equipment. As a rule, it is best to select a sanatorium intended solely for the treatment of tuberculosis.

Patients with tuberculosis constitute the large majority of those who visit New Mexico for reasons of health. But the advantages of the climate are sometimes more conspicuously shown by remarkable gains in cases without manifest disease. There are several hot springs which enjoy a local reputation for the treatment of rheumatism and kidney diseases, among which may be mentioned the Faywood Hot Springs, about twenty-five miles north of Deming on the Silver City branch of the Atchison, Topeka & Santa Fe Railway, station Faywood, and the Mimbres Hot Springs near the Mimbres River, reached by stage from the same station. Carlsbad in the southeastern part of the state derives its name from the similarity of its waters to those of its European prototype.

A brief description of the towns most visited by invalids follows:

Alamogordo is situated on the El Paso & Southwestern railroad (Rock Island route), eighty-six miles north of El Paso, at an elevation of 4,338 feet.

* Bulletin Univ. of New Mexico, Biolog. Series, vol. iii., Art. 13.

The town lies a few miles west of the Sacramento Mountains. The population numbers 1,948. There is a good supply of mountain water and large numbers of shade trees, chiefly cottonwoods, have been grown. The heat in summer is too great for most invalids, but the resort known as Cloudcroft, at a high elevation on the neighboring mountains, is much frequented by summer visitors on account of its coolness. The Fraternal City Sanatorium is located near Alamogordo. The average annual precipitation at Alamogordo is 10.34 inches; the mean annual temperature 61°, the highest recorded temperature 109°, the lowest 0°.

Albuquerque, a town of 11,020 inhabitants at the last census,* is situated in about the center of the state on the main line of the Atchison, Topeka & Santa Fe Railway, the line down the Rio Grande to Las Cruces and El Paso diverging here. The "Old town," inhabited chiefly by Mexicans, is near the Rio Grande. The business portion of the new town adjoining on the east is flat and, being situated in the river bottoms, there is some annoyance from mosquitos and malaria is not unknown. The newer residence portion of the town still farther to the east on a mesa which slopes up to the Sandia Mountains, is a dry and healthful site but exposed to the west winds. Hotel accommodations are good. The water supply, derived from wells sunk in the river bottoms, is abundant and of fair quality. There are four sanatoria devoted solely to the treatment of tuberculosis: the Southwest Presbyterian Sanatorium, Dr. Shortle's Sanatorium, Dr. Cipe's Sanatorium, and the St. Joseph's Sanatorium conducted by Catholic Sisters. The annual precipitation at Albuquerque is 7.51 inches, the mean annual temperature 55.7°, the highest recorded temperature 104°, the lowest −10°. The altitude is 4,943 feet.

Deming, a small but rapidly growing town in the Mimbres valley in southwestern New Mexico, with a population of 1,864 inhabitants at the last census, has long been noted for the excellence of its water. The town and a wide extent of the surrounding valley is underlaid by a subterranean lake which seems to be inexhaustible. Many pumps have been installed to utilize this water for agricultural purposes, and the surrounding country is being rapidly converted into farms. The winter climate of Deming is excellent, the summers are rather warm for comfort and in the spring months high winds are prevalent. The annual precipitation is 9.54 inches, the mean annual temperature 59.4°, the highest recorded temperature 110°, the lowest 9°. The altitude is 4,315 feet.

Las Cruces, a town with a population of 3,836, is situated in the Rio Grande valley about forty-four miles north of El Paso on the El Paso branch of the Atchison, Topeka & Sante Fe Railway. The valley is here wide and the town is not well protected from the winds. On account of the low altitude, 3,883 feet, the summers are hot. The meteorological data are from Mesilla Park, about three miles south of Las Cruces. The annual precipitation is 8.62 inches. The mean annual temperature is 61.6°, the highest recorded temperature 106°, the lowest 1°. The annual mean relative humidity is fifty-one per cent.

Las Vegas is situated on the main line of the Santa Fe Railway, east of Santa Fe, at the base of the Gallinas Mountains. Las Vegas proper is a Mexican town, the American portion of the town is known as East Las Vegas. The water supply of Las Vegas is excellent. The location of the town to the west of a mountain range cuts off the west wind, but the town is unprotected in other directions and wind and dust storms sometimes occur. The town is picturesquely located and the neighboring mountains afford opportunity for interesting excursions. There are good hotels. Six miles from Las Vegas are the Las Vegas Hot Springs. A hotel, the Montezuma, equipped with bath-houses, has been built at the springs, but is at present closed. The only sanatorium at Las Vegas is the St. Anthony's Sanatorium conducted by Catholic Sisters. The climate of Las Vegas, delightful in the summer, is somewhat colder than that of the other towns frequented by visitors. The average annual precipitation is 18.97 inches, the mean annual temperature 50.3°, the highest recorded temperature 98°, the lowest −31°. The altitude is 6,383 feet. The population is 3,179.

Santa Fe, the capital of the state and one of the oldest towns in the United States, is a picturesque and interesting town of 5,072 inhabitants, situated at the base of the main range of the Rocky Mountains at an altitude of 6,947 feet. The town lies in a sheltered valley well protected from the winds. There is one good hotel. The water supply is excellent. The region is interesting not only on account of the scenery but from the historic associations. Remains of cliff dwellings may be visited after a comparatively easy excursion, and the upper Pecos valley in the neighboring mountains has one or more summer boarding-houses and is an attractive region for camping parties. The Sunmount Sanatorium is devoted exclusively to the care of the tuberculous, who are also received into the St. Vincent's Hospital and Sanatorium. The average annual precipitation at Santa Fe is 18.97 inches, the mean annual temperature 49.2°, the highest recorded temperature 97°, the lowest −13°, the mean relative humidity forty-six per cent.

Silver City, a town with a population of 3,217 inhabitants, is situated in the extreme southwestern part of the state, forty-eight miles from Deming, at the termination of a branch of the Santa Fe Railway. The location of the town in a basin surrounded by high hills on the south and west, affords an admirable protection from the prevailing winds. The water supply is good but not abundant. The region of the headwaters of the Gila, best reached from Silver City, is noted for its magnificent scenery. The country, however, is exceedingly rugged and the trip should only be undertaken by the robust. There are two sanatoria in Silver City, the St. Joseph's, conducted by Catholic Sisters, and the New Mexico Cottage Sanatorium three miles to the northeast. The altitude of Silver City is 5,851 feet. Fort Bayard, the sanatorium conducted by the War Department, is nine miles distant from Silver City. The climatic conditions being practically the same as those of Silver City and the meteorological observations having extended over a greater number of years, the data given are from the latter place. The average annual precipitation at Fort Bayard is 15.2 inches, the mean annual temperature 55.5°, the highest recorded temperature 103°, the lowest −12°. No observations as to humidity have been made at Fort Bayard. The annual mean relative humidity of Silver City is stated to be forty-six per cent.

The old army post of Fort Bayard was converted in 1899 into a sanatorium for the treatment of tuberculous officers and men of the Army and of the tuberculous among the beneficiaries of the U. S. Soldiers' Home, Washington, D. C. (who are discharged soldiers). On account of the advanced state of the disease in the majority no large percentage of soldiers are returned to duty with troops. The chief object of the institution is a benevolent one—to furnish the best treatment possible for those who have lost their health in the military service. Since civilians not connected with the Government service are not admitted, the details of the management and of the results obtained are not probably of general interest. The experiences gained at Fort Bayard have, however, this importance: that they have to do with the treat-

* The data as to population are from the census of 1910.

ment out of doors of a large number of cases of tuberculosis. For ten years all except the old and the very sick of an average of about 300 patients, have been required to live and sleep out of doors throughout the year. Very few are the days in which driving storms necessitate a relaxation of this rule. The sleeping is done upon covered porches, preferably within an open court. The results obtained have been excellent. No harm is known to have resulted from the practice and the benefits have been unmistakeable. Soldiers from their vocation are accustomed to the outdoor life. But many of the patients come more or less directly from the tropics and even these have no difficulty in becoming habituated to life out of doors.

For many, sleeping out of doors in the cold seems a formidable undertaking and their fear of chill leads to an overloading with coverings and the use of artificial heat by means of hot water bags, etc., which produces a relaxation of the skin that defeats in some measure the end aimed at. Undoubtedly a hardening within certain prudent limits is desirable. The experience at Fort Bayard teaches that coddling is not necessary for the average patient under the local conditions.

Old Fort Stanton, an army post situated in the eastern part of the state, has been secured by the United States Public Health Service as a sanatorium for the treatment of the sailors of the merchant marine. Here too the outdoor life is led, under somewhat different conditions but with the same end in view and with good results. The institution has an average of some 250 patients. Fort Stanton has about the same climate as that of Fort Bayard and its altitude is but slightly higher.

The fact that New Mexico has been selected by the Government for the establishment of two of its sanatoria has been rightly deemed a tribute to the climate of the state. G. E. Bushnell.

New Orleans.—This great Southern city and port is situated upon a double curve of the Mississippi River, one hundred and seven miles from its mouth, although a much less distance from the coast in a straight line. The city lies chiefly upon the left bank of the river, and actually covers about forty square miles, although the city limits embrace an area of something like one hundred and eighty square miles. One of the peculiarities of this city, and one that is doubtless conducive to its healthfulness, is the great area which it covers, thus permitting liberal air spaces and grounds about the buildings in the residential districts. The city is built upon low land, lower than the surface of the river at high-water mark, and huge embankments of earth called "levees" are required to prevent an overflow, and even these are occasionally broken through. The soil is of an alluvial nature, and by digging from three to four feet one usually reaches water; hence the houses have no cellars, and the dead have to be buried in tombs elevated above the ground.

There are a large number of bodies of water—lakes, bayous, swamps, and the like—about the city, and to the north of the city is Lake Pontchartrain, forty miles long and twenty-four miles wide. This lake is connected with the Gulf of Mexico, and forms with the Mississippi River an isthmus upon which the city is built. The population at the census of 1910 was 339,075, composed of Creoles, Americans, and negroes.

It is obvious from the low, level situation of the city that the problem of drainage and sewerage was a difficult one, and for a long time this was partially accomplished by open canals which ran with a sluggish current into Lake Pontchartrain. In 1903 a comprehensive system of sewerage was begun, separate from that required for drainage of surface water, and there are now 393 miles of drains, and by means of gravity and the lift system, the sewerage is discharged into the Mississippi River at the lower end of the city. The surface water collected in canals and subsurface drains is discharged at present by pumpage and gravity into Lake Pontchartrain.

The water for general use is taken from the Mississippi River at the upper end of the city, and after being purified by sedimentation, coagulation, and filtration is distributed throughout the city through 517 miles of pipes and mains. This system is now capable of delivering 63,000,000 gallons of filtered water, and is to be still further enlarged. Over $19,500,000 have already been expended upon this system of drainage, sewerage and water supply, and the work is still going on.

The city itself and its surroundings are very attractive, especially to a Northerner. The vegetation is of a semi-tropical nature and very luxuriant. The variety of races and the common use of the French language, the streets, markets, cemeteries, parks, and various points of historic interest, and the extensive wharves with the vast amount of inland and foreign shipping, all afford interest and diversion. The French market is the great "sight" of New Orleans, and is best visited in the early morning.

The accommodations are good, the principal hotel being the comparatively new St. Charles, occupying an entire square in the heart of the city. A favorite winter excursion is to New Orleans at the time of the famous "Mardi Gras," which is said to be more brilliant than the carnival at Nice or Rome.

The mortality of the city for 1910 was 19.73 per 1,000, and of this the whites showed a mortality of 15.77 and the colored 29.37. Tuberculosis caused the greatest mortality of any one disease, followed in order by heart disease, intestinal infections, pneumonia, and Bright's disease. Since the discovery of the cause and prevention of yellow fever, it is now a thing of the past and epidemics are no longer feared. The following meteorological table gives the principal characteristics of the climate of New Orleans:

Climate of New Orleans, La. Latitude, 20° 58′; Longitude, 90 °4′. Period of Observation, Thirteen Years.

	Jan.	Mar.	June.	Aug.	Nov.	Year.
Temperature:						
Average mean temperature or normal (degrees Fahr.)...	54.7°	63.1°	81.0°	81.7°	61.0°	69.8°
Average range.....	13.9	15.0	12.4	12.1	13.1	.....
Mean of warmest..	61.2	71.7	87.2	88.1	67.8	.....
Mean of coldest...	47.3	56.7	74.8	76	54.7	.....
Highest or maximum.....	78.0	84.0	97.0	96.5	82.0	.....
Lowest or minimum	20.0	36.5	65.0	69.0	31.5	.....
Humidity:						
Average mean relative.....	72.2%	70%	72.3%	73%	71.6%	71.4%
Precipitation:						
Average in inches.	5.52	5.75	6.04	5.99	5.58	64.63
Wind:						
Prevailing direction.....	N.	S. E.	S. E.	S. E.	N.	S. E.
Average hourly velocity in miles.	7.8	8.6	6.0	5.5	8.0	7.4
Weather:						
Average number of clear days.....	7.6	10.1	8.0	7.8	9.5	110.5
Average number of fair days.....	12.2	10.6	16.0	18.4	10.2	156.4
Average number of fair and clear days	19.8	20.7	24.0	26.2	19.7	266.9

It will be seen that the climate is tropical or semi-tropical in nature, warm and moderately moist. The mean temperature of the year is 69.8° F. The highest

average summer temperature is 94° F., and the lowest average winter temperature is 27° F. On February 13, 1899, an extraordinary and unheard-of event occurred, in the formation of ice at the mouth of the Mississippi River, the thermometer indicating a temperature of 10° F. On the seventeenth of the same month ice flowed past New Orleans into the Gulf of Mexico.*

Snow is a rare phenomenon, but cold waves occasionally occur, accompanied by frost, which nips the sugar cane and cotton plant.

The annual rainfall varies from 31 to 64 inches, the spring and summer being the rainiest seasons. The average mean relative humidity is 71.4 per cent., about the same as that of New York City.

According to Hinsdale ("Climatology, Health Resorts," vol. iv., part ii., of "Physiological Therapeutics") there is about sixty-two per cent. of possible sunshine. Such a climate is more or less enervating, but in itself not unhealthy. A strict quarantine is exercised against the importation of yellow fever, of which several epidemics have in former years occurred. The amount of water about the city would appear to be favorable for the propagation of the mosquito, and hence malaria must be frequent. All open cisterns, however, are required to be screened.

There are several resorts on the gulf coast at not a great distance from New Orleans, which are frequented both in summer and in winter. Indeed, the entire route from New Orleans to Mobile along the Gulf is very attractive.

Pass Christian on this line has a mild winter climate, favorable for persons suffering from bronchial disease, from malaria, or from Bright's disease, for convalescents from some acute disease, and for those of feeble vitality. It possesses a good hotel, cottages, and boarding-houses. The sanitary conditions are good; there is pure artesian well water; the soil is dry and porous; and extensive pine forests lie immediately in the rear of the town. The average mean winter temperature is given by Solly as 70° F. There are opportunities for driving, boating, fishing, and hunting.

Covington, thirty miles to the north of New Orleans reached by a picturesque journey across Lake Pontchartrain and up the Tchefuncta River, situated in the midst of pine woods, is said to have a very salubrious winter climate, with a "soft air," and is sheltered from all "Northers." It is considered by some local physicians to be favorable for pulmonary diseases.

Bay St. Louis is another resort frequented by the New Orleans Creoles, and said to be rapidly growing in favor with winter visitors. Biloxi, Beauvoir, Ocean Springs, and Long Beach are other resorts on the Gulf coast.

For those seeking rest and diversion the trip down the Mississippi River can be recommended, and from personal experience the writer can testify to its charm and variety. The portion from Baton Rouge to New Orleans along the sugar plantations is of especial delight and interest to the Northern traveler. Below New Orleans, through the "delta country" to the jetties and the Gulf, the voyage is also one of great interest.

New Orleans can be reached from the north by various lines of railroads, and steamers with good accommodations run directly there from New York, occupying about five days on the voyage.

New Orleans is a convenient port of departure for Central America, Panama, and the West Indies.

EDWARD O. OTIS.

Newport, R. I.—Newport, until 1900, one of the capitals of Rhode Island, and in some respects probably the most celebrated of American seaside resorts, occupies the isthmus and much of the rest of the peninsula which forms the southwestern termination of the island of Aquidneck or Rhode Island. This island, lying in the middle of the lower portion of Narragansett Bay, is entirely exposed at its southern end to the full force of the Atlantic, so that Newport, although partly sheltered by the land, partakes in a measure of the climate of the neighboring oceanic islands of Block Island, Martha's Vineyard, and Nantucket.

The city is made up of the old town, which has long lost the great commercial importance it possessed before the Revolution, and the modern portions, originating in the comparatively recent times when Newport's charms of scenery and climate began to draw to its shores an increasing number of visitors. It has a resident population (1910) of 27,149, increased in summer by about ten thousand, contains, besides its public buildings, of which the old State House is the most interesting, many churches, banks, schools, shops of all kinds, the historic Redwood and other libraries, the Newport Casino, and an admirably equipped institution, the Newport Hospital with a training school and nurses' home. Two large and costly buildings of the Young Men's Christian Association, one of them for the exclusive use of the Army and Navy Branch, have been given by summer residents. The city is also the home of numerous societies, clubs, and associations. It is lighted by gas and electricity and has two electric street railways, one of which running north and south has a branch line to the beach. Both of these lines also carry passengers for the north of the island and points beyond.

Newport is the headquarters of the Naval Station of Narragansett Bay, and is the seat of the Naval War College, the Naval Training Station, the United States Torpedo Station, and of a new Naval Hospital. A large and important coaling station has been established a few miles up the bay. At the entrance to the land-locked harbor is the large military post of Fort Adams.

The old town, settled in 1639, is built along the shore of the harbor and on the western slopes of a broad ridge, rising at its most elevated part to the height of some ninety feet above the water. It still retains much of the aspect of colonial days, and in its narrow streets and ancient buildings, of which many noteworthy for their historic associations are still standing, presents, in spite of the encroachments of modern civilization, the features of an old New England seaport town and contrasts vividly with the newer suburbs by which it is surrounded, which have spread far beyond its original limits. Bellevue Avenue, a modern extension of one of the main city thoroughfares, Touro Street, has been continued due south as far as the ocean, and forms a wide and splendid highway two and a half miles in length, on each side of which are placed the stately houses and beautifully kept grounds of the wealthier summer residents. To adjust the peculiarities of the old town to the demands of a fashionable watering place has afforded a problem of some difficulty, especially in relation to the narrowness of several of the most frequented streets, which become overcrowded in midsummer. The whole subject has been suggestively treated in a recent valuable report to the Newport Improvement Association, by the distinguished landscape architect, Mr. C. L. Olmsted.

The natural features of Newport and vicinity, though rarely bold and picturesque, are very attractive. Bishop Berkeley justly described the island to his friends as "pleasantly laid out in hills and vales and rising grounds, and hath plenty of excellent springs and fine rivulets and many delightful landscapes of rocks and promontories and adjacent lands." On one side, the waters of Narragansett Bay studded with islands offer many inducements to the lovers of sailing, boating, and fishing and constantly display in summer

*"The Cold Wave of February, 1899," Guy Hinsdale, Transactions of the American Climatological Association, 1899.

a scene highly animated and full of interest, from the presence of every variety of naval vessel, from battleship to torpedo boat, or of graceful yachts and many other craft. In the opposite direction, the ocean is quickly reached at the First or Easton's Beach, at a point where the coast line of the island turns sharply to the east. This beach, seven-eighths of a mile in length, lies in a sheltered bay and in the season is thronged with bathers and often becomes, of late years, densely crowded with excursionists. Hot salt baths are provided there in summer. Little has yet been done in the way of utilizing to the best possible advantage for the benefit of the public, by the use of the judicious measures adopted at the best European health resorts, the great natural attractions of this fine beach, the tastes of the summer excursionists having been, so far, chiefly considered. At a distance, farther to the east, beyond Easton's Point, lies the longer Second or Sachuest Beach, and still farther, facing the east passage of Narragansett Bay, is the Third Beach. Bailey's Beach, in another direction, is much used for bathing, but is under private management. Apart from these, the principal beaches, the remainder of the shore near Newport presents a very varied and irregular outline. One of the most striking parts is "The Cliffs," which extend from the west end of Easton's Beach to the end of Bellevue Avenue, for nearly three miles. The public walk along these cliffs through the grounds of some of the finest places constitutes one of Newport's greatest attractions. Of the various drives, the "Ocean Drive" from the southern end of Bellevue Avenue, westward along the shore, is justly celebrated. The interior of the island, traversed by two main thoroughfares, the East and West roads, and numerous cross roads, presents a pleasing diversity of hill and dale with charming views of the bay and ocean, and there are many peaceful woodland lanes bordered with dense shrubbery, which remain quite secluded even in summer. The roads on the island are generally suitable for automobiles, and the East road, which is a part of the main automobile routes to Fall River, Providence, and Boston, is usually kept in perfect condition.

The geological formation underlying Newport and its vicinity is somewhat complex, and consists mainly of rocks of the carboniferous period. Newport Neck, as the extreme southwestern corner of the island is called, consists of pre-carboniferous rocks, partly of igneous origin. In the middle portion of the Neck a conspicuous reddish granite is to be observed. Here, the rocks are largely exposed, and are grouped in picturesque masses. The Paradise Rocks back of the Second Beach offer interesting features to geologists by whom they have been frequently studied. Many of the rocks about Newport have undergone metamorphic processes, and have also been greatly disturbed, and in many cases bent and folded, besides having been eroded by glacial action. There are several large ponds in the vicinity of the city. The geology of the whole region is exhaustively treated in Monograph 33 of the United States Geological Survey.

The climate of Newport is less trying and more equable than that of most other places on the New England coast. Although snow and ice are far from infrequent, yet the winters are milder and the daily thermometric range is less than in New York, Providence, and Boston. Owing to the influence of the ocean, the spring is rather more backward, the summer cooler, and the autumn warmer than in the interior. Cultivated flowers have been observed in bloom at Newport as late as December. Indeed, the average temperature of that month has been recorded as slightly higher at Newport than at Washington, D. C., though colder for the other months of the year. The humidity in summer is often excessive, and in consequence of this there are many days extremely close and relaxing, although the temperature is not remarkably high, seldom rising above 85° F. The prevailing winds at Newport are from the southwest. The rainfall is about the average for the New England coast. Fogs are frequent during the warmer part of the year, especially in early summer. Thunderstorms are infrequent in Newport itself, but are occasionally severe. June, except for those who dislike the occasional heavy fogs, is a very pleasant month, when the foliage is at the height of its beauty. The temperature of the water at Newport in summer is remarkably warm, making bathing very agreeable, and a large proportion of the fishes and marine flora are southern forms. Whether this warmth, as supposed by Lorin Blodget, Storer,* and others, is due to currents from the Gulf Stream, which is more than one hundred miles distant, may possibly be doubted, but

Climate of Newport, R. I., Latitude, 41° 29′; Longitude, 71° 19′ Condensed from a Climatic Chart of Seven Years and Eight Months (August 1, 1875, to March 31, 1883).

From Observations of the United States Signal Service, in the First Edition of This Handbook.

Data.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Average for Year.
Temperature:																	
Average mean	30.3°	31.7°	36.2°	44.5°	54.4°	64.4°	70.4°	69.7°	63.7°	54.6°	42.4°	36.2°	45.0°	68.1°	53.5°	31.9°	49.6°
Average daily range	15.4	15.0	14.1	9.4	14.0	14.5	8.7	12.6	12.2	13.6	12.8	14.1	12.5	11.9	12.8	14.8	13.0
Average maximum	37.7	39.0	43.7	50.2	62.3	71.3	74.7	76.3	70.9	62.6	49.3	42.2	.....	.....	.....	.....	.....
Average minimum	22.3	24.0	29.6	40.8	48.3	56.8	66.0	63.7	58.7	49.0	36.5	28.1	.....	.....	.....	.....	.....
Absolute maximum	61.5	56.0	63.0	69.5	85.2	89.0	92.0	87.0	88.3	81.5	71.2	60.0	.....	.....	.....	.....	.....
Absolute minimum	−7.8	−2.0	8.9	22.0	33.0	44.8	53.5	53.0	41.0	30.0	4.0	−3.0	.....	.....	.....	.....	.....
Humidity:																	
Average relative	74.8%	74.0%	62.7%	70.6%	74.3%	76.2%	77.8%	79.6%	79.1%	75.7%	76.0%	75.2%	72.5%	77.9%	76.9%	74.7%	75.5%
Precipitation:																	
Average in inches	4.38	4.58	6.50	4.81	2.75	3.28	3.67	3.65	3.10	3.83	3.50	3.86	14.06	10.60	10.43	12.82	47.91
Wind:																	
Prevailing direction	W.	W.	N.W.	S.W.	S.W.	S.W.	S.W.	S.W.	S.W.	S.W.	W.	W.	S.W.	S.W.	S.W.	W.	S.W.
Average hourly velocity in miles.	11.1	11.1	11.1	9.9	8.1	7.1	6.8	6.4	7.7	9.5	11.1	11.5	9.7	6.8	9.4	11.2	9.3
Weather:																	
Average number clear days.	9.2	8.3	7.5	7.8	8.2	9.5	8.6	9.0	8.4	11.0	8.2	8.0	23.5	27.1	27.6	25.5	103.7
Average number fair days	12.2	11.9	12.5	11.1	12.9	13.6	13.8	12.4	12.4	10.7	10.0	13.0	36.5	39.8	33.1	37.1	146.5
Average number clear and fair days.	21.4	20.2	20.0	18.9	21.1	23.1	22.4	21.4	20.8	21.7	18.2	21.0	60.0	66.9	60.7	62.6	250.2

* "The Mild Winter Climate of Newport, R. I., as the Effect of the Gulf Stream," by H. R. Storer, M. D., *Medical Record*, December 22, 1883.

there is no question of the fact itself, and to the temperature of the waters which surround its shores the mild climate of Newport is in large measure undoubtedly due. There are decided climatic as well as other differences between the various parts of Newport. The situations in and about the city proper, which is two miles from the south end of the island, and some distance from the Atlantic Ocean, are the warmest and most relaxing in summer, though on the other hand generally preferable and more convenient in winter. The cottage sites on the cliffs are cooler and always in great demand both on account of the sea breezes and beauty of scenery. The southwest point of the island, Brenton's Point, as the prevailing winds are from the southwest, is the most exposed and coolest locality. Lying along the harbor at the north end of the city is a district known as "The Point," which offers conveniences for boating and is sheltered from easterly winds in winter. Another attractive but limited section is the high ground just south of the harbor.

The accompanying meteorological table is reproduced from the former editions of this Handbook, and still remains the most satisfactory and complete summary of the climatic conditions. The government station at Newport was discontinued in March, 1883, so that no recent records from this source are obtainable. Additional partial observations until 1895 will be found in the Bulletins and Investigations of the New England Meteorological Society and in the Bulletins and Reports of the United States Weather Bureau. Climatic records are also given in the local daily papers.

The death rate of Newport is low and the temperate and equable climate, one of the causes which have induced a considerable number of prominent and influential persons who have retired from the more active pursuits of life to select it as their home, seems to be especially favorable to longevity, which is further aided by the abundance of air space and the absence of injurious trades and occupations.

Newport is admirably adapted for children, who thrive there greatly, with the exception that in early autumn a tendency is noticed to the prevalence of diarrheal diseases. For those suffering from tuberculosis and from bronchial, renal, and rheumatic affections, Newport shares too much in the general character of the New England climate to be recommended, and catarrhal and respiratory diseases as well as pneumonia have been observed to be prevalent at the Naval Training Station, but for convalescents and delicate persons who reside in more inclement places and who for any reason are not able to seek an ideal climate at a distance, it will often be found in winter to be very advantageous. Though well known to the residents, the mildness of the winter climate is hardly, as yet, generally appreciated. The very sedative and soothing effect of the Newport climate renders it useful in many cases of overtaxed brain and nervous system, and neurasthenia—particularly those which require a sedative rather than a tonic treatment. On the other hand, in a limited number of cases, especially in women, the summer climate exercises such a weakening and relaxing influence (felt by everyone in a slight degree) that its effect is actually harmful. For gastrointestinal disorders it is generally speaking contraindicated, chiefly during summer. Asthmatics are sometimes benefited, but sometimes the reverse is the case.

In sanitary matters, Newport is under the direction of an efficient Board of Health, with somewhat restricted powers. The sanitary conditions are, on the whole, good, and the bad ones are slowly being removed. There is a satisfactory sewerage system.

The city water supply, taken from Easton's Pond and supplementary sources, is under the management of a private corporation, and though not entirely free from organic matter and baeteria, is of fair quality and has never been recognized as the source of any epidemic. As the soil under the city proper is a tenacious clay, beneath which frequently occurs a stratum of water-bearing gravel, and as most of the wells in the compact quarters of the city receive their supply from this gravel, they are apt to be dangerous from liability to contamination from deep cesspools dug through the clay.

Newport is deficient in hotel accommodations but there are many excellent boarding-houses open at all seasons. The city is crowded only in July and August, but the season for the cottage colony may be said to last from June 1 to October or even November. It is, however, much frequented by visitors before and after these dates, and in fact to some extent throughout the year.

Newport is reached from New York by the large and comfortable night boats of the Fall River line in ten hours, or by railway to Wickford in five hours, thence by steamboat across Narragansett Bay in another hour. With Boston and Providence it is connected by rail as well as by trolley, and the latter city may also be visited by boat. Automobiles may be driven to Newport over the "Stone Bridge" at Tiverton, or by way of the ferries from Saunderstown or Bristol, the latter ferry available only in summer. The neighboring pleasant resorts of Jamestown and Narragansett Pier are readily accessible, and there is also daily communication for the greater part of the year with Block Island. William C. Rives.

Newport News.—See *Old Point Comfort.*

Newsom's Arroyo Grande Warm Springs.—San Luis, Obispo County, California.

Post-office.—Arroyo Grande. Hotel and cottages.

Access.—Viâ the Southern Pacific Railroad from either San Francisco or Los Angeles to San Luis Obispo, California, thence by the Pacific Coast Railroad to Arroyo Grande, thence three miles to Springs; or viâ Southern Pacific to Oceano, thence by stage to Arroyo Grande, four miles. There is a good road from Arroyo Grande to the Springs.

The ocean beach road affords one of the finest drives in that section of the country. The springs are pleasantly situated at an altitude of about 400 feet. They lie about fourteen miles south of San Luis Obispo. The climate here is one of almost perpetual sunshine, with occasional spring and autumn rains. On the place are three principal springs whose waters range in temperature from 40° to 100° F., and flow 49,000 gallons hourly. The following analysis was made by Winslow Anderson:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	4.10
Sodium carbonate	1.75
Sodium sulphate	3.92
Potassium carbonate	0.15
Potassium sulphate	2.90
Magnesium carbonate	6.41
Magnesium sulphate	2.47
Calcium carbonate	8.25
Calcium sulphate	0.75
Ferrous carbonate	3.99
Alumina	0.33
Silica	2.03
Organic matter	0.27
Total solids	37.32
Gases.	**Cu. in.**
Free carbonic-acid gas	14.90
Free sulphureted hydrogen	3.56

Temperature of water analyzed, 100.5° F.

These waters have gained considerable reputation in the treatment of old cases of chronic rheumatic

troubles, hemorrhoids, nasal catarrh, neuralgia, disorders of stomach, liver, and kidneys, gout, catarrhal affections of the bladder and bowels, and skin diseases. For uterine disorders the hot sulphurous douche has been highly recommended. EMMA E. WALKER.

New York is situated in 41° North Latitude, 74° longitude west from Greenwich. Its temperature range is wide (from −6° F. to 100° F. with a mean of 51.3° in 1914), subject to extremes, especially to extreme heat in summer and often to sudden changes. Owing to its insular and sea-board position the extreme summer heat is usually a few degrees less in New York than the average for sister cities. Its climate is moist, the relative humidity in 1914 averaging 74 per cent. at 8 A.M. and 69 per cent. at 8 P.M. In that year the rainfall was the lowest ever recorded, 33.5 inches, or 10 inches below the average. The snowfall was 35 inches for the year. The average hourly movement of wind varied from 12 miles in August to 21.3 miles in November. The maximum velocity ever recorded in New York City was 90 miles on May 27, 1914. The prevailing direction of wind is northeast. In 1914 there were 28 thunderstorms and 24 days with dense fog; there were 96 clear days, 114 partly cloudy and 155, cloudy. There was precipitation on 111 days. There were 2530 hours of sunshine, or 56 per cent. of the amount possible. Both in summer and in winter the temperature in New York is milder than that of Chicago, and, compared with that city, its relative humidity is less (in spite of its seaboard situation) and there is less wind, but there are fewer clear days and more foggy days. There is more sunshine in New York than in Boston, Chicago, St. Paul, or Portland, Ore.; but less than in Philadelphia, Baltimore, or Denver. The climate of New York, though stimulating, being moist, changeable, and in winter rather cool, is unfavorable for those subject to bronchial and laryngeal disorders, and for patients ill with, or convalescing from, pulmonary tuberculosis. In spite of this, New York is a healthful city. Its water supply, from the Cattskill reservoir at Ashokan, 590 feet above sea level, and from Croton and Kensico Lakes and deep artesian wells in Brooklyn and Queens, is of excellent quality and free from contamination. The death rate from typhoid fever was only 6 per 100,000 in 1913. Malaria in recent years is quite rare although this class of affections formerly prevailed in Harlem and the East River districts. Contagious diseases, developing at home or in schoolhouses, are watched by an active health board; and tropical diseases and such as cholera and typhus fever, are almost unknown in New York. The city's annual mortality records for the last three years show a death rate of 14.11 per 1,000 in 1912; 13.76 in 1913; and 13.40 in 1914; the total number of deaths in 1914 being 74,803. This is the lowest rate recorded and lower than for any other large city. The mortality from pulmonary and other forms of tuberculosis was 10,286; 8,916 were deaths from pulmonary tuberculosis or 1.60 per 1,000; from bronchial and lobar pneumonia, 9,582 or 1.80 per 1,000. The mortality from typhoid fever for 1914 was 334; considering that the population now approximates 5,615,000 this is a remarkably low record and only one-sixth of what obtained fifteen years ago. Organic heart disease caused 10,054 deaths, or 1.80 per 1,000; nephritis and Bright's disease, 5,615 or 1.01 per 1,000; cancer 4,463, or 0.80 per 1,000. Of the deaths from diarrheal diseases a little more than one-half were among children under five years of age, who supplied one-third of the deaths from all causes.

New York has the lowest infant mortality rate of any large city in the United States. This is largely due to the efficient Division of Child Hygiene to which the city appropriated in 1913, $650,000. The division of Child Hygiene in its Department of Health was established in 1908 and exercises a control and supervision of nearly 1,400 midwives in whose care forty per cent. of all the births in New York occur. The total number of births in New York in 1912 was 135,655. This division has the supervision of foundling babies; day nurseries; institutions harboring dependent children; the medical inspection and examination of school children; their vaccination; dental clinics for children and milk stations and the enforcement of that part of the Child Labor Law which relates to the issuing of employment certificates. The staff consists of 185 medical inspectors, over 350 nurses and ten dentists besides various assistants. To the efficiency of this division is doubtless due the fact that the general mortality rate for children under one year of age in the city is less than for the remainder of the State. The great value to the city of this division of child hygiene ought to be more widely known. The mortality rate for children under one year has dropped one-half between 1898 and 1913 or from 203 per 1,000 living at that age to 102. The death rate from diarrheal diseases under two years of age has dropped in the same period from 41.2 per 1,000 to 13.6 per 1,000 living.

The New York City Department of Health has a division of Public Health Education which issues a series of monographs and reprints illustrating the various activities of the Department. Besides the annual report the following are noteworthy: A Guide to some of the Hygienic Features of New York City; The Division of Child Hygiene of the Department of Health; the Tuberculosis Campaign; Veneral Diseases, the Attitude of the Department of Health in Relation Thereto; The Contagious Disease Hospitals; Typhoid Fever in New York City, etc.

New York City maintains a Municipal Sanatorium for Tuberculosis at Otisville, in Orange County, seventy-six miles from the city on the Erie Railroad. It is on a site comprising over 1,300 acres varying from 800 to 1,500 feet above sea level on the southern slope of the Shawangunk Mountains. There are accommodations for 600 patients, of whom sixty-five per cent. are in the moderately advanced stage. The average length of stay is six months. The outdoor treatment and a systematic form of graduated labor are well carried out. This sanatorium was opened in 1906 and the results compare very favorably with those obtained in other sanatoria at Liberty and Saranac Lake. There is no charge whatever for treatment and admission is limited to residents of New York City.

The great concentration of population in New York, now embracing over five and a half millions of people, complicates all problems of health and municipal hygiene. There are over forty-five thousand hotels, apartments, and tenement houses in the city. The extremes of society are more widely separated than in any other American city. Philanthropic measures on a very large and generous scale have been carried out for years in New York and have done much to improve the condition of the poor and sick and outcast. It is impossible to enumerate them, but they are rapidly extending their work and are more and more generously supported.

New York is now well provided with small parks in which the poor have an opportunity for recreation and temporarily escape from their crowded quarters. Music is provided on summer evenings, and public-school properties which formerly were tightly closed all summer, are now thrown open as playgrounds for the children. Recreation piers along the river front serve a similar purpose and are specially grateful to tired mothers with sick infants. The floating hospitals of St. John's Guild, the country week associations, kindergartens, and free ice funds contribute largely to diminish misery and promote health. Van Cortlandt, Bronx, and Riverside parks are largely uncultivated, but very popular. Van Cortlandt has

fine golf links and skating facilities; in the Bronx there are opportunities for picnicking, rowing, and flower-gathering. Prospect Park, Brooklyn, and Central Park, Manhattan, are the largest cultivated parks in the city. Facilities for tennis, baseball, football, croquet, and amusements for small children are provided. Taken in connection with its superb water front, the bay, the rivers, and the sound, New York, aside from its commercial supremacy, is one of the most desirable places of residence in the world.

GUY HINSDALE.

Nicaise, Edouard.—Born at Port-à-Binson, France, on May 10, 1838. He began his medical studies at Rheims and completed them at Paris in 1866, the title of his graduating thesis being: "Des lésions dans les hernies." Three years later he was made a *Professeur agrégé* of the Faculty of Medicine. In 1874 he was surgeon at the Bureau central, in 1876 at the Hospice des Incurables, in 1879 at the Lourcine, and finally, in 1880, at the Hôpital Laënnec. He held this last position up to the time of his death, from pulmonary hemorrhage, on July 31, 1896.

According to Pagel, Nicaise was a most learned surgeon and an admirable writer. Up to the year 1890 the number of his published writings had already exceeded two hundred. The most important of these publications are, unquestionably, the three monographs on "La Chirurgie de Mondeville" (1893), "La Chirurgie de Guy de Chauliac" (1890), and "La Chirurgie de Pierre Franco" (1895). Just before his death Nicaise published a most useful compendium, entitled: "L'antisepsie dans la pratique de la chirurgie journalière, Paris, 1896. A. H. B.

Nice.—This city is the most popular resort on the Riviera, as it is the largest, containing nearly 100,000 inhabitants. It is 140 miles northeast from Marseilles, nineteen and one-quarter miles northeast from Cannes, and nine and one-half miles west from Monaco. It is situated on the Baie des Anges, opening toward the south, at the mouth of the little river Paillon. To the east is the hill of Villefranche, affording protection from the east winds, and to the west the promontory Cap d'Antibes, which affords partial protection from the mistral or northwest wind. To the north are the foothills of the Maritime Alps, the highest of which is Mount Chauve, with an elevation of 2,824 feet, and standing seven miles back from the coast. These foothills, as Dr. Sparks has observed, are too far distant and too much intersected by valleys to afford very good protection against winds coming from that direction.

The city of Nice consists of three distinct portions: the old town, on the left bank of the Paillon; the Port, with a seafaring population; and the Strangers' Quarter, on the right bank of the river, which is the portion occupied by the winter visitors. This last section is the fashionable part of the city, and contains attractive avenues and gardens, broad streets with fine buildings, and innumerable hotels and pensions.

Along the coast runs the Promenade des Anglais, a beautiful, broad-terraced walk, two miles in length. It is shaded by palms and other trees, with a pier and casino near the beginning, and is bordered with hotels and villas.

In the season from November to May, Nice is visited by one hundred thousand people, and it then resembles a northern capital with all its gayety. During the year about one million people are said to visit it. Between the foothills proper and the shore, a distance of four or five miles, is a sloping area of country consisting of low ridges and shallow valleys. Immediately adjacent to the coast is a level tract of ground.

In seeking a health resort along the Riviera it must not be forgotten that Nice is a large, extensive city, and consequently possesses the disadvantages and perturbing influences of a city, viewed from a health-resort point of view.

The sanitary condition of Nice is said to be the best on the Riviera, and the water supply "excellent in quality and quantity" (Linn).

Nice, by reason of its situation and size, possesses innumerable resources for diversion and pleasure. Here congregate visitors from almost every civilized country, and life in this gay winter city is made most attractive for them. At the height of the season the carnival is celebrated with great display. Nice is considered a healthy city, its death rate comparing favorably with that of most French towns. In 1890 there were 21.63 deaths per 1,000.

The following table from Teysseire's figures give some of the meteorological data for the season, October to April inclusive, extending over a series of years:

	October.	November.	December.	January.	February.	March.	April.
Temperature (degrees F.): Mean.....	61.61°	52.80°	48.2°	46.72°	48.43°	51.22°	57.54°
Absolute maximum..	88.16	74.7	65.3	66.6	66.0	70.5	82.0
Absolute minimum..	36.7	31.1	36.9	36.5	38.3	33.1	37.2
Humidity: Mean relative....	62.6%	62.4%	63%	65.8%	59.9%	55.7%	60.4%

"The mean annual temperature," according to Burney Yeo, "is 60.3° F. The mean winter temperature 49.1° F., and the mean spring temperature 58.1° F. The minimum temperature at night is 26.6° F. The coldest months are January and February. The relative humidity is small, as is seen by the table. The mean annual rainfall is 32.43 inches, and 19.45 inches for the six winter months November to April. The mean proportion of sunny, cloudy, and rainy days for twenty years is: sunny 219.2, cloudy 77.3, rainy 67.4, and for the winter season, from October 1 to May 31, sunny 135.8, cloudy 55.3, rainy 52.8." March, April, and May are the windiest months. Of the stormy winds the east wind is the most common, says Burney Yeo, and blows forty-five days in the year. "Though sharing with its neighbors," says Huggard, "the blue sky and magnificent scenery, it is much more exposed to winds from all quarters, and to variations of temperature, than is any other winter station on the same coast." . . . "Windiness is thus the prevailing climatic characteristic of Nice as distinguished from its neighbors."

"It must be admitted," says Sir Hermann Weber, "that the changes of temperature are very great, even in sunny places, when passing from a sheltered position to a spot exposed to winds, and likewise on passing from the sun into the shade. A great part of the town is also exposed to the northeast wind, owing to a gap left in the surrounding heights by the Paillon torrent, and the mistral is often very annoying, the protection by some rather low hills to the northwest being inefficient. But the character of the climate is remarkably sunny and invigorating, and the bright days considerably exceed in number the dull and rainy ones." Frost rarely occurs, and then at night. Fogs are unknown. The temperature of the sea water in winter is between 53° and 61° F., and in summer between 64° and 75° F.

"Nice enjoys," says Dr. Wendt, in a previous edi-

tion of this Handbook, "nothing more nor less than a fair average of Riviera climate. This means that it is not devoid of drawbacks, and that ideal winters are not found there. Nice is more sheltered than some places, but is nevertheless exposed to the mistral, which blows at Nice just as it blows at most other Riviera spots. It should be borne in mind by invalids and tourists that Nice and the Riviera in general really possess two distinct and different climates, viz., seashore or marine climate and an inland or mountain climate. It is quite well known that immediate proximity to the sea may induce sleeplessness and other symptoms, denoting too exciting an action on the nervous system. The dry, sunny inland air is tonic and sedative; the air in immediate proximity to the shores of the sea is bracing and exciting. The air of the city and its suburbs is often a mixture of the two. It is thus apparent that a number of local climates are found at Nice, concerning which the resident physicians will inform invalids."

As a genuine health resort it will be seen from the preceding climatic considerations that Nice possesses grave defects, and is perhaps the least desirable of the Riviera stations, particularly toward the close of winter and the beginning of spring. As has been well said, it is "rather a pleasure resort than a refuge for invalids." It does, however, offer much to a certain class of patients or semi-invalids. Those seeking sunshine, a certain degree of warmth, dry air, and comfortable living, even luxury, will find it here, under most attractive surroundings.

Anemia, chlorosis, scrofula, gout, rheumatism, dyspepsia, diabetes, Bright's disease, chronic bronchitis, asthma, and catarrhal conditions of the upper air passages are said to be more or less favorably influenced by the climate of Nice and on the other hand pharyngeal and bronchial catarrh are said to be frequent. Pneumonia and pleurisy occur often in the spring and rheumatic affections are not uncommon in the autumn (Huggard). It is not to be recommended for pulmonary tuberculosis, although it was formerly much resorted to by this class of cases. For the feeble, from old age or other cause, it is of value.

The suburb of Cimiez, two miles from the sea, appears to possess especial climatic advantages. It is said to be better sheltered and has a more equable climate, and its influence is more sedative. The late Queen of England visited this quarter of Nice several times.

Three and a half miles to the east of Nice is Beaulieu, said to be one of the best protected spots on the coast. The high mountains rise directly in the rear, cutting off the north winds. The situation of this little place is most attractive, and the groves of olive trees, orchards of orange and lemon, and the luxuriant vegetation enhance the beauty of the scenery.

The excursions in the vicinity of Nice are many and most attractive, affording marvellously beautiful views of this picturesque region. La Turbie, 1,600 feet above the level of the sea, on the Corniche road between Nice and Monaco, is perhaps one of the most strikingly beautiful spots in all this region of magnificent scenery.

For the true invalid the Riviera may possess many disadvantages, but for one weary with the routine of life, to roam along this coast from Genoa to Cannes in the late spring or early summer when the vegetation is at its best, is a source of unending delight, as the writer can testify from personal experience.

Edward O. Otis.

von Niemeyer, Felix.—Born at Magdeburg, Germany, on Dec. 21, 1820. At the age of nineteen he began his medical studies at the University of Halle, and in 1843 he received from that institution the degree of Doctor of Medicine. In 1844, after spending a few months at Vienna and Prague for the purpose of still further perfecting his knowledge of medicine, he settled in his native city as a general practitioner. In 1849, before the severe epidemic of Asiatic cholera in that city had run its course, he published his first medical treatise of any conspicuous importance—viz., "Die symptomatische Behandlung der Cholera mit besonderer Rücksicht auf die Bedeutung des Darmleidens." In 1855 he accepted a call to fill the Chair of Pathology and Therapeutics in the University of Greifswald, and to be the Director of the Medical Clinic connected with that institution. In 1858 he completed the text-book—"Lehrbuch der speziellen Pathologie und Therapie," 2 volumes, Berlin, 1859–1861 (many later editions, and translations into French, Italian, and English)—which soon gave him such great celebrity. Two years later, he removed to Tübingen, where he had been given the same positions in the university as those which he held in Greifswald. In 1865 he was appointed Consulting Physician of the King of Wuerttemberg, and in 1866 he was made a noble. During the Franco-Prussian War (1870–1871) he undertook, notwithstanding the poor state of his health, the management of a military hospital at Pont-à-Mousson. He died on March 14, 1871.

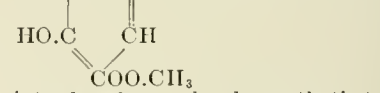
In the judgment of Pagel, Niemeyer should be ranked as one of the greatest clinical teachers of modern times. Besides the famous text-book already mentioned he published the following treatises which deserve to receive special notice: "Ueber Haus- und Volksmittel und ueber die Aufgaben der populären Medicin," Tuebingen, 1864; "Die Behandlung der Corpulenz nach dem sogenannten Banting system," Tuebingen, 1866; "Klinische Vorträge ueber die Lungenschwindsucht," Tuebingen, 1867 (Paris, 1867); and "Ueber das Verhalten der Eigenwärme bei gesunden und kranken Menschen," Tuebingen, 1869.

A. H. B.

Nightmare.—See *Consciousness, Disorders of.*

Night-Terrors.—See *Pavor Nocturnus.*

Nirvanine is the diethyl-glycocoll derivative of orthoform, and is represented by the formula



It was introduced as a local anesthetic to replace cocaine, but while it is less toxic than cocaine its anesthetic power is also less; further, it is very irritant and has little or no anesthetic action on the unbroken mucous membrane.

R. J. E. Scott.

Nitric Acid.—Under the title *Acidum Nitricum*, Nitric Acid, the United States Pharmacopœia makes official a liquid composed of sixty-eight per cent., by weight, of absolute nitric acid (HNO_3) and thirty-two per cent. of water. Such grade of nitric acid is a heavy liquid of about 1.403 specific gravity at 25° C. (77° F.); colorless when freshly made and perfectly pure, but, as met with in the shops, apt to be of a distinctly yellowish shade. It is prepared by the action of sulphuric acid on potassium or sodium nitrate: $H_2SO_4 + NaNO_3 = NaHSO_4 + HNO_3$, and then $NaNO_3 + NaHSO_4 = Na_2SO_4 + HNO_3$. The acid fumes upon exposure, is powerfully corrosive and stains animal tissues and woollen fabrics a bright yellow. It dissolves silver, mercury, copper, and other metals with evolution of red fumes. It mixes in all proportions with water and alcohol. It is a pretty potent oxidizer, yielding up a portion of its oxygen to oxidizable material, and it has a strong

affinity for water, by reason of which affinity, in part, it is powerfully caustic to animal tissues. It should be kept in well-stoppered, dark amber-colored bottles. Impure commercial nitric acid is often called *Aqua fortis*.

The valuable properties of strong nitric acid are the power of the acid to oxidize on the one hand, and to cauterize on the other. By its oxidizing virtues nitric acid is a serviceable disinfectant in situations where its corrosive action will do no injury; and its cauterant powers are convenient for surgical application. The acid burns searchingly and thoroughly, yet not unmanageably. When using nitric acid as a caustic, it is well to bound the area intended for cauterization by a ring of oil or of adhesive plaster, to prevent the action from spreading unduly. The acid is then applied by a glass rod or bit of stick, care being taken to avoid excess. Swallowed in any considerable quantity nitric acid is a powerful corrosive poison, producing effects substantially similar to those caused by sulphuric acid (see *Sulphuric Acid*). The most striking difference between the poisoning by the two agents is, that in sulphuric-acid corrosion the sloughs tend to be brown or blackish, while in that from nitric acid they are yellow. Inhalation of the fumes of nitric acid also may kill.

In proper dilution nitric acid operates physiologically as do all the sour mineral acids (see *Sulphuric Acid*), and shares with hydrochloric acid a sort of selective efficacy in disorders of the digestive apparatus. Vomiting, from many causes, is often relieved effectually by nitric acid, and so is diarrhea, and so is the functional disorder of digestion commonly ascribed to sluggish action or even congestion of the liver. Even a special curative action over constitutional syphilis has been proclaimed for nitric acid, but is at the present day quite properly discredited. For internal use the following preparation of the United States Pharmacopœia is to be given:

Acidum Nitricum Dilutum, Diluted Nitric Acid. This preparation is a simple dilution of the official strong acid with distilled water, in the proportion a little less than six parts of added water to each one of acid. It represents ten per cent., by weight, of absolute nitric acid; is a colorless and strongly sour liquid, non-corrosive but highly irritant. Its specific gravity is 1.054 at 25° C. (77° F.). The internal dose is from twenty to forty drops, largely diluted with water, and the mouth to be rinsed well after the taking of each dose.

EDWARD CURTIS.
R. J. E. SCOTT.

Nitrites.—Physiological experimentation and clinical testing with a number of different nitrites, both of metallic and ethereal bases, have now developed the fact that such compounds possess certain strongly marked properties in common. These properties evidently belong to the acid radical of these salts, so that the nitrites are to be regarded as forming a natural group of medicines whoso peculiar virtues are due to nitrous acid. The effects wrought by nitrites upon the animal system are, broadly, twofold, as follows: On the one hand, a chemical change in the composition of hemoglobin, and, on the other, an influence upon nervous and muscular structures, showing itself by profound and, in sufficient dosage, even fatal derangement of function. As regards the effects upon the blood, it is observed that in an animal under the influence of a nitrite the arterial and the venous blood both have acquired in common a peculiar chocolate hue, which does not change when the drawn blood is agitated with air. Examined by the spectroscope such blood shows a replacement of the bands of hemoglobin by those of a new compound (Gamgee) very probably identical with the *methemoglobin* of Hoppe-Seyler; and, tested chemically, this changed hemoglobin is found to have its ozonizing power very seriously compromised. Treatment with ammonia restores normal color and normal functional power to this nitrite-poisoned blood. The nitrites cause a dilatation of the arteries with a marked diminution of blood pressure; this is due partly to relaxation of the involuntary muscles in the arterial walls, and partly to depression of the nervous mechanism of the heart. The nervous and muscular derangements produced by nitrites are as follows: In moderate dosage there are felt a fulness and throbbing of the head and neck, with almost simultaneous very rapid and disorderly action of the heart, and excited and panting breathing. The face is deeply flushed and feels uncomfortably hot, but the internal general temperature is found by the thermometer to fall. So, too, although the heart and carotids are felt to throb disagreeably hard, yet arterial tension is proved to suffer a very great decline, obviously due to the general capillary dilatation, of which the flushed face is an evidence. In large doses, as observed in animal experimentation, initial great acceleration of the heart's action, and violent and hurried breathing are followed by slow, irregular, and failing pulse and respiration, fall of temperature, weakened voluntary and reflex motor activity, and finally, death by respiratory arrest. As regards the mechanism of these derangements, the initial circulatory phenomena—acceleration of pulse, capillary dilatation, and sinking of blood tension—are mainly the expressions of paralysis, severally, of cardiac inhibition, of resisting power of the muscular elements of the arterioles, and, to a less degree, of vasomotor control over the same. The heart failure following large dosage is probably due to direct poisoning of the cardiac musculature; the agitated and panting breathing of the earlier stages of the nitrite effect seems to be secondary to the other derangements, but the final arrest of respiration in fatal poisoning appears to result from direct paralysis of the nerve centers concerned in the function. Similarly, the failure of voluntary and reflex motor power seems to be mainly from paralysis of the motor tract of the cord, although to a certain extent the muscular contractility is itself impaired.

Nitrous acid in combination is thus seen to be an agent that immediately attacks the ozonizing function of the blood and the vital endowments of nerve and muscle tissues. Many have thought that the paralytic phenomena are probably but consequences of the blood lesion, but various physiological considerations make it more likely that they result from immediate and independent poisoning of the substance of the nerve centers.

The principal therapeutic applications of the nitrites are to relieve spasms, or pains referable to spasm, and to arouse the heart in syncope. The most notable instances of the first application are the use of nitrites in the treatment of angina pectoris, spasmodic asthma, and epilepsy. In the first two of these diseases nitrites often prove of astonishing temporary power, but in the last they are, as compared with bromides, inferior in efficacy. Still, in some cases of epilepsy, where bromides have ceased to impress or where the supervention of bromism has forced their discontinuance, nitrites have shown themselves serviceable alternates (Law). For the relief of syncope nitrites are theoretically indicated where the cardiac arrest is presumably referable to excess of inhibition; and, clinically, the nitrite of amyl has been reported to have restored heart action in cases of syncope from emotion, from hemorrhage, and from chloroform poisoning.

The nitrites recognized by the United States Pharmacopœia are the ethereal nitrites of amyl and of ethyl, respectively—the latter in the single preparation, *spirit of nitrous ether* and the salt sodium nitrite. Properly also, *nitroglycerin* should be included in a summary of the group of nitrite medicines, since, though not itself a nitrite, there is little doubt that

its medicinal effects are wrought by a nitrite resulting from decomposition of the nitroglycerin within the body. In this place the nitrites, respectively, of *ethyl*, *amyl*, and *sodium* will be discussed, nitroglycerin being treated of under its own title.

Ethyl Nitrite: $C_2H_5NO_2$. Ethyl nitrite, formerly called *nitric ether*, and now *nitrous ether*, is a compound that forms by reaction of nitric acid with alcohol. It is an ethereal fluid of agreeable apple-like flavor and pungent taste—exceedingly volatile, somewhat soluble in water, and more freely in alcohol. Experimented with in the pure condition, this body produces promptly and fully the classical effects of the nitrites as above set forth (Richardson). It is used in medicine, however, only in the form of a weak alcoholic solution—the time-honored and well-known preparation formerly called *sweet spirit of niter*, but now official in the United States Pharmacopœia under the title *Spiritus Ætheris Nitrosi*, Spirit of Nitrous Ether. This preparation is made by distilling a mixture of solution, in alcohol and water, of sodium nitrite, and of sulphuric acid. After purification of the ethereal product, enough alcohol is added to make a spirit containing in solution four per cent. of ethyl nitrite. Spirit of nitrous ether is a clear, mobile liquid, volatile and inflammable, of a pale straw color, inclining slightly to green, and a fragrant, ethereal odor. Its taste is sharp and burning. Specific gravity, about 0.823 at 25° C. (77° F.). It slightly reddens litmus paper, but should not effervesce when a crystal of potassium bicarbonate is dropped into it. It should be kept in small glass-stoppered vials, in a dark place, remote from lights or fire. Spirit of nitrous ether as found in the shops is apt to be of deficient strength from the fraudulent addition of water or alcohol.

The effects of this spirit are the conjoint effects of its two constituents, alcohol and ethyl nitrite. In the small doses commonly prescribed for medicinal purposes the peculiar nitrite effects are but faintly seen, and the medicine operates as a grateful stomachic, which is at the same time mildly diaphoretic and antispasmodic. The spirit is accordingly much prescribed as an ingredient of so-called fever draughts or mixtures, its tendency being to ameliorate the discomforts of the febrile state. In large dosage with this preparation the typical nitrite effects are clearly seen—giddiness, headache, and throbbing arteries having been reported as following an overdose, while in another case death occurred from inhaling the fumes from a broken three-gallon jar of the spirit accidentally spilled in a room. Spirit of nitrous ether is prescribed in doses of two grams (practically ℥ xxx.) several times a day. The dose may be mixed with water for the taking, or prescribed as an ingredient of mixtures containing saline solutions. Such mixtures should not be ordered in quantity beyond present need, since dilution with water tends to set on foot chemical changes in the ethereal spirit. Spirit of nitrous ether is an ingredient of the official *Mistura Glycyrrhizæ Composita* ("Brown Mixture") of the United States Pharmacopœia.

Amyl Nitrite: $C_5H_{11}NO_2$. Amyl nitrite is used in medicine under its own form. Under the title *Amylis Nitris*, Amyl Nitrite, the United States Pharmacopœia recognizes the ordinary article of pharmacy, which is an ethereal liquid containing about eighty per cent. of amyl nitrite. The remainder of the percentage is made up of various associated but undetermined ethers. The substance is a clear, very mobile ether, of a pale yellow color, having a fruity odor almost exactly resembling that of ripe bananas, and an aromatic taste. When freely exposed to the air it decomposes, leaving a large residue of amyl alcohol. It is insoluble in water, but soluble, in all proportions, in alcohol, ether, chloroform, benzol, and benzine. Its specific gravity is 0.865 to 0.875 at 25° C. (77° F.); and it boils at about 96° C. (205° F.), giving an orange-colored vapor. It burns with a fawn-colored flame. It should be kept in small, dark glass-stoppered vials, in a cool and dark place. Amyl nitrite is excessively volatile, and the utmost care is necessary to preserve a specimen both from loss of bulk and from spontaneous decomposition by exposure.

Amyl nitrite is the nitrite commonly used in medicine for the specific sake of the nitrite effects proper, and it is, perhaps, the most striking of medicines in the matter of rapidity and intensity of action. From its extreme volatility and pleasant odor it is efficiently and conveniently given by inhalation. When the quantity of from three to five drops, poured upon a handkerchief is inhaled, the subject is conscious, within so short a time as from three to ten seconds, of a sensation of heat, fullness, and throbbing of the face and head, immediately followed by an indescribable and most distressing commotion within the chest, the heart beating fast and furiously, and the breathing being panting and hurried. Giddiness and some muscular languor accompany these phenomena, and perspiration may break out; but in a very few minutes the derangements of function begin to recede, and rapidly, and upon their complete disappearance the subject is left without after-effects, save, possibly, a little dull headache and lassitude, lasting from half an hour to an hour. Assuming such dosing to have been in a case open to the therapeutic powers of the nitrites, the therapeutic effect will have been as swift and pronounced as the physiological derangement. No medical relief, indeed, so nearly merits the designation of "as if by magic," as the sudden and complete abrogation of an anginal or asthmatic seizure that is so often wrought by the swift and profound action of amyl nitrite. The drug, however, must not be expected to be infallible, for many cases of angina pectoris, of asthma, and syncope—notably profound chloroform syncopes—often set the nitrite at defiance.

Amyl nitrite is an important medicine for the conditions enumerated above as being peculiarly amenable to the nitrite influence, and also has proved serviceable in dysmenorrhea and other affections, painful or spasmodic. The remedy is most conveniently given by inhalation, from three to five drops being poured upon a handkerchief, and the cloth then held to the nose and mouth. Those who are subject to angina or asthma, and who find relief from amyl nitrite, may carry a small vial of it about with them, and, upon the occasion of a seizure themselves dash a few drops upon a handkerchief. Or it may be sufficient to sniff strongly at the opened vial itself until the characteristic sense of flushing and arterial throbbing proclaim the absorption of a sufficiency of the vapor. If a vial be so carried and used, it should be but a small one, not over 2 c.c. (℥ xxx.) capacity, since by frequent uncorking of the bottle the contained sample of amyl nitrite gets "flat" and loses its efficacy through chemical change brought about by the exposures to air. More convenient than a vial, both because of better preservation of the medicine and because of combined rapidity, ease, and certainty of dispensing of the dose, are what are commonly called *pearls* of amyl nitrite. These pearls are small, flattened, sealed chambers, blown of very thin glass, and charged with fixed quantities of the nitrite, generally from two to five minims. For use a single "pearl" containing the prescribed dose, is crushed in a handkerchief and the fumes of the liberated ether are inhaled in the usual way. The glass of which the pearl is made is so thin that the broken fragments do no harm. These pearls are not official, but are quite universally to be procured. Amyl nitrite can, if preferred, be given by the mouth, dropped upon sugar, or dissolved in alcohol, in doses of from two to five drops.

Sodium Nitrite: $NaNO_2$. The salt is official in the United States Pharmacopœia under the title *Sodii Nitris*, Sodium Nitrite. It occurs in crystals or fused sticks, freely soluble in water. Commercial samples

are rarely pure, being composed of nitrate and nitrite in varying proportions. The better grades may contain 98.5 per cent. of nitrite, but specimens of a salt sold as sodic nitrite have been found to contain but the merest trace of that body — 0.011 per cent. only (McEwen). The condition of small crystals, as against that of large transparent crystalline forms or the fused nitrite, is said to be the best for purity. Sodium nitrite deteriorates on keeping—a fact doubtless accounting for the poor quality of the drug so often found.

Sodium nitrite produces the peculiar nitrite effects and, when a good sample is employed, can be fatally poisonous, as has been proved by experimentation upon animals. In full dosage with the human subject, extreme distress, and even an alarming condition, have been reported; the prominent complaint being of excessively violent and turbulent heart action, with great giddiness and general weakness. In such cases lividity of the lips and nails has quite commonly been observed.

Therapeutically sodium nitrite has proved efficient in the usual way of nitrites to control the pain in many cases of angina pectoris, and in cases of frequently recurring paroxysms has, in single dose, established freedom therefrom for half a day in subjects to whom amyl nitrite gave immunity for but an hour or two (Matthew Hay). Such immunity, furthermore, was secured by a dosage small enough not to produce any pronounced throbbing or giddiness or headache. In epilepsy this nitrite has also been used with some abatement of the fits; but it is, in a general way, inferior to bromides for this particular therapeusis. From the experience with the salt so far acquired, sodium nitrite can be said to be available for all the therapeutics of the nitrites, and to have the advantages over the ethereal salts of a more deep-rooted and lasting influence, and of much greater cheapness. On the other hand, as compared with amyl nitrite, the sodium salt is slower in establishing its effects, so that when urgency of relief is demanded the amylic salt is preferable. Sodium nitrite gives rise to some disagreeable eructations of gas, but in therapeutic dosage the occurrence is slight. The *dose* of sodium nitrite is one grain (0.065 gram). Care should be taken in prescribing this medicine that the sample is of good quality and not too old.

Edward Curtis.
R. J. E. Scott.

Nitrogen Monoxide.—Nitrogen monoxide (N_2O) is the body commonly called *nitrous oxide gas*, and formerly popularly known as *laughing gas*. It is a colorless gas, practically without smell, and with a very faintly sweetish taste. It dissolves in a little more than its own measure of cold water, to a less extent in warm water, and to a less extent still in a saturated aqueous solution of sodium chloride. By combined exercise of cold and pressure the gas can be condensed to the liquid condition, yielding a colorless and very mobile fluid. Upon release of pressure this fluid immediately springs again into the state of gas. Nitrogen monoxide actively supports the combustion of inflammable bodies, undergoing decomposition and yielding up its oxygen to the burning substance.

Nitrogen monoxide is, physiologically, absolutely bland, and being also odorless is perfectly respirable even when substituted, pure, for atmospheric air. When so respired, the gas, from its free solubility in watery fluids, is rapidly absorbed into the blood. If inhaled with admixture of enough atmospheric air for the ordinary needs of the system, nitrogen monoxide proves peculiarly exhilarant. A sort of tingling thrill runs through the nerves down to the very finger ends, and, if enough of the gas is taken, the experimenter is irresistibly driven to the commission of some extravagant and silly act, almost always such as betokens an uncontrollably joyous state of mind. Singing, shouting, laughing, dancing, and capering are thus the common expressions of the exhilaration-manifestations whence comes aptly the old name *laughing gas*, applied to a mixture of nitrogen monoxide and air. When inhaled pure, in entire substitution for atmospheric air, there is, first, a very transient exhilaration, and then rapidly follow the same phenomena as when pure nitrogen is respired, namely, such as result from the respiration of an atmosphere devoid of available oxygen. The blood returning from the lungs ceases to acquire the arterial hue, its free oxygen rapidly diminishes in quantity, the animal speedily loses consciousness, and, if the inhalation be continued, dies by asphyxia, in the same time that it dies in an atmosphere of plain nitrogen, and with a similar reduction of the percentage of free oxygen contained in the blood. These various facts sufficiently prove that at the temperature of the animal body nitrogen monoxide resists decomposition, so that the oxygen of its molecule is unavailable for the purposes to which ordinarily respired oxygen is put.

Nitrogen monoxide inhaled pure is, then, practically an agent that will, without other derangement, produce the unconsciousness of coma from asphyxia, while not interfering with the free play of the lungs in the respiratory act. The clinical phenomena of the inhalation are, *subjectively*, a beginning feeling of the peculiar tingling and sense of exhilaration noted above, which, however, is soon overwhelmed in swift-rushing unconsciousness. According to the fulness of the respirations the unconsciousness may supervene in from a few seconds to two or three minutes. During the continuance of the unconsciousness anesthesia is absolute; and upon withdrawal of the gas and substitution of atmospheric air the senses are regained as rapidly as they were lost, and in two or three minutes the experimenter is in perfectly normal physiological status again. *Objectively* the phenomena are a swiftly developed lividity of the skin and mucous membranes, staring, and sometimes convulsively rolling eyeballs, a convulsive twitching of the hands, and, when unconsciousness has supervened, a slow, snoring respiration. The pulse is little affected. During the unconsciousness the muscles, with the exception noted above, are quite thoroughly relaxed.

Nitrogen monoxide is used as a medicine proper and as an "anesthetic." Taken in small quantities, so as not to interfere with normal absorption of oxygen, the substance often seems to abate symptoms of nervous debility or exhaustion, and hence to be of value in the treatment of many so-called functional nervous diseases. For such purposes the gas may be given by inhalation, a few whiffs being drawn from a bag through the usual mouthpiece, while at the same time atmospheric air is breathed through the nostrils, purposely left unclosed. Nitrous oxide water has but little odor, and is slightly sweetish to the taste. But by far the commonest use of nitrogen monoxide is the administration of the pure gas by inhalation, in order to produce anesthesia. (See *Anesthesia*, in Volume I of this Handbook.)

Nitrogen monoxide is obtained from the salt *ammonium nitrate* by heating the same in a retort. At an elevated temperature the salt decomposes, and from its constituents water and nitrogen monoxide form $NH_4.NO_3 = 2H_2O + N_2O$. The gas is supplied by manufacturers, condensed to a liquid in strong iron cylinders—a convenient method of storage, since in this way a large volume of gas occupies but a small space. From these cylinders the administration bag is filled as occasion demands. It is not wise to attempt to make the gas, unless provided with apparatus constructed for the purpose, since, unless the distillation be done in a certain precise manner, the resulting gas may contain dangerous impurities. A pure article of fused ammonium nitrate is to be used; the heat is to be gradually applied and never allowed to exceed 400° F. and the gas, after passing through a series of

wash-bottles, one of which contains a solution of potassium hydroxide, is to be collected in a gasometer, over warm water, or over an aqueous solution of common salt.

EDWARD CURTIS.
R. J. E. SCOTT.

Nitroglycerin.—See *Glyceryl Trinitrate.*

Nitrohydrochloric Acid.—(Aqua Regia.) Under the title *Acidum Nitrohydrochlorieum*, Nitrohydrochloric Acid, the United States Pharmacopœia recognizes the product of mixing together 180 measures of nitric acid and 820 of hydrochloric. On making such mixture effervescence occurs and a golden-yellow, fuming fluid results, strongly acid and intensely corrosive—more so than the original acids of its composition—and also possessed of the peculiar properties of smelling of chlorine and of dissolving readily gold-leaf. This fluid is wholly volatilizable by heat. As its smell suggests, nitrohydrochloric acid contains free chlorine, and the fresher the sample of the acid the higher the percentage of chlorine, since by keeping, especially if exposed to light, the chlorine constantly tends to undergo conversion into hydrochloric acid, deriving hydrogen by the decomposition of water. Nitrohydrochloric acid should therefore be made and kept only in small quantities, and these, after all effervescence has subsided, should be put up in glass-stoppered bottles, half filled only, and stored in a cool place, protected from the light. The reactions whereby free chlorine is evolved in a mixture of nitric and hydrochloric acids are now commonly regarded by chemists as the following:

$$HNO_3+3HCl=2H_2O+NOCl+Cl_2.$$
$$2HNO_3+6HCl=4H_2O+2NOCl_2+Cl_2.$$

It will be seen that nitrosyl chloride and nitroxyl bichloride are produced at the same time, and these together with the free chlorine make it an exceedingly irritant preparation. During these reactions the original acids have lost their identity.

As already said, nitrohydrochloric acid is intensely corrosive to animal tissues. The acid is possible, therefore, as a surgical caustic, but the more manageable nitric acid is commonly and properly preferred. The special medicinal value of nitrohydrochloric acid lies in the influence of the preparation over the functions of the liver, and also over certain obscure derangements of metabolic processes, notably over that leading to considerable appearance of calcium oxalate in the urine or *oxaluria*. As regards influence over the liver, nitrohydrochloric acid has long enjoyed the reputation of tending to abate congestions of the organ, to oppose the march of cirrhosis, and even to favor the limitation of abscess, and, in so-called functional disorders of the liver, to cause recedence of the symptoms. Experimentally, also, Rutherford has shown that the acid possesses considerable cholagogue power. Nitrohydrochloric acid is therefore a standard remedy for the treatment of oxaluria and the various above-named diseases of the liver. The medicine can be introduced into the system either by baths or by swallowing. For a bath the acid should be diluted in the proportion of eight grams of the acid to a liter of water (one fluidounce to the gallon), and the bath taken in a *wooden* tub. Such baths should be about blood-warm, and should be administered daily, or twice a week, according to indications. The duration of the bath will range from ten to thirty minutes, or until a tingling or pricking sensation is experienced. After removal from the bath the skin of the bather should be wiped very dry. Instead of a general bath, a foot-bath or a sponging with a dilution of the acid of the strength already given may be substituted. These external applications are undoubtedly efficient, and an occasionally developed salivation proves beyond question the absorption of the acid when administered in this way. For internal giving the dose is a very few drops—from three to five—diluted, at the time of taking only, with a wineglassful or so of water, and the draught sucked through a glass tube, with subsequent thorough rinsing of the mouth. For prescription internally there is also in the United States Pharmacopœia an official preparation entitled *Acidum Nitrohydrochlorieum Dilutum*, Diluted Nitrohydrochloric Acid, consisting of freshly made nitrohydrochloric acid diluted, after making, with nearly four times its measure of distilled water. The preparation is a colorless or faintly yellow liquid, odorless, or having a slight odor of chlorine, and a very acid taste and reaction. By heat it is wholly volatilized. This dilute acid is, medicinally, objectionable, because the mere fact of dilution tends to favor the conversion of the free chlorine of nitrohydrochloric acid into hydrochloric acid. As actually dispensed and used, this preparation is, therefore, much more likely to be a mere mixture of nitric and hydrochloric acids than the specific chlorine-containing compound represented by a freshly made sample of the strong acid. The dose of the dilute acid may range as high as twenty drops, to be taken in the same manner as a dose of the strong acid.

EDWARD CURTIS.
R. J. E. SCOTT.

Nits.—A name often given to the eggs of human lice. See *Insects, parasitic.*

A. S. P.

Nobscot Mountain Spring.—Middlesex County, Massachusetts.

POST-OFFICE.—Framingham.

ACCESS viâ the Massachusetts Central Railroad to South Sudbury, one and one-half miles distant from the spring.

The spring is located three miles from the center of the town of Framingham, at the base of Nobscot Mountain (an Indian word meaning "place of the falling rocks"), the highest point in Middlesex County, and comes through crevices in what appears otherwise to be a solid ledge of rock. The water has a uniform temperature of 41° F., and an average flow, summer and winter, of 15,000 gallons per day. The surrounding watershed is a heavily wooded glacial moraine, free from human habitations of any description. Several sanitary analyses have shown the water to be thoroughly pure and wholesome. The following mineral analysis was made in 1891 by Davenport and Williams, of Boston:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Organic and volatile matter	0.64
Silica	0.53
Iron oxide and alumina	0.02
Lime carbonate	0.75
Magnesium carbonate	0.23
Sodium chloride	0.36
Sodium carbonate	0.38
Potassium sulphate	0.30
Total	3.21

The sanitary analysis made by the Massachusetts State Board of Health is as follows:

PARTS PER 100,000.

	Sample Taken from Spring.	Sample as Sold.
Color	0.00	0.00
Residue on evaporation	4.30	3.90
Ammonia, free	0.0000	0.0000
Ammonia, albuminoid	0.0010	0.0024
Chlorine	0.21	0.21
Nitrogen as nitrates	0.0040	0.0050
Nitrogen as nitrites	0.0000	0.0000
Oxygen consumed	0.00	0.00
Hardness	1.3	1.4
Iron	0.0040	0.0040
Bacteria per cubic centimeter	33.0	0.0

Note that this analysis taken "at spring" and after bottling is practically the same, showing that the packages are kept clean and sanitary.

There is no hotel on the spring property. The Wayside Inn, made famous by Longfellow's Tales, is near Nobscot Mountain. The water is shipped in glass packages and supplied to the markets of numerous New England towns and cities.

EMMA E. WALKER.

Nodositas Crinium.—See *Atrophia Pilorum Propria.*

Noguchi Reaction (Noguchi Butyric Acid Test for Increased Globulins).—In the course of his study of the Wassermann reaction, Noguchi observed that the syphilitic antibody was contained in or precipitated with the globulin and that the globulin was increased in those fluids which gave a positive Wassermann reaction. Further investigation showed that there was no necessary connection between these two bodies though they were apt to be associated. He found that the globulin content of body fluids was often increased when the antibody was present in such small amounts that the Wassermann was negative. He then devised a method for the detection of increased globulin in the body fluids but which has been used almost wholly in the examination of the cerebrospinal fluid. The method is very simple when applied to this fluid. "Two parts of the cerebrospinal fluid to be examined are mixed with five parts of a ten per cent. butyric acid solution in physiological salt solution, and are heated over a flame and boiled for a brief period. One part of a normal solution of NaOH is then added quickly to the heated mixture, and the whole boiled once more for a few seconds." The quantities he used were 0.1 or 0.2 c.c. of the spinal fluid, 0.5 c.c. of the butyric acid solution, and 0.1 c.c. of the normal sodium hydrate. It is necessary that the fluid be entirely free from blood. The presence of an increased content of protein in the cerebrospinal fluid is indicated by the appearance of a granular or flocculent precipitate which gradually settles to the bottom of the tube beneath a clear supernatant fluid. The velocity and intensity of the reaction vary according to the quantity of protein contained in a given specimen. The granular precipitate appears within a few minutes in a specimen containing a considerable increase in protein, while one hour may be required to obtain a distinct reaction in specimens weaker in protein. In obtaining the reaction the time period should not be greater than two hours. Normal cerebrospinal fluid gives with this test a slight opalescence or sometimes a marked turbidity. A granular precipitate may occur only after several hours.

Noguchi obtained positive results with this test in ninety per cent. of the cases of general paresis and practically all the cases of tabes and cerebrospinal lues. The results with this test closely paralleled increase in the cell count but showed many more positive reactions than the Wassermann reaction. In addition the test is always positive in infectious forms of meningitis while it is negative in serous meningitis, meningismus, and in normal cases. This reaction may therefore be of great service in the diagnosis of tuberculous meningitis as well as cerebrospinal lues or the various syphilitic affections of the central nervous system. The results closely parallel those obtained with the Nonne and gold chloride tests.

It should be mentioned that the term "Noguchi reaction" is sometimes applied to a modification of the Wassermann reaction introduced by Noguchi, in which the antigen is composed of acetone-insoluble lipoids and the hemolytic system is an antihuman one used with human erythrocytes. A description of this modification will be found in the article on the Wassermann reaction. RALPH G. STILLMAN.

Noma.—See *Gangrene.*

Nonne-Apelt Reaction.—Like the Noguchi butyric acid test, the Nonne reaction is a test for increased proteins in the cerebrospinal fluid. The test is performed by adding to a small quantity of cerebrospinal fluid in a test-tube, an equal amount of hot saturated solution of ammonium sulphate. If an opalescence appears in the mixture within three minutes the test is positive. Normal fluids give no trace of opalescence. Nonne divided the reaction into two phases. The above is the Phase I reaction. In the Phase II reaction, if no turbidity develops in the performance of Phase I, two to three drops of acetic acid are added. If a turbidity appears Phase II is positive. Many normal fluids give a positive Phase II reaction so that it has been universally discarded. A modification has been introduced which is known as the Ross-Jones test and which is very simple. A small quantity of a saturated solution of ammonium sulphate is placed in a test-tube and the cerebrospinal fluid is carefully layered over it. If the test is positive a white ring develops between the fluids within three minutes. The reaction is positive in all infections of the nervous system and is of great value in the diagnosis of syphilitic affections. It is positive in over ninety per cent. of the cases of paresis, tabes, and cerebrospinal lues. A negative reaction therefore is strong evidence against a diagnosis of syphilis. The Ross-Jones modification is said to be somewhat more sensitive than the original Nonne technique. A positive test is generally associated with an increased cell count and a positive Noguchi butyric acid test. It is of course important that the specimen of fluid examined be absolutely free from blood.

RALPH G. STILLMAN.

Nordrach.—See *Baden-Baden and the Black Forest.*

Norwegian Itch.—A disease caused by *Sarcoptes scabei crustosæ*, an itch-mite. This disease is very contagious, and is much more resistant than the ordinary scabies. Unlike the latter it may occur on the face and scalp. See *Arachnida.* A. S. P.

Nose, Injuries and Deformities of the.—The treatment of injuries and deformities of the nose has been so completely changed by the introduction of methods based upon more scientific principles, it would seem that the time is ripe for the exclusion from our text-books and works of reference operations which have long since been supplanted by more efficient procedures. No useful purpose is subserved by describing in detail year after year experimental operations and procedures originally suggested by enthusiastic seekers after the truth, who, themselves later discovered that their efforts were in the wrong direction. Furthermore the recording of such matters in a book of reference is confusing to the average practitioner who consults his book for real assistance when emergencies arise, and who has neither the time nor the facilities for finding out which of the measures recorded has stood the test of practical usage and may be employed with the best chances of success. We will consider, therefore, only those procedures which have been subjected to thorough clinical test and have been found most useful, while some of those which have been superseded will be mentioned only for the purpose of showing by comparison the superiority of the method advocated.

Traumatic injuries of the nose may be conveniently divided into: (1) Injuries without loss of tissue; (2) those in which there has been more or less destruction of the bony, cartilaginous, and soft structures of the nose.

INJURIES WITHOUT LOSS OF TISSUES.—Practically all fractures of the nose are compound into the nose, the mucous membrane being lacerated. Compound fractures of the nose do not carry with them the same

serious significance that attends corresponding injuries in other parts of the body, for the reasons: (1) The remarkable vascularity of the structures involved offers unusual resistance to infection and hastens the process of repair. (2) The secretions of the normal nose inhibit the growth of bacteria, for cultures taken from the nose are either sterile or show only attenuated growths. (3) The tissues of the nose have developed a certain local immunity to the infectious organisms resident in and around the nose, and it is only when bacteria of a foreign strain or specific variety are introduced into the wound that serious infection results. For this reason, therefore, antiseptic and aseptic precautions should be observed as strictly here as in injuries in other parts of the body.

Fractures of the nose usually result from direct violence, such as a blow from the fist, a fall, a kick from a horse, etc. In extent they may vary from a slight dislocation of the columnar cartilages or of the nasal bones to the complete crushing of the entire nasal arch; in such injuries as the latter the septum is always involved. The injury to the latter is usually confined to the cartilaginous septum and to the vertical plate of the ethmoid; the vomer, owing to its protected position, is seldom involved. Luckily the cribriform plate is rarely fractured, even in very severe injuries. In extreme cases the ethmoid cells, the frontal sinuses, and the antra may be involved.

The most common injury to the nose involves the separation of the nasal bones and their fracture or dislocation from the nasofrontal processes of the superior maxillæ. In such an injury the nasal bones override the nasal processes and the deformity resulting is a broad, flat nasal bridge. Later semilunar folds of skin may cover the inner canthi, producing the effect normally seen in the Mongolian races.

Transverse fracture of the nasal bones usually occurs at a point corresponding to the tip of the nasofrontal spine. However, fractures in a longitudinal direction are common, the line of fracture following the grain of the bone.

In practically all traumatic injuries of the nose there is a tendency for the nasal bones to separate from each other, for in the white races the internasal suture is almost never obliterated; on the other hand, in the Mongolian and Negro races, bony union between the nasal bones occurs occasionally, while in apes there is always osseous union at this point.

In very severe injuries the nasal bones, the nasal processes of the superior maxillæ and the septum are crushed. If the frontal sinus, the ethmoid cells, or the antrum are involved in the injury they are very apt to become infected, in which case external fistulæ may form or the pus may find its way out through the nose. These cases are usually prolonged and very difficult to heal, and unsightly scars mark the sites of the fistulæ. If the case is seen early and antiseptic treatment instituted at once these results may usually be avoided.

The extreme degrees of injury to the nose, therefore, are widely separated from each other, and the details of surgical treatment must vary accordingly. There are certain general indications, however, which are common to all fractures: (1) The field must be rendered aseptic and the fractured parts must be placed as nearly in apposition as possible. (2) The nasal arch must be reconstructed and supported by forces properly and continuously applied by means of a suitable apparatus until fixation of the broken parts has occurred.

If the patient is seen immediately after the injury, before swelling of the parts has taken place, the fracture may be set at once and the retaining apparatus applied. If much swelling, or if emphysema, caused by the patient's blowing his nose, is present, we must wait until this has subsided before attempting to adjust the fractured segments of the arch. These segments are practically always displaced and separated from each other. The nasal arch thus becomes broader and is established on a lower plane. This is due partly to the direction of the force that produced the injury and partly to the elasticity of the skin constantly pulling down on the nasal bridge. It is impossible to raise the nasal bridge or to hold the fractured segments in their proper position solely by means of splints introduced through the nares, for the vertical diameter of the entrance to the nose is only about one-fourth that of the nasal cavity itself. Therefore Bernay's sponges, gauze packing, etc., introduced into the cavities of a fractured nose, not only do not support the nasal bridge, but they broaden the base of the nasal triangle and thus depress it.

Fig. 4142.—Carter's Bridge Splint for Correcting Nasal Deformities.

Treatment of Recent Fractures.—After insuring the surgical cleanliness of both the exterior and interior of the nose, the bridge splint should be applied.

This instrument consists of a light steel bridge, the wings of which are curved, fenestrated and hinged together in the middle. The distance to which the wings can be separated is regulated by a thumb screw. The intranasal splints which are used in connection with the bridge are moulded from gutta-percha at the time of the operation and are threaded into medium curved needles. By means of these needles the sutures are passed through the roof of each nasal cavity at a point just below the ends of the nasal bones, and the intranasal splints are drawn into the nose and adjusted. The bridge is placed in position and the proper amount of pressure applied to the base of the nasal triangle by means of the adjustment screw. The nasal bridge is then lifted to the desired height by means of the sutures which are attached to the intranasal splints, and are tied together over the

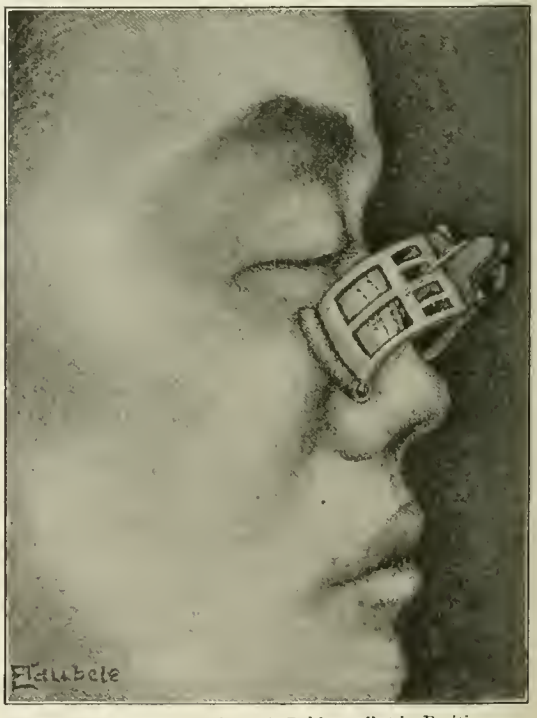


Fig. 4143.—Showing Carter's Bridge-splint in Position.

hinge of the bridge. The effect of pressure and counterpressure is to make it a self-retaining instrument. This apparatus is left in position for ten days or two weeks. Every day it is loosened up and the skin under the wings is bathed with alcohol in order to prevent necrosis.

If we consider the dynamics of this instrument we will see that the force is applied along lines diametrically opposed to those of the force that produced the injury, and in a direction that would tend to construct a normal nose. Before putting on the bridge it is sometimes necessary to adjust the fragments, this is especially so when the septum is badly fractured. The Adams forceps is a good instrument for this purpose.

The use of the bridge splint dispenses with any other treatment for a broken nose, for it corrects the abnormal conditions within as well as without the nasal cavities. Its application is advised in the treatment of all fractures of the nose where the fragments are displaced.

The only contraindication to the use of this instrument is where there has been extensive destruction of the bony and cartilaginous framework, for the success of this method depends upon the presence in the nose of a sufficient amount of bony and cartilaginous tissue to maintain the correction after the removal of the bridge splint.

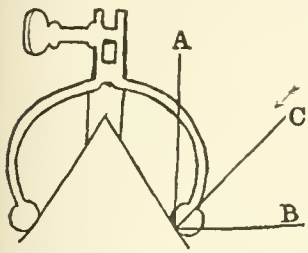


Fig. 4144.—Illustrating the Dynamics of the Bridge-splint.

In cases where there has been extensive destruction of the organ, every effort should be made to prevent infection and the nose should be dressed in such a way as to place the remaining tissues in as nearly a normal position as possible, thus favoring the chances of success in any operation which may be attempted later for the correction of the deformity. In these severe traumatic cases the destruction of bony and cartilaginous framework is more frequently due to a subsequent infection, usually erysipelas, than to the traumatism itself.

If the destruction of the nasal tissues, whether they be bony, cartilaginous, or soft, is due directly to the traumatism itself, and if we are reasonably certain that we have a clean field and that aseptic healing can be secured, the transplantation of tissue to supply the deficiency should be attempted at once. But if the wound is infected no attempt should be made to remedy the defect until after healing has occurred.

Nasal Deformities.—Basic nasal deformities, *i.e.* those involving the framework of the organ may be: (1) Congenital. (2) Acquired. (3) Traumatic (accidental or the result of operation). (4) The result of such diseases as syphilis, lupus, atrophic rhinitis, etc.

1. There may be a deficiency in the bony and cartilaginous framework or in the soft parts of the nose. The correction of this class of deformities usually requires the transplantation of the particular tissue involved, whether it be bone, cartilage, or skin, from some other part of the body.

2. Cases in which there is an excessive amount of material require the removal of the superfluous tissue.

Under this heading may be considered those cases where superfluous tissue in one part of the nose may be shifted to fill up a deficiency elsewhere.

3. Disarrangement of the segments of the nasal arch. Here the parts must be placed in proper position and held until union occurs.

In correcting a deformity we must have in our minds an ideal conception of the result we hope to attain, and by a careful study of the conditions presented, select those methods which seem to suit the particular case. No two deformities of the nose are exactly alike, and it would be a hopeless task to attempt to prescribe fixed rules for their individual correction.

This work is so distinctly specialized and is so dependent for success upon the mechanical talent, manual dexterity, and artistic sense of proportion, all personal attributes of the operator, that it would seem best for all concerned that most of this work should be placed in the hands of those especially equipped in these respects.

All of the work here outlined should be accomplished without the introduction into the tissues of any foreign body. It is a principle which it would seem the surgeon is extremely slow to recognize that nature abhors the presence of foreign substances in the living tissues, for such substances, even though introdnced aseptically, sooner or later cause trouble and are expelled. This result follows much more quickly when the body introduced is required to overcome resistance of any kind (as in lifting a depressed nasal bridge) for the contiguous tissues deprived of their capillary blood supply gradually slough away and the foreign snbstance is expelled.

Congenital Deformities.—Wolf Nose.—In this deformity the nose is very broad and the two sides are more or less separated by a sulcus running down the center. The septum is double and is very thick. The nasal processes of the superior maxillæ are rudimentary and widely separated. The nasal bones, if present, are rudimentary and usually cannot be identified if the patient is young. The eyes are widely separated and show a tendency to occupy their embryonic position on the sides of the head. The inner extremities of the eyebrows are very far apart. The two sides of the nose may be on different levels. The condition is one of defective development and the whole face and skull may share in the asymmetry. Such cases are comparatively rare—I have seen only two.

Each case should be considered in the light of the problems that it presents. The treatment calls for the exercise of much ingenuity, and should be begun as early as possible, usually when the child is about four months old. The deformity is so great that it would be impossible to correct it at one operation or within a short space of time, for in addition to the operative procedures, much has to be accomplished by digital manipulation and moulding by means of splints and apparatus. It will be found necessary to perform three or four operations, as a rule, and these should be separated by intervals of six months or more, so as to take advantage of the developmental forces exerted by nature. The operations have for their object the bringing together of the two sides of the nose and the approximation of the eye-brows. In doing this it is necessary to remove a large wedge-shaped piece of tissue from the center of the nose and stitching the two nostrils closer together. The rudimentary nasal processes of the superior maxillæ are then chiseled loose from their attachments and by subcutaneous manipulation are approximated.

A case of wolf nose, patient six months of age, referred to me by Dr. Robert C. Myles, has now been under my care for the past year and a half and the ultimate results obtained by the treatment here outlined will be excellent.

Deformities of the Tip and Alæ.—In general these may be corrected by subcutaneous procedures conducted from within the nose by means of small knives of various shapes and sizes. The redundant tissues are transposed subcutaneously to those portions of the nose where they are needed to fill in deficiencies.

Collapsed alæ constitute a deformity objectionable not only from an esthetic point of view, but the condition is a serious menace to the health and comfort of the patient, for it limits greatly the power of nasal respiration. This condition may be congenital, it

may be due to an injury, to the effect of an ulcerative process such as syphilis, lupus, or tuberculosis. It is, however, more frequently due to a lack of tone in the dilator muscles of the nares. When the contraction of the nares follows an ulcerative process the scar tissue is usually abundant, this must be excised and the deficiency may be supplied by transplanting a flap from the adjacent skin or a fragment of skin and subcutaneous tissue from the back of the neck or a piece of the lobe of an ear. Where the collapse of the alæ is due to deficiency in muscular tone, the wings may be set further out by means of an incision made in the floor of the nares and out under the bases of the wings—the gap thus left is filled in by a flap from the floor of the nose or from the lip. A very satisfactory method, but one requiring considerable skill and a very delicate technique consists in transplanting long thin strips of costal cartilage into the edges of the wings.

Deflections and Dislocations of the Nasal Septum.—Lateral deviations of the entire nose, of the cartilaginous dorsum, bulging of one side and flattening of one half of the nose are generally due to dislocations or deviations of the septum. Where the deformity is due to a deviated septum, it may be corrected to a large extent by the submucous operation, but when the entire septum is dislocated and lies diagonally across the nasal cavity, it is very unwise to do a submucous operation, for under these conditions the cartilaginous dorsum of the nose will surely fall in, producing a very objectionable step-like depression, or a drooping of the nasal tip.

In such cases as these the septum must be replaced into its normal vertical position. When this has been done the cartilaginous dorsum and the tip of the nose are raised and both the external and intranasal deformities are corrected. The operation is performed in the following manner: The base of the septum, as far back as the dislocation reaches, is sawn through parallel to the floor of the nose, to the mucous membrane on the other side. The upper part of the septum parallel with the roof of the nose is then cut through from the opposite side. We now have the dislocated segment of the septum detached above and below. This segment is now grasped between the blades of an Adams forceps and forcibly brought into a vertical position. In doing this the posterior end of the segment must be dislocated or fractured from the posterior unaffected portion of the septum and all resiliency and tendency of the septum to resume its abnormal position must be overcome. The bridge splint is then applied to hold the parts in position and the nasal cavities packed with vaselin gauze.

The operation just described is the only one to be recommended in deflections of the septum occurring in the young, where it is always essential to preserve the septum which fulfils a very important function in the development of the nose.

Hump-nose.—With this condition may be considered also irregular excrescences of cartilage and bone resulting from traumatic injuries.

The treatment consists in making an incision from within the nose (left naris) through the mucous membrane and intercartilaginous tissue lying between the upper and lower lateral cartilages. Through this opening the periosteum over the dorsum of the nose is elevated, and by means of a special rasp, which I have devised for this purpose, the hump or excrescence is removed. All débris is removed from the subcutaneous sac, it is irrigated with physiological saline solution, and the nasal cavity is packed with vaseline gauze.

Bony and cartilaginous excrescences may be detached through this same incision by means of a special hook-shaped knife or chisel and either removed or transplanted to some other part of the nose where there is a deficiency.

It is necessary to say that in these subcutaneous operations strict asepsis is absolutely necessary to the success of the procedure, for if infection occurs the transposed tissue dies and sloughs out.

Overhanging Nasal Tip.—This deformity is what is commonly called hook-nose, the tip of the nose in marked cases reaches to the level of the upper lip. This deformity may be corrected by working entirely from within the nose, no scar whatever resulting from the operation. The technique is somewhat difficult and special subcutaneous instruments are required.

A fan-shaped segment consisting of the entire thickness of the septum is removed. The apex of this segment corresponds to the anterior nasal spine, which must be chiseled off. The base corresponds to the roof of the nose, from which on either side is removed a wedge-shaped flap of mucous membrane. The tip of the nose is then raised and pushed back and the two edges of the septum are brought together and sutured.

The results that I have obtained by this method are excellent. The nose may be shortened to any extent desired.

Saddle-back Nose.—This condition may be congenital, of traumatic origin, or the result of such destructive diseases as syphilis, lupus, atrophic rhinitis, etc. The most common causes are syphilis and atrophic rhinitis.

Abscess of the septum and the submucous operation, when unskilfully performed, or when the operative field becomes infected, cause step-like depressed deformities of the cartilaginous dorsum of the nose.

The treatment of saddle-back deformities depends upon the amount of bony and cartilaginous tissue remaining in the nose. If this is sufficient to build up a normal arch, the bridge splint is indicated, the application of which has already been described. If this framework material is deficient in amount, the deficiency must be supplied by the transplantation of bone or cartilage from some other part of the body.

Saddle-back deformities where the amount of bony and cartilaginous tissue remaining in the nose is sufficient to reconstruct a normal nose as a rule are due to old traumatic injuries, which either have been neglected or improperly treated. The preliminary treatment of these cases is directed toward preparing the

Fig. 4145.—Carter's Chisel for the Nasal Process of the Superior Maxilla.

field for the application of the bridge splint. This is the only method, as far as I know, capable of restoring normal conditions in such cases.

As a rule the nasal bones have been fractured or dislocated from their attachment to the frontal bone. They are widely separated and override the nasal processes of the superior maxillæ, which may also have been crushed. The displaced fragments are held in their false position by bony and fibrous union. Scar tissue resulting from the injury is usually abundant, and the tendency of this to contract adds greatly to the difficulties to be overcome.

Success in dealing with these cases depends largely upon the thorough preparation of the operative field, that is, the entire framework of the nose, both cartilage and bone, must be so completely mobilized, and the scar-tissue bands so incised that when the parts are pulled into their normal position by the bridge splint there will be no resilient or elastic tissue under tension and exerting a force tending to reproduce the deformity. The wings of the nasal arch must first be separated from their attachment to the nasal processes of the superior maxilla. (In some instances portions of these processes are chiseled off from the body of the bone, to be used in building up the nasal arch.) In order to do this the blade of the nasal chisel is placed against the anterior edge of the process from within the nose, and is driven upward. When the chisel is well engaged it is turned inward by means

of the cross-bar on the handle of the chisel, this splits off a piece of the desired size. There is no danger of wounding the lacrymal canal, for this is posterior and the grain of the bone runs upward and forward and thus away from the canal. The same procedure is carried out on the other side.

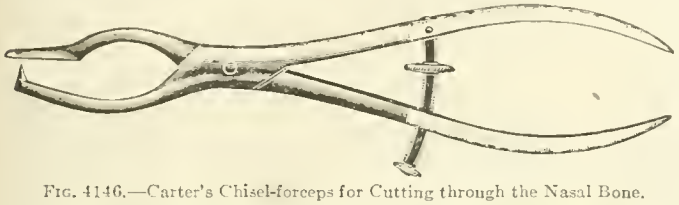


Fig. 4146.—Carter's Chisel-forceps for Cutting through the Nasal Bone.

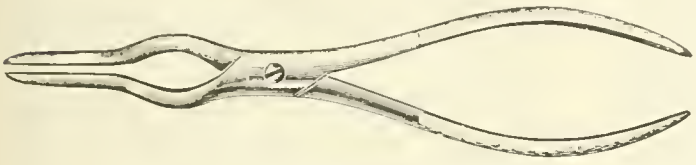


Fig. 4147.—Carter's Modification of Adams' Forceps.

The chisel forceps is then used for separating the nasal bones from their attachment to the frontal bone. This instrument has a small narrow chisel on one blade which is passed into the nose, while the flat blade, padded with rubber tubing rests on the outside. The depth to which the chisel cuts is regulated by an adjustment screw on the handle. We now have the bony nasal arch practically separated from all of its attachments. Complete mobilization of this arch is then effected by means of the Adams forceps, one blade of which is passed within the nose while the other, protected by rubber tubing, rests on the outside.

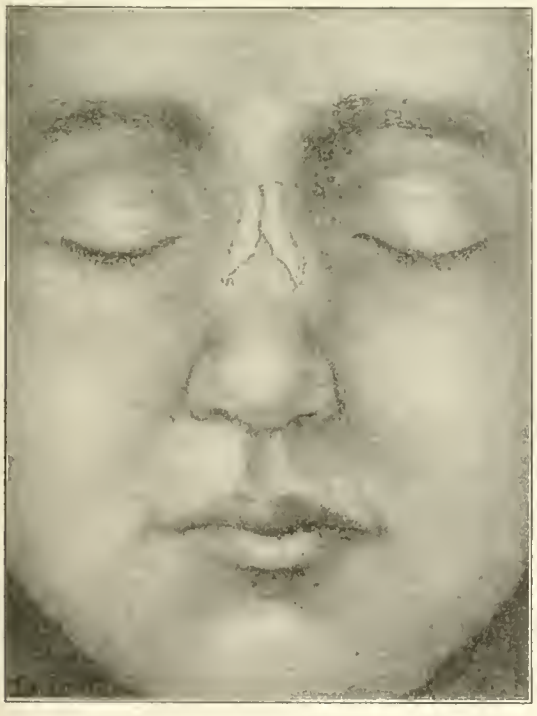


Fig. 4148.—Traumatic Deformity Showing Separation of Nasal Bones.

The septum in these old traumatic cases is usually thick and irregular and obstructs nasal respiration, in addition it is so short that it is impossible to raise the bridge of the nose without lengthening it. I have succeeded in doing this on several occasions by cutting or sawing diagonally through the septum. Beginning the incision near the floor of one nasal chamber and emerging into the opposite chamber near its roof. When this is done the two segments of the septum will slide partially by each other when the nasal bridge is raised without leaving a perforation. If the bulk of the septum is excessive it is better to do a submucous operation two or three weeks before attempting to correct the nasal deformity. When all of the nasal structures have been completely mobilized, the bridge splint is applied in the manner already described. The deformity should be overcorrected in order to allow for subsequent cicatricial contraction.

In these severe cases it is better to keep the apparatus in position for three weeks if possible, for there is a marked tendency, owing to the elasticity of the skin and cicatricial contraction, for the parts to resume their faulty position and bony fixation is necessary to prevent this.

Transplantation of Bone.—This expedient is used in correcting deformities where there is a deficiency in the bony and cartilaginous framework of the organ. This method was first advocated by me about five years ago, and experience with a large number of cases since this time enables me to state that in my opinion it is the only satisfactory method of dealing with cases for which hitherto little or nothing could be done.

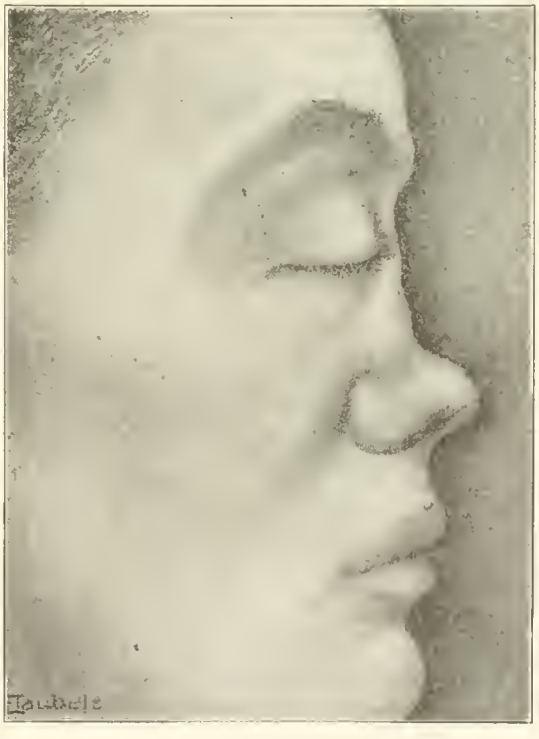


Fig. 4149.—Deformity Resulting from an Old Injury.

Deformities resulting from a deficiency in the framework of the organ may be: (1) Congenital. (2) Traumatic. (3) The result of such ulcerative diseases as syphilis, tuberculosis, atrophic rhinitis, etc.

The most hideous deformities with which we have to deal come under this classification. In extent and degree they vary from slight and easily remedied defects to complete destruction of the entire nose.

Fig. 4150.—Showing Deformity Resulting from Extensive Destruction of Septum and Nasal Arch. (Specific case.)

Some of the mild cases may be corrected by the subcutaneous transposition of tissue from one part of the nose to another where it is needed. Where, however, there is considerable destruction of tissue, the transplantation of bone, and in some instances of soft parts is imperative.

The transplantation of bone is now established upon a practical and scientific basis. My work in this field, having been begun six years ago, now embraces a large series of cases. Some of my patients have been under constant clinical and *x*-ray observation and their present condition shows that the transplant lives and that its growth is regulated by the physiological requirements of the part.

The transplantation of bone is an operation of extreme delicacy and the success of the operation depends upon the careful selection of the patient, accuracy in every detail of the technique, the strict observance of antiseptic precautions and proper after-treatment.

The patient should be Wassermann negative and in good physical condition. There should be no active local manifestations of disease and there should be no dead nor diseased bone in the operative area.

Preparation of Patient.—The nose, face, and right side of the chest should be thoroughly scrubbed with green soap and water and a wet bichloride dressing (1–5,000) applied two hours before the operation. Just before beginning the operation both of these areas should be painted with tincture of iodine.

Operation.—An incision two and one-half inches long is made over the ninth rib at its junction with the costal cartilage. The periosteum over the anterior surface of the piece of rib and cartilage to be removed is preserved. A segment of sufficient length to correct the deformity, half rib and half cartilage,

Fig. 4151.—External Route for Transplantation of Bone.

is then shelled out from its bed and removed. This is split in its transverse diameter and the outer periosteum-covered piece shaped to suit the deformity. The object in having the transplant composed of both bone and cartilage is to restore natural conditions: the bony bridge being reconstructed with bone and the cartilaginous bridge with cartilage. The latter insures the resiliency and flexibility of the nasal tip. This is the latest modification of my operation and has proved very satisfactory.

The next step in the operation is the preparation of the nasal field for the reception of the graft. As

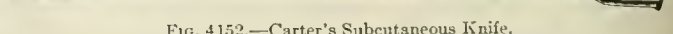


Fig. 4152.—Carter's Subcutaneous Knife.

there are two routes by which this may be introduced, each having its indications and special advantages, it would be well to describe both.

The External Route.—The nose and adjacent portions of the face are painted with iodine and the eye-brows are covered with collodion. A curved incision, convexity downward, is made from the inner extremity of one eye-brow to that of the other. This incision extends down to the periosteum but not through it. The semilunar flap is then lifted by means of a tenaculum and a short transverse incision is made through the periosteum and into the

Fig. 4153.—The Intranasal Route for the Transplantation of Bone. The insert shows the interval between the upper and lower lateral cartilages, through which the transplant is introduced.

bone. This is done in order to excite osteogenesis which comes from the bone and not from the so-called periosteum which covers the frontal bone, as this has no osteogenetic function, the bones of the skull having been developed in membrane. By means of a small specially constructed spatula-shaped knife having a cutting edge at the end and on either side the skin and subcutaneous tissues are elevated over the entire nose and in marked deformities over the adjacent cheeks. The transplant is then introduced, the lower end reaching to within one-half inch of the tip of the nose and the upper end being anchored under the periosteum in close contact with the nasofrontal process. The semilunar flap is then brought down and sutured with horsehair.

The above operation is preferable in some difficult cases, and in every case should be chosen by the novice in this work, for he will probably find it easier to anchor the upper end of the transplant by this method. The chief objection to the external route is that it leaves a slight scar, this, however, is not noticeable a few months after the operation.

The Internal Route.—The vibrissæ are clipped from the left naris and the nasal cavities are thoroughly cleansed with Dobell's solution. The tip of the nose is then raised with the left thumb and by means of the spatula-shaped knife previously mentioned an incision is made in the roof of the left nasal cavity at a point corresponding to the interval between the upper and lower lateral cartilages. Through this opening the skin and subcutaneous tissue over the entire nose are elevated and an incision is made through the periosteum over the nasofrontal process. All of this extensive dissection is done under the guidance of the fingers of the left hand placed on the outside of the nose; the knife is not withdrawn until it is finished. The transplant, which has been prepared as has been previously described, is then introduced through the incision and by the sense of touch the upper end is guided to its position under the periosteum over the nasofrontal process and the lower end is pocketed about a half inch from the

Fig. 4154.—Showing the Correct Position of the Transplanted Bone.

Fig. 4155.—Bone Transplanted with Periosteum—20 months after operation.

tip of the nose. No suture is needed to close the incision. The nasal cavity is lightly packed with vaseline gauze. Complete rest to the part should be afforded. If the swelling becomes excessive, hot applications should be made almost continuously until it subsides.

Fig. 4156.—Specific Destruction of Entire Nose. In this case bone from rib was first transplanted into the arm, and later flap containing bone was transplanted to face. Patient breathes through nose. Condition excellent two years after operation. See Figs. 4157, 4158, and 4159.

It may be that the best we can do at the first operation is to establish a firm bony foundation which may be used as a basis for further correction of the deformity at some later date, after this first transplant has become strongly anchored to the frontal bone. It should be remembered that each case is a law unto itself, and in correcting the deformity we should be guided by its requirements. In some instances it is necessary to superimpose several fragments of bone. This should be done in preference to using a single large fragment, for small pieces of bone are more easily nourished and in these osteogenesis is proportionately greater than in large fragments.

Fig. 4157.—See Fig. 4156.

Fig. 4158.—See Fig. 4156.

The transplant is nourished by the serous pabulum which surrounds it until the minute capillaries which subsequently supply it with nutrition have been formed. It is evident therefore that immobility of the part is necessary in order to insure the life of the graft or at least to give it the best chances to survive the traumatism incident to the operation.

Fig. 4159.—See Fig. 4156.

Value of the Periosteum.—An *x*-ray study of my oldest cases shows that where the periosteum has been preserved the transplant is more vigorous and the results are far better, whereas in those cases where the bone has been stripped of its periosteum, the

graft has acted more in an osteoconductive capacity, the new bone spreading along the transplant from the live periosteum-covered bone to which it is attached. It is advisable, therefore, in all cases to preserve the periosteum.

Complete Destruction of the Nose.—This injury may result from traumatism, but it is more frequently caused by syphilis, epithelioma, and tuberculosis. No more hideous deformity can be imagined. Life to such a patient is a burden and any procedure which will offer relief will be welcomed. The location of the nose in such cases is marked by a hole in the face surrounded by a ring of cicatricial tissue. Through this hole one may note that all of the intranasal structures have been destroyed, and the nasopharyngeal wall is plainly visible.

Appliances made from vulcanite, fashioned in the shape of a nose and held in place by means of a spectacle frame, have been used but they are extremely unsatisfactory.

Attempts have been made to supply the lost member by grafting on a finger and later amputating it. Such an operation should not be considered, for the gain in personal appearance does not compensate for the loss of such a useful member, and besides if the patient is a laboring man, in view of the recent enactment of the Workman's Compensation Law, the loss of a finger would place him at a great disadvantage in his efforts to secure employment.

Operation for Loss of Entire Nose.—I consider the following procedure very satisfactory, it was employed in the case of a woman thirty-two years of age who had lost her nose from syphilitic ulceration when she was sixteen years of age.

A section of the ninth rib two inches long was removed. This was split and the periosteum-covered half was grafted into the subcutaneous tissues of the left arm. Ten days later a flap about one-third larger than would be needed for constructing a new nose and containing the bone transplant, was sutured in the proper position between the eyes, the upper end of the transplant being anchored under the periosteum over the nasofrontal process. The other end of the flap remained connected with the arm which was secured to the head by means of plaster-of-Paris bandages. Two weeks later union with the face had occurred, so the flap was severed from the arm, shaped into a nose and sutured into its proper position. When the flap was severed from its connection with the arm, it became blue and cold and it was evident that it would die from deficient circulation, so I secured a leech, and succeeded in getting it to take hold near the distal end of the flap. As soon as this worm began to fill the flap became warm, the circulation was established and there was no further difficulty from this source.

In any case where flaps having long pedicles are used, I would recommend this procedure as being most useful where the life of the flap is endangered by a deficiency in the blood supply.

Circumstances may make it desirable to use a flap turned down from the forehead to supply a deficiency, but the use of tissue from the arm does not scar the face and for this reason would seem to be preferable.

Skin from the arm assumes the same shade as that of the face in about eight months.

William Wesley Carter.

Nosebleed.—See *Epistaxis.*

Nosophen—tetra-iodo-phenolphthalein $(C_6H_2I_2OH)_2CO.C_6H_4CO$—is obtained by the action of iodine on phenolphthalein, and is a fine yellowish, odorless, and tasteless powder, insoluble in water and acids, and soluble with difficulty in alcohol, ether, and chloroform. It contains 61.7 per cent. of iodine and may be heated to 220° C. (428° F.) without decomposition. It forms soluble salts with alkalies and insoluble salts with the heavy metals.

Antinosin, the sodium salt of nosophen, is a dark blue amorphous powder, which is freely soluble in water and alcohol.

Eudoxin, the bismuth salt of nosophen, contains 52.9 per cent. of iodine and 14.5 per cent. of bismuth, and is used internally as a gastric and intestinal antiseptic. Dose, 0.2–0.5 gram (gr. iij.–viij.), or for an infant 0.06 gram (gr. i.) or less.

Nosophen is a non-irritant iodoform substitute which does not liberate iodine. It is an impalpable powder, of use not only as an antiseptic but also for drying up wound secretions. It forms crusts, however, which must be lifted to allow the escape of the underlying secretions. Owing to its freedom from odor, it meets with much favor in nasal cases. Nosophen has been used in capsule as an intestinal antiseptic; and, in combination with antinosin in cases of chronic suppurative otitis media. The antinosin was instilled into the ear in two- or three-per-cent. solution, and the nosophen dusted into the canal. Antinosin in two-per-cent. solution is also used for bladder irrigations.

W. A. Bastedo.
R. J. E. Scott.

Nostalgia.—Homesickness was regarded originally as a definite disease; one moreover which when confirmed was always serious and at times fatal. In its essence it was looked upon by some authorities as a form of impulsive insanity. Having little by little lost its nosological status, it has for many years past been almost without a medical literature; perhaps the last pretentious effort to describe it as a special disease having been the monograph of Benoist de la Grandière, published 1873. In quite recent years nostalgia has come to light in forensic medicine as a cause of apparently unmotivated crimes and this viewpoint has been well sustained by records of old trials for arson and murder committed by homesick girls and others. This entire subject has been dealt with exhaustively by Jaspers in the *Archiv. f. Kriminal-Anthropologie* 1900, vol. xxxv., p. 1.

The sensations which make up homesickness are within certain bounds entirely rational and may be experienced even by the stronger minds. There is nothing specific about them, for such occur as a result of all depressing emotions. The subject is like one bereaved, grief stricken, or desolate. To feel isolated and desolate it is not necessary for a youth to leave home; he would feel much the same if his associates had all emigrated. But upon leaving home for the first time the sense of loss may be acute and act profoundly on the subject. Normal subjects who merely leave home with a prospect of an early return do not as a rule experience acute homesickness, and at most "miss" people and things. Even under these circumstances, however, the first feeling of homesickness may be so acute that students have at once renounced their ambitions, to return ignominiously home; nor could any amount of ridicule force them to a second start.

Homesickness is a somewhat vague conception. While it may be primitive, essential, like a blind homing instinct, it is very often secondary because conditions in the new abode are burdensome, and home looms up as the only refuge. Moreover, homesickness may be associated with the absence of some individual or inanimate object, and may in part be unconscious. It is worth noting that individuals seldom admit their homesickness. The public usually tease a homesick youth about an absent sweetheart, or perhaps call him "mammy sick." The well-known homesickness of mountain

dwellers has been ascribed in part to breathing a less rarefied air.

Homesickness becomes pathological when it produces physical and psychical disorders. Anorexia brings about failure of nutrition and insomnia favors the supervention of psychasthenic states, chiefly expressed as hypochondria, fixed ideas and impulsive thinking and acts. Jaspers even recognizes a group of nostalgic psychoses, comparable for example with prisoners' psychoses. The subjects dream constantly of home and even have hallucinations of the latter. As a rule all active manifestations are preceded by a more or less prolonged period of homesick sensations which furnish the motive for desperate acts. Thus the boy sent away to school may beg repeatedly to go home and may threaten suicide before he really attempts it. These belated acts are in contrast with the impulsive actions of early homesickness, and the result of cumulation is seen. Similarly we may see both early and late desertions of young army recruits.

The infantile minds of savages, children, imbeciles, psychopathic degenerates, and certain adolescents, who seem in general to rank as normal, are those in which homesickness leads to crimes of violence. In forensic practice most of these have been girls from thirteen to sixteen. They may be quite indifferent after the commission of the crime, or may show repentance, and say that the act was beyond self-control and unpremeditated. The purpose in these cases is now clear, for the domestic or nurse who sets fire to the house, or murders the infant has become unbalanced as a result of cumulative homesickness (often attended with severe physical symptoms) and reasons that if there is no longer a house or child to care for she will be sent home. These young girl criminals have usually shown very gentle and admirable behavior, in the absence of which they could neither have obtained nor held their situations.

EDWARD PREBLE.

Nothnagel, Hermann.—Born at Alt-Lietzegoericke, Germany, on Sept. 28, 1841. He studied medicine at the Friedrich-Wilhelms-Institute in Berlin, chiefly under Traube and Virchow, and received his doctor's degree in 1863. During the years 1865–1868 he was Leyden's assistant in the University of Königsberg. From 1868 to 1872 he was Privatdozent and Military Physician, first at Berlin, and next at Breslau. Then in 1872 he accepted a call to be the regular Professor of the Medical Policlinic and of Pharmacology at the University of Freiburg-im-Breisgau. In 1874 he was called to Jena to be Professor of the Medical Clinic in that university; and finally, in 1882, he removed to Vienna to occupy the same chair in that city. He held the latter position up to the time of his retirement. He died in 1905.

Of Nothnagel's published writings the following deserve to receive special mention: "Handbuch der Arzneimittellehre" (several editions); "Anämie und Hyperamie, Blutungen und Erweichungen des Gehirns;" "Topische Diagnostik der Gehirnkrankheiten;" and "Die Krankheiten des Darms und des Peritoneum." Besides these he has published a large number of articles in *Virchow's Archiv* and other periodicals—articles relating chiefly to the physiology and pathology of the nervous system, to Addison's disease, and to cirrhosis of the stomach. In 1894 he began the publication of a huge Handbook of Special Pathology and Therapeutics, in twenty-four volumes. Besides acting as editor of this great work he contributed to its pages the chapters on diseases of the intestine and peritoneum. A. H. B.

Notochord.—The notochord, or *chorda dorsalis*, is a rod of peculiar tissue, constituting the primitive axial skeleton of vertebrates. The phylum *Chordata* is so named because every species included in this group possesses a *chorda dorsalis* at some stage of development.

Morphology.—A typical notochord is found in the adult Amphioxus (Branchiostoma) and the allied genera which together constitute the small subphylum *Cephalochordata*, or Leptocardii. In these animals the notochord is a stiff, elastic, subcylindrical rod extending from the tip of the snout to the tip of the tail. It consists of a row of disc-shaped cells wrapped up like a roll of coins in a dense connective-tissue sheath that is continuous with the sheath of the spinal cord and with the general connective-tissue framework

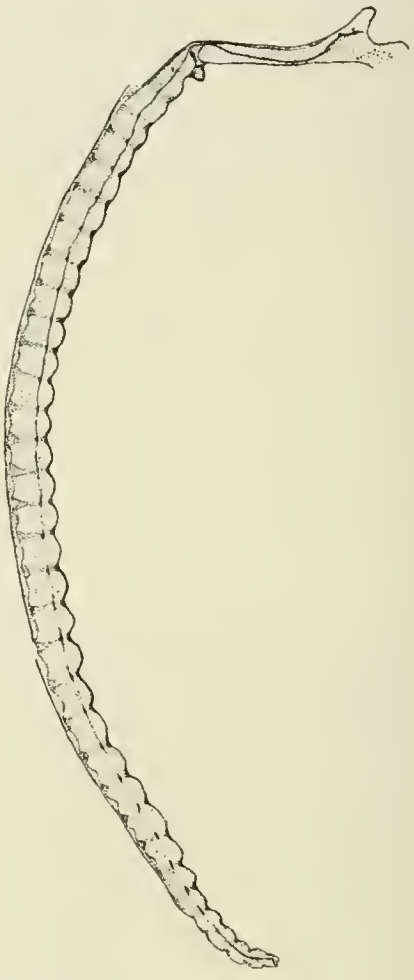


FIG. 4160.—Reconstruction of a Median Section of the Notochord and Chondrostyle from a Human Embryo of 32 mm. × 6. (After Williams.)

of the body. It is dorsal to the aorta and ventral to the spinal cord. The nuclei of the cells are displaced to the dorsal and ventral sides of the chorda by large vacuoles filled with a clear, fluid or gelatinous substance, which probably distends the cells, producing the turgescence of the rod.

Chorda tissue throughout the phylum is peculiar. Its resemblance to the parenchyma of plants was noted by Schleiden and Schwann and suggested their famous cell theory.

In the Enteropneusta, Balanoglossus and its allies, there is a tubular diverticulum extending anteriorly

from the dorsal wall of the pharynx. In some respects this structure resembles a notochord, and its presence together with gill-clefts and a dorsal nervous system led Bateson and others to classify these animals with the chordata as the subphylum *Hemichordata*.

The Tunicates (subphylum *Urochordata*) have an undoubted notochord. But it is confined to the tail. In the pelagic appendicularians it persists throughout life, but in the fixed ascidians the tail is only a larval organ, and there is no trace of the notochord in the adults.

In the Vertebrates, proper (subphylum *Craniata*) the notochord, when fully developed, begins in the base of the cranium just behind the hypophysis cerebri and extends to the tip of the tail (Fig. 4160). As in the lower chordata, the chorda tissue consists of vacuolated cells with peripheral nuclei and it is surrounded by a non-cellular sheath, which may consist of two or three parts. The outer sheath is the first one formed. The others are formed within it, all as secretions from the notochordal cells. The inner one is very thin and is frequently absent. The middle one may be very thick. It is tough and fibrous in the lower vertebrates (Fig. 4161) and mucoid in the mammals. The notochord is not converted into either cartilage or bone, but the sheath and even the chorda itself may be invaded by mesenchyme cells which produce these tissues.

In Cyclostomes the notochord retains its primitive structure, and is throughout life the chief part of the spinal column, giving support to the small cartilages that protect the spinal cord. In the lower orders of true fishes the cartilaginous elements are larger and more numerous, but the notochord is persistent. As we go upward into the higher orders of vertebrates, we find that with the development of the vertebræ the notochord shares in the segmentation of the cartilaginous or bony spinal column, first becoming constricted in the center of the vertebræ and finally losing its continuity, persisting only in the intervertebral discs or perhaps disappearing entirely in the adults.

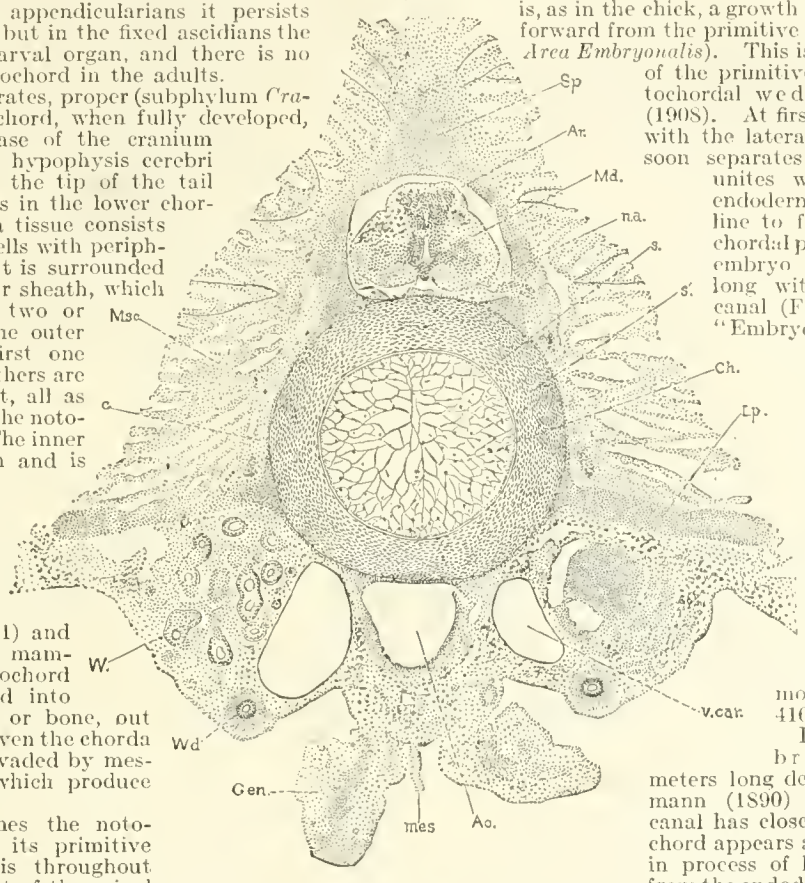


Fig. 4161.—Transverse Section of an Advanced Embryo of a Shark, *Scymnus lichia*, through the Abdominal Region. (The dots represent nuclei.) *Sp.* Spinal process of the vertebra; *Ar.*, arachnoid space *Md.*, spinal cord; *n.a.*, neural arches of the vertebra; *s.*, inner sheath of the notochord; *s'.*, outer sheath of the notochord; *Ch.*, notochord; *t.p.*, transverse process of the vertebra; *v.car.*, cardinal vein; *Ao.*, dorsal aorta; *mes*, mesentery; *Gen.*, genital fold; *W d.*, Wolffian duct; *W.*, Wolffian body with tubules; *c*, young cartilage; *Msc*, muscles developing.

Development in Mammals.—The earliest stages in the development of the notochord are intimately connected with the process of gastrulation (see article *Gastrula*); the later stages are bound up with the formation of the cranium and spinal column. The answer to the question as to whether the notochord is endodermal, ectodermal, or mesodermal in origin depends upon our definition of these germ layers. Keibel defines endoderm as the layer of cells that gives rise to the intestinal epithelium, and thus excludes the notochord. But if we regard as endodermal all cells that line the archenteron, or primitive digestive cavity, then at least part of the notochord in mammals is endodermal, as it appears to be in Amphioxus and the Amphibia. The origin of the notochord occurs at the same time with the first appearance of the mesoderm, during the second phase of gastrulation, which Hubrecht calls *notogenesis* because these structures are differentiated at that time.

In mammals the first indication of the notochord is, as in the chick, a growth of cells extending forward from the primitive knob (see article, *Area Embryonalis*). This is the *head process* of the primitive streak, or protochordal wedge of Hubrecht (1908). At first it is continuous with the lateral mesoderm, but soon separates from that and unites with the general endoderm in the median line to form the notochordal plate. In a human embryo 1.54 millimeters long with a neurenteric canal (Fig. 4138), Spee's "Embryo Glaevecke" (1889), the notochordal plate is everywhere continuous with the endoderm, and is in contact with the medullary groove above. Just in front of the neurenteric canal it is several cells thick; anteriorly it thins out to a single layer of cells as in the mole (Figs. 4162 and 4161).

In the "Bulle embryo" 2.5 millimeters long described by Kollmann (1890) the neurenteric canal has closed and the notochord appears as a ridge of cells in process of being pinched off from the endoderm. Posteriorly near the primitive streak the process is nearly completed, that part of the notochord having become cylindrical.

As the notochordal cells become condensed into a cylindrical rod, the endoderm comes together on its ventral side to form the continuous epithelium of the gut (Fig. 4164). This process extends gradually forward, the separation in the region of the pharynx being relatively late (Fig. 4165).

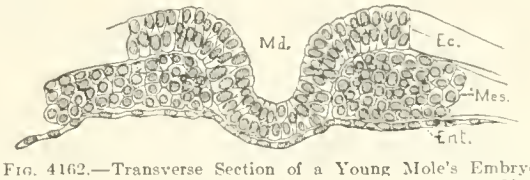


Fig. 4162.—Transverse Section of a Young Mole's Embryo. (After Heape.) *Ec.*, Ectoderm; *Md.*, medullary groove; *Mes.*, mesoderm; *Ent.*, endoderm. Site of the notochord is the central line of the endoderm.

The notochord in a human embryo of 2.1 millimeters, Mall's "Embryo XII" (1897), extends from the hypophysis to the eighth cervical somite, and is probably formed by the method just described. In

later stages the thoracic, lumbar, and caudal portions of the notochord appear to be formed by a progressive differentiation in the cells of the primitive streak, without any connection with the intestinal endoderm.

During the early stages the notochord may inclose a narrow cavity, the *notochordal canal*, which

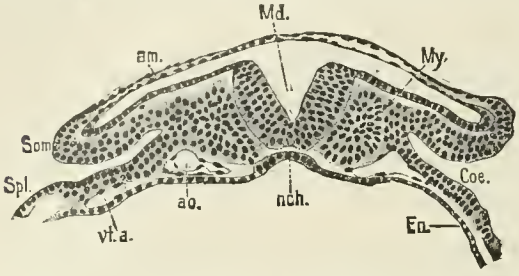


Fig. 4163.—Transverse Section of an Embryo Mole, Stage H. (After Heape.) *am.*, Amnion; *Md.*, medullary groove; *My.*, myotome; *Coe.*, cœlom or body cavity; *En.*, endoderm; *nch.*, notochord; *ao.*, aorta; *vt.a.*, vitelline artery; *Som.*, somatic mesoderm; *Spl.*, splanchnic mesoderm.

varies greatly in extent in various mammals. It is relatively long in the bat and the guinea-pig (Fig. 4166), opening posteriorly into the neurenteric canal and anteriorly and ventrally into the endodermal vesicle. A sheep embryo of two millimeters (Bonnet, 1889) has a similar canal. In some mammals the canal

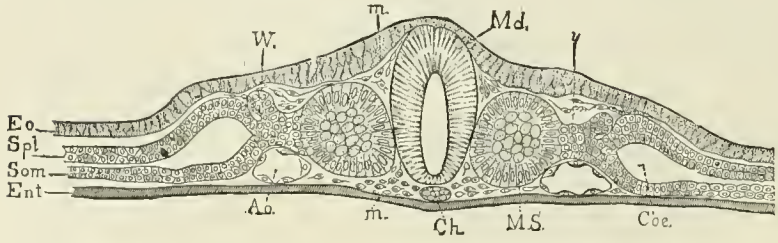


Fig. 4164.—Section of a Chicken Embryo of about Thirty-six Hours. (After Waldeyer.) *Ec.*, Ectoderm; *Som.*, mesoderm of the somatopleure; *Spl.*, mesoderm of splanchnopleure; *Ent.*, endoderm; *W.*, Wolffian duct; *m*, mesoderm cells; *Md.*, medullary canal; *v*, vein; *Coe.*, cœlom: *MS.*, myotome; *Ch*, notochord; *Ao.*, aorta.

ends blindly in the head process, in others it appears simply as a groove on the ventral surface of the notochordal plate. In the pig, hedgehog, and man there is no true notochordal canal, the neurenteric

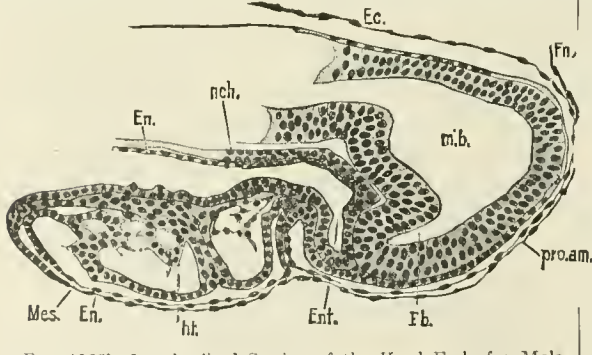


Fig. 4165.—Longitudinal Section of the Head End of a Mole Embryo, Stage H. (After Heape.) *Ec.*, Ectoderm; *En.*, endoderm; *pro.am.*, pro-amnion; *mb.*, midbrain; *fb.*, fore-brain; *Ent.*, pharynx; *ht.*, heart; *Mes.*, mesoderm; *nch.*, notochord.

canal being a simple vertical perforation of the blastoderm. The notochordal canal with the neurenteric canal may be regarded as a vestige of the blastopore (see articles *Blastopore* and *Neurenteric Canal*).

Histogenesis.—After the notochord has been formed as a rod of cells, it becomes surrounded on all sides by mesenchyme cells (Figs. 4164 and 4167), which give rise to the *chondrostyle*, or primitive cartilaginous spinal column. The notochord itself undergoes a process of histogenesis that results in

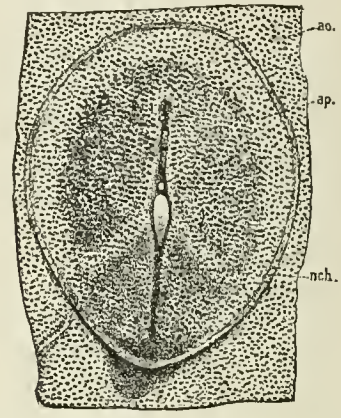


Fig. 4166.—Germinal Area of a Guinea-pig at Thirteen Days and Twenty Hours. (After Lieberkühn.) *ao.*, Area opaca; *ap.*, area pellucida; *nch.*, notochord with several irregular openings on the ventral side. × 24.

the formation of the notochordal sheaths and in changes in the character and arrangement of the cells.

These changes in the notochord of mammals has been studied with care by Williams (1908). In a pig embryo of 5.5 millimeters the notochord is a dorsoventrally flattened rod with the major and minor diameters approximately fifty and twenty-five micra long. In section it exhibits about eight wedge-shaped cells whose exposed walls form a distinct boundary to the chorda. The notochord, as was first shown by Minot, is as a whole thrown into a series of undulations, the crests of the waves being nearly intersegmental (Fig. 4168).

The outer notochordal sheath appears first in pig embryos 7 millimeters long and is fully formed in embryos of 7.8 millimeters. It is a non-cellular membrane 1 to 1.5 micra thick and shows fine concentric striations. The notochord is now larger and has about fifteen cells at the periphery and three or four at the center of each section.

By the time the pig has reached a length of eleven millimeters, the notochordal cells have lost all definite arrangements, have become closely packed together, and flattened anteroposteriorly. In the cells vacuoles have appeared and contain a substance that stains like mucin. The vacuolization of the cells is more advanced in a fourteen millimeter pig, and the inner sheath has appeared. This is much thicker than the outer sheath, and is composed of mucin like that in the vacuoles.

Segmentation of the Notochord.—The condrification of the vertebræ begins in pig embryos before they are twenty millimeters long. The cell walls in the notochord now break down and the cells form a spongy syncytium (Fig. 4169) with mucin-filled meshes, and surrounded by the inner sheath of mucus. At the same time the notochord begins to be constricted in the center of the vertebræ and to dilate in the intervertebral discs (Fig. 4168). The constriction of the notochord is much more pronounced in a pig of twenty-four millimeters and the intervertebral enlargement is correspondingly increased.

In later stages what notochordal cells have re-

mained in the bodies of the vertebræ degenerate, the notochordal sheaths first become calcified and then are destroyed by the process of ossification. The notochord is thus confined to the intervertebral spaces when it enlarges to form the *nucleus pulposus*, which in a half-grown pig forms three-quarters of the intervertebral disc. It is surrounded by a ring of cartilage

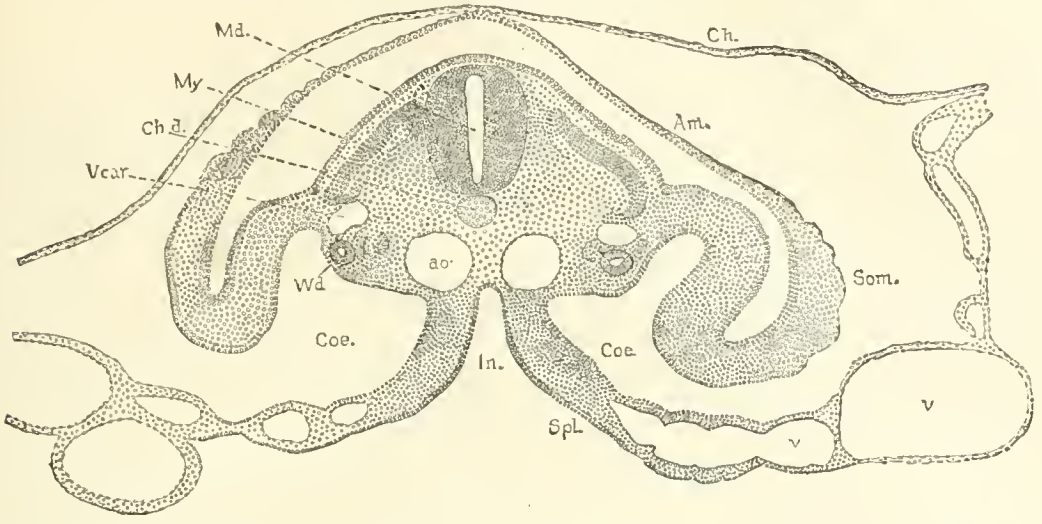


Fig. 4167.—Section through the Rump of an Embryo Chick of the Third Day. *Ch.*, Chorion; *Am*, amnion; *Som.*, somatopleure; *v*, *v*, *v*, blood-vessels; *Coe.*, celom; *Spl.*, splanchnopleure; *In.*, intestine; *ao.*, caudal branch of the aorta; *Wd.*, Wolffian duct; *Vcar.*, vena cardinalis; *Ch.d.*, chorda dorsalis; *My.*, myotome; *Ml.*, medullary canal.

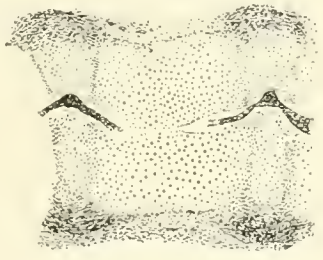


Fig. 4168.—Third Dorsal Vertebra of a Sheep Embryo of 26.1 mm. × 36. (After Williams.)

and this in turn is bounded by a ring of fibrous tissue.

It was shown by Williams (1908) that the notochord does not degenerate in the development of mammals, but persists in the intervertebral discs as

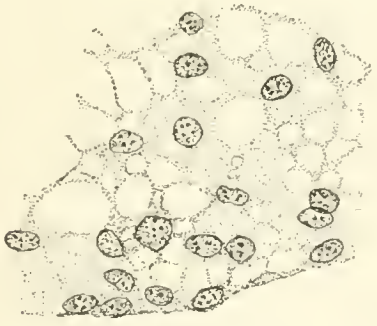


Fig. 4169.—Notochordal Syncytium with Mucin Filled Spaces from a Pig Embryo of 150 mm. × 800. (After Williams.)

the nucleus pulposus and has an important function in connection with the flexibility of the spine. This view is confirmed by Schaffer (quoted by Bardeleben, 1912), who proposes the name, *chorda segment*, for the persistent portion. In the adult pig it is relatively smaller than in the half-grown animal, forming four-tenths of the diameter of the disc, the remaining six-tenths being chiefly composed of fibrous tissue with a thin layer of fibrocartilage lining the notochordal cavity. The notochordal tissue has undergone a further change. The mucin now divides the notochordal tissue into large masses, which are subdivided by smaller quantities of mucin. The smaller collections of notochordal tissue are composed of cells (Fig. 4170) bound together by small quantities of syncytial cytoplasm and containing one or two small nuclei and two or three large vacuoles filled with a substance of unknown character. In some mammals the surrounding cartilage sends papillæ into the notochordal tissue so that the two become intimately associated, but they can be distinguished by their staining reactions. This is the condition in man.

Fig. 4170.—Three Vacuolated Cells from the Nucleus Pulposus of an Adult Pig. × 452. (After Williams.)

The nucleus pulposus contributes largely to the strength and flexibility of the spine, for it forms between the vertebræ an incompressible pad capable of resisting axial thrusts and at the same time readily changing shape in conformity with the movements of the body. The relation between its size and struc-

ture in comparison with the habits of animal is an interesting problem for future investigation. Schaffer has called attention to the fact that in some animals where the intervertebral discs are absent the nucleus pulposus, or chorda segment, is of great importance.

Chordoma.—This is the name given to a tumor composed of normal notochordal tissue growing in an abnormal position. These tumors occur usually in the base of the cranium, most frequently upon the dorsum sellæ, less frequently in the hypophysial fossa and at the spheno-occipital junction; one malignant case occurred upon the upper surface of the basi-occipital bone.

The position of these tumors is accounted for by the peculiar position of the notochord in the base of the skull (Fig. 4160). Here it makes a large sigmoid curve, coming to the surface of the cartilage at four places, once on the ventral side halfway from the foramen magnum to the hypophysial fossa, and at three places on the dorsal side, namely, in the hypophysial fossa, a short distance behind it, and near the foramen magnum. It is rather remarkable that no case of chordoma has been reported from the retropharyngeal region. ROBERT PAYNE BIGELOW.

REFERENCES.

Bardeleben, K. von, 1912: Skelet (Ausser Kopf) Gelenke, Muskeln und Mechanik. Erzeb. d. Anat. u. Entw., Bd. xx., Hälfte 2, pp. 917–934.

Bonnet, R., 1889: Beiträge zur Embryologie der Wiederkäuer. Arch. f. Anat. u. Physiol., Anat. Abt., Jahrg., 1889, pp. 1–106.

Heape, W., 1883–87: Development of the Mole. Q. J. Mic. Sci., vol. xxiii., pp. 412–452., vol. xxxvii., pp. 123–163.

Hubrecht, A. A. W., 1908: Early Ontogenetic Phenomena in Mammals. Q. J. Mic. Sci., vol. liii., pp. 1–181.

Keibel, F., 1889: Zur Entwickelungsgeschichte der Chorda bei Säugern." Arch. f. Anat. in Physiol., Anat. Abt., Jahrg., 1889, pp. 329–388.

Kollmann, J., 1890: Die Entwickelung der Chorda dorsalis bei dem Menschen. Anat. Anz., Bd. v., pp. 308–321.

Mall, F. P., 1897: Development of the Human Cœlom. Jour. Morph., vol. xiii., pp. 395–453.

Spee, F. Graf, 1889: Beobactungen an einer Menschlichen Keimscheibe. Arch. f. Anat. u. Physiol., Anat. Abt., Jahrg., 1889, pp. 154–176.

Williams, L. W., 1908: Later Development of the Notochord in Mammals. Amer. Jour. Anat., vol. viii, pp. 251–284.

Nova Scotia.—Nova Scotia is one of the maritime provinces of Canada to the northeast of the State of Maine, lying in latitude 43° to 46° N. and longitude 60° to 66° W. It is a long, rather narrow peninsula, with a great extent of coast line, parallel to the mainland, extending in a direction from northeast to southwest. It is 350 miles in length, including Cape Breton, and varies in breadth from 50 to 100 miles. Its area is 21,428 square miles and it has a population of 492,338 (1911). The surface is undulating and is traversed by several ranges of hills. It has a cool, marine climate, and is a favorite summer resort for visitors. The principal industries are fishing, mining and agriculture. At Sydney, Cape Breton, are extensive coal mines and iron works.

The following table, condensed from the more elaborate ones in the article on Nova Scotia in the previous edition of the HANDBOOK, conveys an idea of the summer and autumn climate of this region, the seasons when one would visit Nova Scotia as a resort. As will be seen, the mean summer temperature is about 61° F., similar to that of the British Isles at this season, the highest temperature being about 80° F. and the lowest between 43° and 46° F.

The relative humidity is high and there is considerable rain. Fogs are also not infrequent. The number of fair days is, moreover, not large for the summer.

Such a climate is manifestly unsuited for an invalid or delicate person, but affords a grateful change to those who have become debilitated by the summer heat of a large city, or for such as need a change of

CLIMATE OF HALIFAX.—LATITUDE, 44° 39′; LONGITUDE 63° 36′. MOSTLY FOR THE YEAR 1883 ONLY.

	June.	July.	Aug.	Sept.	Oct.	Year.
Temperature (degrees Fahr.):						
Mean average.....	57.26°	63.40°	63.77°	57.56°	47.99°	42.74°
Average range.....	18.67	17.19	19.78	18.63	15.95	
Mean of warmest.	68.82	70.85	73.26	65.66	54.23	
Mean of coldest...	50.15	53.66	54.48	47.03	38.28	
Highest or maximum.....	80.4	81.7	81.2	76.8	73.4	
Lowest or minimum.....	43.2	46.7	45.6	40.5	29.0	
Humidity:						
Mean relative.....	85%	86%	86%	83%	84%	84%
Precipitation:						
Average in inchea.	3.32	3.54	5.34	3.86	5.81	48.52
Wind:						
Prevailing direction.	S. E. & W.	S. E.	S. W.	W., S. W.	W.	
Average hourly velocity in miles.	4.51	4.88	4.88	5.78	6.97	6.75
Weather:						
Number of fair daya	16	19	16	21	15	172
Number of daya on which rain fell.....	17	16	12	14	15	145

scene and air. One is always sure of finding it cool in Nova Scotia, and it is wise for those intending to visit this region to be provided with warm clothing.

"Certain sufferers from hay fever," says Huntington Richards, "enjoy perfect immunity from that disease at Halifax, and probably the same experience may be had at many other points in Nova Scotia." The natural attractions of Nova Scotia are many and varied, and its chief city and port, Halifax, population 46,619, "The Garrison City by the Sea," presents many objects of interest to the American traveller. It possesses a superb harbor in which, in the summer, is the headquarters of the British North Atlantic fleet, and is a frequent port of call for transatlantic steamers on their way to points farther west or to Europe, and on land a garrison is always quartered here. The public gardens are very attractive, and the drives in Point Pleasant Park afford delightful views of the water. The country round about Halifax offers many attractive excursions: and the roads are fairly good either for driving or for automobiling.

In the interior is "Evangeline's Land," a lovely, pastoral region immortalized by Longfellow. The Annapolis basin and valley, the Bay of Fundy, and the numerous shore places likewise offer many attractions, both to the casual traveller and to those interested in the early history of America. Cape Breton, Prince Edward's Island, and Newfoundland are conveniently visited from Halifax.

Good facilities for hunting and fishing are to be had in various portions of this province. One has a choice of various routes to Nova Scotia: by boat from Boston or New York direct to Yarmouth or Halifax; or by boat along the coast to St. John and then across the Bay of Fundy to Digby; by rail to St. John; or all the way by land by the Intercolonial Railway from Montreal or Quebec. The steamers to Yarmouth and Halifax afford excellent accommodations.

EDWARD O. OTIS.

Novaspirin is the methyl citric acid ester of salicylic acid. It is a white, odorless, crystalline powder with a slightly acid taste, and no smell. It is soluble in alcohol, slightly so in chloroform and ether, not perceptibly so in water. It is said to contain sixty-two per cent. of salicylic acid; and its general action is similar to that of aspirin. Novaspirin is one of the many salicylic-acid derivatives or com-

binations and is used in the same doses, 0.7 to 1.0 gram (ten to fifteen grains), and for the same purposes as the salicylates. Its diaphoretic action is slight.

R. J. E. Scott.

Novatophan.—A preparation recommended as a substitute for atophan. It is the ethyl ether of paratophan, or ethyl 6-methyl-2 phenyl-quinoline-4-carboxylate ($CH_3.C_9H_4N.C_6H_5COOC_2H_5$). It comes in the form of a yellowish crystalline powder, without odor or taste, soluble in alkaline solutions, strong acids, and hot alcohol, but not in water. It is given in the same doses and to meet the same indications as atophan (*q.v.*). T. L. S.

Novocaine is one of the many local anesthetics offered as substitutes for cocaine. It is chemically the para-amino-benzoyl-diethly-amino-ethanol hydrochloride, $NH_2C_6H_4.COO.C_2H_4N(C_2H_5)_2HCl$. It occurs as colorless needle-like crystals which melt at 156° C. It is soluble in equal parts of cold water and one part to thirty parts of alcohol. Solutions are neutral, are incompatible with caustic alkalies and their carbonates; sodium bicarbonate, however, does not cause turbidity of novocaine solutions. Pharmacological studies show novocaine in the same concentrations to have an equal action on the peripheral nerves as does cocaine, while the action is more prolonged. Irritation is not in evidence even in the strongest concentrations, while circulation and respiration are uninfluenced. Intravenous injections are followed by a brief lowering of the blood pressure, while the respiration becomes slower and shallower. The heart beats are not weakened. It therefore doubtless acts upon the vasomotor centers. Novocaine is less toxic than cocaine or stovaine.

The strength of novocaine solution is from one-half to two per cent. when injected into the tissues; ten per cent. in ophthalmology; five to ten per cent. when applied to the mucous membrane. It should, as a rule, be used in connection with one of the suprarenal principles, smaller quantities of both being used when combined than when used singly. It can be sterilized by boiling, which should precede the addition of the suprarenal principle, as this is injured by boiling.

A nitrate of novocaine is to be had which can be used with silver nitrate to lessen the pain following the application of the latter to inflamed tissues, such as the urethra, bladder, etc. It may also be used alone or with a suprarenal principle to anesthetize the urethra before dilatation or the introduction of instruments. The solution recommended is the same as of the novocaine, one-half to two per cent.

R. J. E. Scott

Nuck, Anton.—Comparatively little is known about Nuck beyond the facts that he was Professor of Anatomy at the University of Leyden, Holland. Even the dates of his birth and death are not positively known, one authority giving them as 1650 and 1692, another as 1669 and 1742 respectively. Besides being an anatomist, he practised as an oculist and a dentist, paracentesis of the cornea and the making of artificial teeth from ivory being credited to him in these specialties. In memory of his anatomical labors we have the canal of Nuck (processus vaginalis peritonei) and Nuck's hydrocele or dropsy of this canal. He also added very materially to the then existing knowledge of the lymphatics. T. L. S.

Nuclease.—This is an enzyme having a specific action upon nucleoprotein whereby the latter is broken down into its constituent parts—phosphoric acid, xanthine or purin bases, etc. There is some question concerning the identity of nuclease with erepsin as erepsin is capable of producing a similar reaction. F. P. U.

Nucleic Acids.—These are compound proteins which are rich in phosphorus, and yield phosphoric acid, purine bases and a carbohydrate group as cleavage products. In some the pyrimidine bases are also contained. As a rule not more than two purine bases are obtained, namely, adenine and guanine and if others do appear it is probable that they are derived from those mentioned above since it is now well recognized that xanthine and hypoxanthine can be produced secondarily from guanine and adenine. Some nucleic acids yield only one xanthine base, for example from guanylic acid guanine is obtained and from inosinic acid hypoxanthine may be derived. The simplest nucleic acids fail to show the presence of the pyrimidine bases and certain others yield only two out of the three—thus, triticonucleic acid of the wheat kernel, yields only cytosine and uracile—with no thymine.

Of the carbohydrate groups that may be present both pentoses and hexoses have been found and the nucleic acids may be divided into two groups in accordance with the type of carbohydrate group contained in them.

The nucleic acids are white, amorphous bodies with an acid reaction. They are soluble in dilute alkalies, and concentrated acetic acid and form insoluble compounds with copper chloride and salts of the heavy metals. The nucleic acids are more or less decomposed by the proteolytic enzymes, as pepsin and trypsin, although there is not a complete decomposition the final products arising only by the action of erepsin or of a specific enzyme, nuclease.

Of the best-known nucleic acids may be mentioned thymonucleic acids obtained from the thymus, guanylic acid from the pancreas, spleen and liver, and inosinic acid contained in beef extract and the nucleic acids obtained from yeast and wheat. See also *Aliment.* Frank P. Underhill.

Nuclein.—Upon treatment of nucleic acids with dilute acids or with peptic digestion substances called nucleins are formed. As a rule, the nucleins are resistant to the ordinary types of digestion. They are rich in phosphorus and on treatment with alkalies may be decomposed into protein and nucleic acid (which see) and as there are a variety of nucleic acids so there is a corresponding variation in the nucleins. The nucleins behave like strong acids and contain iron. They are colorless, amorphous, and either insoluble or only slightly soluble in water. The nucleins give the biuret test and Millon's reaction and show a great affinity for dyes, especially those of a basic nature with which they unite from either watery or alcoholic solutions.

Frank P. Underhill.

Nucleins are a class of organic bodies of acid reaction, intermediate in composition between proteid and nucleinic acid, and containing from three to ten per cent. of phosphorus. They occur in association with proteids in all animal and vegetable tissues, especially in the nuclei, and in milk. They are separated from the proteids by artificial digestion, the latter being changed to soluble peptones which are removed, while the nucleins undergo little if any alteration (Bunge). The nucleins are then brought into solution by potassium hydroxide. The commercial article is prepared from yeast or yolk of egg, and may be either nuclein or nucleinic acid. According to Chittenden, many of the marketed preparations are worthless.

Nucleins are insoluble in water, alcohol, ether, or

dilute mineral acids, but are soluble in alkalies. On boiling with weak acid or alkali, and more slowly with plain water, they yield phosphoric acid in combination with organic bases. Some, at least, of them split in the body into xanthin, hypoxanthin, guanin, and adenin.

The asserted value of nuclein in medicine depends on its ability to stimulate the antibacterial power of the animal body, and to cause an increase in the number of leucocytes. The solutions have been used in tuberculosis and septicemia. (Hare.) Vaughan cured guinea-pigs inoculated with tuberculosis, and rendered others quite immune to pneumococcus infection. J. Mount Bleyer used it with good results in diphtheria. Sir R. D. Powell reports recovery in one out of five cases of malignant endocarditis. The dose is gr. xxx.–xlv. (2.0–3.0) daily. (Shoemaker.) Nuclein is also one of the innumerable remedies which have been suggested for cancer.

W. A. Bastedo.
R. J. E. Scott.

Nucleoproteins are compound proteins which yield protein and nucleic acid on cleavage. They are diffusely distributed in the animal body occurring chiefly in the nuclei of cells. They differ in regard to the type of protein they contain and also to the character of the nucleic acid. The nucleoproteins always contain phosphorus and usually iron, are weak acids, give the usual protein tests, are insoluble in water and in dilute acetic acid but are soluble in dilute alkalies. See also *Nuclein* and *Nucleic Acids*. F. P. U.

Nuhn, Anton.—Born at Schriesheim, near Heidelberg, Germany, on June 21, 1814. He studied medicine at the University of the latter city, chiefly under Tiedemann, and received his doctor's degree from that institution in 1838. During the following years he held various positions in the university: Privatdozent in anatomy, 1841; Prosector in anatomy, 1844; Professor Extraordinary in the Anatomical Institute, 1849; and Honorary Professor of Anatomy, from 1872 to the time of his death, on June 27, 1889.

Nuhn's reputation as an anatomist rests largely on the fact that he discovered the existence, near the tip of the tongue, of the small gland which bears his name—"Nuhn's gland." As an illustration of the extraordinary educational facilities which are often obtainable in the German universities it may be allowable for the writer of the present sketch to state that during the winter semester of 1869–1870 at Heidelberg, he experienced no difficulty in obtaining private lessons from Prof. Nuhn in the somewhat difficult task of removing from the temporal bone, in a continuous unbroken mass, by means of small but very sharp chisels of different sizes, and a wooden mallet, the thin shell of bone which forms the immediate wall of the labyrinth (vestibule, cochlea, stapes, semicircular canals). Prof. Nuhn furnished all the temporal bones needed for the work—several failures having preceded a solitary success—and spared no pains to give his pupil the benefit of all his anatomical and technical knowledge.

Of Prof. Nuhn's published writings the following deserve to receive special mention: "Ueber eine bis jetzt noch nicht näher beschriebene Drüse im Innern der Zungenspitze," Mannheim, 1845; "Lehrbuch der vergleichenden Anatomie," Mannheim, 1878 (2d edition, 1886); and "Lehrbuch der praktischen Anatomie, etc.," Stuttgart, 1882. A. H. B.

Nussbaum, Johann Nepomuk.—Born in Munich, Bavaria, on Sept. 2, 1829. He studied medicine in his native city, largely under the direction of Karl Thiersch, and was for a short time one of von Rothmund's clinical assistants. He received the degree of Doctor of Medicine from the University of Munich in 1853. After graduating he visited in turn all the larger medical centers and thus had ample opportunities for becoming thoroughly familiar with the work of such celebrated surgeons as Civiale, Nélaton, Chassaignac, Jobert, and Maisonneuve, in Paris; of von Langenbeck, in Berlin; and of von Textor, in Würzburg. Upon his return to Munich, in 1857, he passed successfully the examinations in surgery required of those who contemplate being teachers in this department of medicine. In 1859 he received a call to fill the regular chair of surgery in the University of Zurich; but he declined the invitation, as he preferred to remain in Munich. In 1860 he was chosen Professor of Surgery in the University, and he continued to hold this position up to the time of his death, on Oct. 31, 1890.

Nussbaum was an extremely popular teacher; clear and forceful as a lecturer, and possessing the power of showing the practical side of even the driest topics. He was also a bold operator. During his service of nearly thirty years he performed many thousands of operations—his ovariotomies alone amounting to about six hundred. He was also a frequent contributor to medical literature; one of the best known of his published writings being his treatise "Leitfaden zur antiseptischen Wundbehandlung," of which five editions were published during the years 1877–1889. His other writings dealt with such topics as operations for cancer, nerve-stretching, ovariotomy, transplantation of bone, radical operation for hernia, transusion, accidents in surgery, etc. A. H. B.

Nutgall.—See *Galla*.

Nutmeg.—See *Myristica*.

Nutrition.—See *Aliment* and *Metabolism*.

Nux Vomica.—U. S., Br., *Semen strychni;* P. G., *Semen nucis vomicæ; Poison Nut; Dog Buttons; Quaker Buttons*. The dried ripe seed of *Strychnos Nux vomica* L. (fam. *Loganiaceæ*).

Nux vomica seeds are produced in the East Indies by a small tree which bears a fruit similar in appearance to a small orange. There are from one to four seeds, usually with a few undeveloped ones, found embedded in the whitish, jelly-like pulp of the fruit. The smaller the number of seeds the larger they are likely to be, and the richer in active constituents. Although the principal constituent of the pulp of the fruit is the indifferent glucoside *loganin*, yet it also contains strychnine (about five per cent. in the dried pulp) and brucine (about one per cent.) and is highly poisonous. The leaves also contain considerable percentage of brucine, and probably some strychnine, and are poisonous to cattle.

Description.—About 1.5 to 2.5 centimeters. ($\frac{1}{2}$ to 1 inch) broad, lenticular, but irregularly curved, with an elevated central spot upon one or both sides and upon one side a low ridge (the raphe) running thence to the edge; externally gray, greenish-gray or light yellowish-gray, silky in luster and to the touch, densely clothed with a coat of closely appressed, shining hairs; internally hard, very tough, somewhat translucent, consisting of two discs of perisperm which enclose a thin, circular cavity and the embryo which has small heart-shaped, palmately nerved cotyledons; inodorous and intensely and persistently bitter.

Nux vomica seeds are so abundant and cheap that there would appear to be little temptation to adulterate them; yet not only is the powdered drug subject to adulteration, but, what is of more importance, it varies widely in quality. Hence the great importance

of insisting upon official standards as to the alkaloidal assay of the preparations.

Constituents.—The one important constituent of nux vomica, from a medicinal point of view, is strychnine. The activity of the drug is wholly dependent upon that substance, and the degree of this activity conforms closely to the amount which it contains, although the latter statement is subject to certain modifications, in accordance with the following facts. Associated with the strychnine is a certain quantity of the similar alkaloid brucine—a quantity which either may be equal to, or may be twice as great as, that of the strychnine present. The action of this alkaloid is almost identical with that of strychnine, although variously estimated at from five to ten times weaker. This variation in the strength of brucine is undoubtedly due to the presence in it of variable amounts of strychnine, which it is almost impossible completely to remove. It is to be remembered that the alkaloids, besides being highly insoluble, exist in nux vomica intimately associated with an extremely tough, horny, albuminous substance, so that if the powdered drug be taken, they may be less quickly and completely absorbed than when strychnine alone is administered. Constituents which are not important from a medicinal, though more or less so from a pharmaceutical, standpoint are the tannin-like *igasuric* or *strychnic acid* with which the alkaloids are combined, a considerable amount of fixed oil, a small amount of the glucoside loganin, a little gum, sugar, etc. The combined percentage of strychnine and brucine ranges from two to five per cent. or even more, of which the strychnine represents from one-third to one-half. Strychnine will be fully discussed under that title. *Brucine* ($C_{23}H_{26}N_2O_4+4H_2O$) occurs in very fine colorless crystals, forming a whitish powder, soluble in alcohol. It is distinguished from strychnine by being reddened by nitric acid. It forms salts freely, several being upon the market; the sulphate, which is soluble in water, is the one chiefly employed.

Action and Uses.—Excepting as to the preparations and dosage, an account of the action and uses of nux vomica would be a duplication of that given under *Strychnine*, to which the reader is referred. Brucine is somewhat used in a similar way, in doses of gr. $\frac{1}{10}$ to gr. $\frac{1}{2}$, the total daily amount not to exceed gr. iij. It is also sometimes applied externally to relieve itching.

The dose of nux vomica, in very fine powder, is gr. i.–iv. (0.06–0.24). Of nux vomica the following are the official preparations, subject to assay by processes prescribed by the Pharmacopœia: The extract, to contain 15 per cent. of total alkaloid, dose gr. $\frac{1}{8}$ to gr. i. (0.008–0.06); the fluid extract, to contain 1.5 per cent. of total alkaloid, dose ♏i.–iv. (0.06–0.24); the tincture, to be made by dissolving 20 grams of the dried official extract in 1,000 c.c. of a mixture of three volumes of alcohol and one volume of water—this tincture to contain a total of 0.3 per cent. of the alkaloid, and the dose to be ♏v.–xxx. (0.3–2.0). It will thus be seen that the fluid extract is five times as strong as the tincture, and the extract ten times as strong as the fluid extract. Henry H. Rusby.

Nyctalopia. *Synonym:* Night-blindness, which is often incorrectly termed *hemeralopia* but properly named *nyctalopia*. A patient complaining of night-blindness, or seen feeling about during the twilight, should be given a careful examination by the ophthalmoscope, especial attention being given to the periphery of the fundus, as this is one of the first symptoms of pigmentary degeneration of the retina, commonly called *retinitis pigmentosa*, although symptoms of inflammation are absent. Nyctalopia, night-blindness, is not always present, but usually exists. In this pigmentary degeneration of the retina, we have other changes such as great contraction of the blood-vessels.

We frequently find that a patient cannot read large print when illuminated sufficiently for the normal eye to see it, more powerful light being required to excite the functional activity of the retina. This defect is characteristic of all choroidal changes. Often the vision in daytime is so good as to cause no discomfort, but as night comes on vision becomes very much impaired; it has been called "twilight blindness" by some.

The defect is due to changes in the hexagonal pigment cells of the retina, and in the nerve fibers. As the degeneration of the retina continues the night-blindness increases, the prognosis is bad.

Functional Night-blindness.—In this condition there are no retinal lesions; it is a functional complaint, in which there is an imperfect sensibility of the retina, due probably to exposure of the eye to strong light, together with a weak or anemic state of the system.

It is frequently found in residents of the tropics, in soldiers and sailors, and in those exposed to the intense light reflected from the surface of the plains, or the sea, or from chalk pits, or snow.

Physiologically there exists a condition allied to night-blindness, *e.g.* if we suddenly enter a darkened room, after exposure of the eyes to the full daylight, we notice at first a greater difficulty in seeing objects about us than after a few moments have elapsed in the comparative darkness.

An adaptation of the retina takes place slowly, and is longer the more intense has been the glare to which the eyes were previously subjected. Complete adaptation varies in each case, and also depends on the health of the patient; it is occasionally found in pregnancy a few days before confinement; also in those having jaundice, and cirrhosis of the liver.

The condition is one of anesthesia of the retina, which requires a strong stimulus to arouse the normal activity. There are no ophthalmoscopic changes noticeable in functional night-blindness; there is a defect of vision for blue, so that confusion takes place between shades of blue and green, which is not found in congenital color-blindness. In certain countries, especially Russia, it prevails as an endemic during the Lenten fasts, and has also been found in those having scurvy.

In functional night-blindness, the field of vision is contracted in diminished light in its whole extent or in different areas, according to the degree of the retinal disturbance.

Ring scotoma can be shown by gray test objects in daylight or white ones in a diminished light. Color fields contracted in daylight are seen only at the point of fixation, and disappear as darkness is increased. Associated with this condition we frequently see a shrunken appearance of the conjunctiva, called *xerosis;* this is supposed to be due to the glare which caused the defect of vision.

Treatment.—This consists in withholding light, so that the retina may recover, but it is not necessary that the patient should be in complete darkness, but in a subdued light, having the eye protected from strong light. This can be accomplished by wearing colored glasses. Internally strychnine, iron, or phosphorus to improve the general condition should be given. Improvement takes place quite promptly, but the internal medication should be kept up for some time after apparent cure, as these cases have a tendency to relapse.

Some years ago, while connected with a large ophthalmic hospital, I had occasion to see a number of cases of alleged nyctalopia and hemeralopia in sailors who proved to be malingerers. One of these, the diagnosis of whose condition was night-blindness, was not long after caught stealing at night. (See *Hemeralopia.*) William Oliver Moore.

Nyctotherus.—A genus of ciliated protozoans which commonly live as commensals or parasites in the intestines of animals. Three species, *N. fava*, *N. giganteus*, and *N. africanus*, have been found in man—the last may properly belong in some other genus. See *Protozoa*. A. S. P.

Nye Lithia Springs.—Wythe County, Virginia. Post-office.—Wytheville. Hotel and boarding-houses.

Access.—Via Norfolk and Western Railroad to Wytheville, thence two miles over macadamized carriage roads to springs.

These springs are located in the southwestern part of Virginia, in a charming, picturesque locality, one-quarter of a mile from the corporate limits of Wytheville. The elevation of 2,360 feet above the sea-level gives assurance of a cool and delightful summer temperature. The country about Wytheville has long been celebrated in the South as a summer health resort, and the yearly visitors come from far and near. The average yearly temperature of Wytheville is 53° F. The seasonal temperatures are as follows: Spring, 52° F.; summer, 70.6° F.; autumn, 53° F.; and winter, 32.3° F. The highest summer temperature observed during the past three years has been 88° F. in the shade. The climate is salubrious. The springs are surrounded by a tract of eighteen acres of the primeval oak forest, which furnishes a delightful shade in the summer. The accommodations for visitors are as yet somewhat limited, but a commodious hotel is in contemplation for the near future. Two good hotels and numerous excellent boarding-houses will be found in Wytheville. The springs are three in number, two lithia and one chalybeate. The summer temperature of the two lithia springs is respectively 53° and 54° F., and the chalybeate 56° F. Following are the analyses of two of the springs:

Nye Lithia Spring, No. 1.

(Analyzed by W. L. Dudley, Vanderbilt University.)

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	10.63
Lithium carbonate	6.41
Iron and alumina oxide	0.31
Silicic acid	1.19
Total	18.54

Nye Chalybeate Spring.

(Analyzed by J. L. Jarman, of Emory and Henry College.)

One United States Gallon Contains.

Solids.	Grains.
Potassium carbonate	0.01
Sodium carbonate	0.81
Lithium carbonate	1.89
Calcium carbonate	11.60
Magnesium carbonate	2.35
Iron and alumina oxide	1.33
Silicic acid	0.66
Total	18.65

Rating the lithium in these analyses as the bicarbonate it would amount respectively to 11.77 and 3.48 grains per gallon.

The waters have long been highly prized in the treatment of a variety of disorders of stomach, kidneys, and bladder, and diseases of gestation. Their action in cases of dyspepsia and intestinal affections is also very advantageous. The chalybeate water is in high repute among physicians for the relief of menstrual and uterine disorders consequent upon anemia.

Emma E. Walker.

Nymphæaceæ.—*The Water-lily Family.* This small family of aquatic plants contributes several large, coarse, spongy, dark-colored rhizomes which have been used in medicine. The white water-lilies pertain to the genus *Castalia* Salisb., though long miscalled *Nymphæa*, the latter name still being applied to them as drugs. The species most used are *C. alba* (L.) Lyons (*Nymphæa a.* L.), the European white water-lily, *C. odorata* (Dryander) Woodv. et Wood (*Nymphæa o.* Dryander), the Fragrant or Sweet-scented white water-lily, chiefly of eastern North America, and the *C. tuberosa* (Paine) Greene, the tuberous white water-lily, chiefly of central North America. The yellow water-lilies or pond-lilies, Spatter-docks, or Flatter-docks, pertain to the genus *Nymphæa* L., though long miscalled *Nuphar*. The species of this genus which has been most employed, and the nature of which is best known, is *N. lutea* L., the European yellow pond-lily. From this rhizome has been extracted the white amorphous alkaloid *nupharine*, to which its bitter properties are probably due. The constituents of the other species named are but little known, though they contain bitter principles apparently similar to nupharine. All contain resin, tannin, starch, and gum.

The uses of these drugs are not based upon any scientific knowledge other than that they are mild astringents and bitter tonics. In this way they have been used as astringent gargles, intestinal astringents, and for local applications in gonorrhea, leucorrhea, etc. The dose of the fluid extract is fl. ʒ ¼–i. (1.0–4.0).

Henry H. Rusby.

Nyssorhynchus.—A genus of anopheline mosquitos. There are several species. *N. fuliginosus* is believed to carry malaria. See *Insects, parasitic.* A. S. P.

Nystagmus is an involuntary rhythmic contraction of the ocular muscles producing oscillation of the eyeballs. It is due to imperfect cortical innervation of the voluntary muscles of the eye, and may result from either central or peripheral causes, or from both. The movements, which usually affect both eyes, may be vertical, rotatory, or lateral, but the most common form is from side to side. It is most commonly observed in eyes that are defective congenitally, as in albinos, or from coloboma of the choroid, microphthalmos, etc. Various inflammatory or degenerative diseases of the eyes, chiefly when they occur in early infancy or childhood, frequently cause nystagmus. This condition must not be confounded with the slight tremor observed upon voluntary movement of the eyes in efforts at fixation in various directions which is so often found in association with weakness of the ocular muscles.

Nystagmus may be acquired, and is often seen in those employed in coal mines, and is due to the work being done in cramped positions under poor illumination, the gaze being directed obliquely upward. Fatigue is thus induced in the superior recti and inferior obliques, and also in the internal and external recti muscles, finally causing their spasmodic action. This type of nystagmus may also be regarded as a fatigue neurosis.

Nystagmus also occurs in various diseases of the nervous system, and is often a conspicuous symptom in multiple sclerosis, cerebellar disease, and Friedreich's hereditary ataxia. It occurs in many diseases of the brain, such as tumor, softening, hemorrhage, meningitis, sinus thrombosis, etc. As a localizing symptom it is of no value, but it is an important diagnostic sign in the early stage of degenerative affections of the central nervous system.

In multiple sclerosis nystagmus is a frequent symptom. Spontaneous movements like those seen in albinism or in congenital ocular defects are rare.

The nystagmus is usually manifested when the eyes are moved voluntarily in various directions, especially on lateral movement.

In cerebellar disease nystagmus has been classified as an irritative symptom, being ascribed to pressure on the pons and corpora quadrigemina.

The production of different forms of nystagmus by irrigation of the auditory canal with water was described by Bárány of Vienna several years ago. When the temperature of the water is at 86° F. or lower, rotary nystagmus is produced in the direction *away* from the ear irrigated. Substituting water at 110° F., the direction of the nystagmus is *toward* the ear irrigated. These reactions, known as the caloric reactions of Bárány, are almost invariable in normal persons. When the vestibular apparatus is destroyed by disease or otherwise, these reactions are absent.

Nystagmus due to vestibular disease may be horizontal, oblique, or rotary. It must be composed of a quick movement in one direction and a slow movement in the opposite direction. It is increased in rapidity when the eyes are turned voluntarily in the direction of the quick movement; it becomes weak or may disappear when the eyes are turned in the direction of the slow nystagmus movement. These tests are sometimes of value in differentiating cerebellar disease from disease of the vestibule or labyrinth.

William M. Leszynsky.

Oak.—See *Quercus*.

Obesity.—*Synonyms:* adipositas, adiposis, liposis, polysarcia, corpulence, etc. The two which are the most correct are adipositas and obesity. The latter is chosen because it is more commonly understood both by the physician and the laity. Obesity, strictly speaking, is one of the many forms of disturbed metabolism. It is a condition in which there is a well-pronounced overproduction of adipose tissue, usually distributed over wide areas of the body. In some instances, however, the overproduction is more localized, but even then it never is encapsulated, as is the case in a true lipoma. Such cases cannot be classed as that of general obesity, but indicate that certain portions of the body are more likely to accumulate adipose tissue than are some others.

The only reason for classing this form of disturbed metabolism (obesity) as a separate and distinct disease, is the fact that in this particular instance it gives rise, quite early in the process, to changes that are macroscopic and easily discernible by the unaided eye. Anything short of this cannot be classed as true obesity.

The point at which the normal formation of adipose tissue gives place to that which is abnormal can never be determined exactly. The existence of the abnormal is never recognized until some macroscopic change is noted or some definite abnormal symptom is developed.

The one and chief essential fact, to be kept clearly in mind in the study of all abnormal processes, is that they are always produced gradually and progressively. Not suddenly, as is the case in much of the experimental work done in physiological and research laboratories. For this reason, deductions drawn directly from the latter are often misleading when applied to the case as observed by the clinician. Treatment in like manner must be along graduated and progressive lines, rather than to produce sudden and positively radical changes at once.

Etiology.—von Noorden has divided obesity into two forms, largely dependent upon etiological factors. The one he calls exogenous, due to overeating, excessive use of alcohol, and lack of exercise. The other endogenous, in which the overaccumulation of adipose tissue is due to some abnormal changes in the internal secretions.

If obesity is to be classified according to etiological factors, it is better to divide it into three distinct groups: *first*, those dependent upon anatomical or physiological defects, more largely anatomical; *second*, the exogenous or extrinsic; *third*, the endogenous or intrinsic.

First: Obesity is most common in those who are anatomically defective, in that they have *abnormally small lungs*. Physiologically so, as a sequence to the decreased aerating space, as in one very marked instance in which the writer performed the necropsy and found the two lungs weighing respectively five and seven ounces, instead of the normal twenty and twenty-two. The subject from which these lungs were taken was an extreme case of obesity.

From an anatomical standpoint alone, this diminished the aerating capacity by nearly seventy-five per cent. This anatomic physiological deficiency might be compensated for in a measure, physiologically, by a high hemoglobin content, and an unusually large number of red blood cells; and also by a more active blood current with low vascular tension. A high hemoglobin content and an exceedingly large number of red blood corpuscles has often been recorded in cases of obesity, indicating a tendency by nature to overcome the anatomical defect.

With all the conditions most favorable, however, it is impossible to compensate fully for the anatomical defect when very large, as in the above-mentioned case. Subjects with such a build cannot, even under the most favorable conditions, supply sufficient oxygen to oxidize fully the protein substances and maintain the requisite caloric units. Such persons are very prone to develop an overproduction of adipose tissue. It is highly probable that this form of anatomical deficiency enters very largely into the production of the two classes described by von Noorden.

It certainly is the one factor that cannot be fully overcome, and the one that makes the management of obesity so difficult and unsatisfactory in many instances.

Added to this, overindulgence in food and alcohol, with a lack of out-of-door exercise, and there will be still further overtaxing of the oxygenating capacity of the animal economy, and obesity will be rapidly induced and maintained. This is especially true if the food is composed largely of the carbohydrate class.

When the internal secretions are at fault and prevent normal oxidation, the anatomical deficiency is no less a factor in producing the overaccumulation of adipose tissue.

Source of Body Fat.—At this point the question naturally raised is, what is the source, or sources, of the fat supply to the animal economy under normal conditions? This question has been and still is one of the most difficult problems in physiological chemistry. Some investigators have contended vigorously that the fat of the animal economy came from the protein substances only; some that it came from the hydrocarbons only; still others believe that they have proved that both the proteins and hydrocarbons may furnish the system with its supply of fat.

If it be a fact, as some chemists contend, that when a hydrocarbon molecule begins to break up by cleavage or otherwise, it must according to the fixed laws of chemistry go right on breaking up until the final products carbon dioxide and water are produced; it is hard to see how fat and adipose tissue can be produced from these substances. Further than this, it is questionable as to how much, if any, true synthetic reconstruction takes place in the animal economy. This much is known to be true, that synthetic construction is the chief function of vegetable life, while the reduction of the large and complex molecules to those of smaller construction is the chief function of animal life. Even in the light of all these facts, the consensus of opinion upon this subject appears to be that normally some of the fat of the animal econ-

omy is laid on directly from the fat ingested as fat. There can be no question, however, that the larger part of the fat ingested as such, is directly oxidized to produce the caloric force necessary to maintain animal life.

In like manner it seems fairly well established in the minds of some observers, that some of the fat may come from the sugars or carbohydrates, although most of the carbohydrates, like the fats, are directly and completely consumed to produce caloric energy.

That the fat and adipose tissue of the body does come from an incomplete oxidation reduction of the protein substances, is admitted to be a well-established fact. Just how formed is the question. It may be as a direct oxidation reduction product, or it may be due to a splitting of the protein molecule, and synthetic re-formation out of the smaller molecules and disassociated atoms.

In view of the fact that this anatomical deficiency, overindulgence in food and alcohol, and defective internal secretions all tend to lower the oxygenating capacity of the system, and that the hydrocarbons burn most readily, it seems highly probable that in all cases of obesity what oxygen can be supplied to the system is largely exhausted in the conversion of the hydrocarbons into carbon dioxide and water, leaving an insufficient amount of oxygen with which to accomplish the more difficult task of completely reducing the protein substances. Consequently there results a large overproduction of fat and adipose tissue from the incomplete oxidation of the proteins, thus producing the condition known as obesity. Along these lines we find the reason as to why alcohol is so potent a factor in producing obesity. Alcohol is readily attacked by oxygen and converted into carbon dioxide and water. Many alcoholic subjects consume large quantities, not infrequently from four to eight, or even as much as sixteen ounces (124.4 to 248.8 to 497.6 grams) in twenty-four hours, or during the afternoon and evening. Now as each gram so consumed by the system requires for its complete combustion 1.3965 grams of oxygen, the oxygen supply is rapidly drawn upon, owing to the ease with which the alcohol is oxidized. This tends to leave an insufficient supply of oxygen with which to complete the more difficult task of oxidizing the protein substances; hence the imperfect reduction of these compounds and the formation of varying amounts of fat and adipose tissue, instead of the normal end products. Thus we can see how the free or overuse of alcoholic beverages is an important factor in producing obesity, and especially so if there is the anatomical deficiency already noted, or defective internal secretions. On the other hand, if the lungs are large, the aerating space capacious, and the internal secretions normal, enormous quantities of alcohol can be, and are, taken daily, and the individual still remains thin.

As perfection in composition and quantity of all the *internal secretions* is a prerequisite, at least theoretically, for a perfect metabolism, it is highly probable that changes in these secretions may play an important part in all forms of obesity. Defects in the internal secretions, especially that of the thyroid gland, are largely responsible, if they are not the sole causes of the endogenous or intrinsic types of obesity, the deficient or defective secretions of the thyroid gland causing directly the imperfect metabolism of the protein substances and the overproduction of fat and adipose tissue.

Even in the endogenous types the anatomico-physiological deficiency, already referred to, must play an important part in diminishing the oxygenating capacity of the system. Viewed in this light, every form of obesity is a disturbance in metabolism, in which imperfect and incomplete oxidation of the protein substances is the chief factor in producing the overproduction of adipose tissue.

Heredity is mentioned as a prominent etiological factor in obesity. Those who are constructed with relatively small lungs, or with defective internal secretions, unquestionably are more likely to develop obesity than those with reverse conditions; in that sense one might be said to inherit a tendency to obesity.

Age is a factor in connection with obesity. Corpulence may be met with at all ages. It is not uncommon among children, and has been met with in infancy. Barkhausen reports that of a male child who at sixteen months weighed fifty-three pounds. Williams, one a year old, weighing 100 pounds. Regnelle, a child of eleven years, weighing 450 pounds. Abnormal stoutness may be lost during adolescence. Obesity rarely occurs between fifteen and twenty years. The largest number of cases occur between the ages of thirty and sixty, reaching its height in the last two decades. It is more frequent in females than in men. During this adult period cases have been recorded, frequently which weighed from 300 to 450 pounds. Daniel Lambert at thirty-nine years of age weighed 739 pounds. There is one case recorded as weighing over 1,000 pounds. Castration and sexual inactivity are spoken of as predisposing causes to obesity.

Pathological Anatomy.—The macroscopic appearances consist in a large amount of fat and adipose tissue where it is usually found, and in the more extreme cases in structures not usually supplied with adipose tissue, as in intermuscular planes between the muscle fibers or bundles in the heart, and in the intercellular spaces of the pancreatic gland.

A moderate increase in adipose tissue, in many instances, improves the physical appearance of the individual; beyond this point one becomes more or less ungainly in appearance. This is especially true when the adipose tissue is formed to such an extent that it produces great irregular protruding masses, the amount and irregularity of the protrusions determining the ungainly, or even hideous appearance of the individual.

The microscopic changes consist in the presence of varying sizes of oil globules in the bioplasm of the connective-tissue cells, as a result of which the nucleus is pushed to one side or edge of the cell. The nucleus, however, remains normal in appearance. There is also an increase in the number of the connective- and adipose-tissue cells, thus constituting a true metaplasia, the number of the adipose-tissue cells exceeding the number of fibrous connective-tissue cells. In fact both are increased in number. As already noted the heart and pancreatic gland are frequently the site of newly formed adipose tissue, the newly formed adipose tissue often ensheathing the heart from which it infiltrates in between the muscle layers and fibers, without degeneration of the muscle fibers.

In the pancreatic gland the adipose tissue replaces in part the intercellular connective tissue.

The hepatic cells in some instances contain fat globules, without degeneration of the bioplasm of the cell.

Late in the process true fatty degeneration may be developed and act as a serious complication.

The intermuscular and interacinous transformation into adipose tissue always develops from without and not from within the cell, this being the differentiation between infiltration and degeneration. In the former, large volumes of new tissue are formed, while the latter tends to destruction of tissue and reduction in volume. The most marked exception to this general rule is the enlargement of the liver in some cases of degeneration.

Symptoms.—The symptoms may be classified as von Noorden has done under degrees, to wit, as slight, medium, and advanced; or we can follow Ebstein's classification, such as enviable, ludicrous, and pitiable; again, following Traube, we have two forms, the plethoric and anemic to which may be added a third

or hydremic stage, which may be the final termination of all cases. In like manner any number of terms may be applied to the varying stages of obesity.

In the very early stages there are no symptoms save the fact that one can see that there is some abnormal development of fat and adipose tissue. The next symptom is that the general appearance of the individual is improved.

In the plethoric type the skin is ruddy, muscles well developed. In this class the hemoglobin and red blood cells are above the normal average, the appetite good and the digestion vigorous, the blood tension high, pulse slow, and the heart may be hypertrophied. As the suboxidation goes on and more adipose tissue is developed, the diaphragm may be crowded up and thus embarrass the heart's action. This, together with deficient oxygen supply and some toxemia, will cause still further cardiac embarrassment, and dyspnea upon exertion will be a pronounced symptom. There may be vertigo and tinnitus aurium; with more toxemia cardiac asthma and pseudo-angina attacks may occur. Later, when degeneration of the cardiac muscles occurs cardiac dilatation may develop. Finally the hydremic stage may ensue.

In the anemic type dyspnea will occur earlier in the process. The heart action will be feeble and the vascular tension low; the muscular system in general poorly developed. The appetite is poor, with an inordinate craving for food of the carbohydrate class. The hydremic stage supervenes early in the disease. This type is most frequent in women.

Diagnosis.—The diagnosis is made by the presence of the overproduction of adipose tissue. It is differentiated from adiposis dolorosa, or Dercum's disease by the fact that in the latter, while the patient becomes generally obese, fresh lumps of adipose tissue continue to appear. These newly formed adipose masses are quite firm and hard, and there is considerable pain in the nodules.

Complications consist in fatty degenerations or any other pathological condition that may be developed in conjunction with the obesity.

Prognosis.—The prognosis will depend upon the extent of the etiological factors entering into the production of obesity. If the anatomic discrepancy is large, the indulgence in food and alcoholic beverages excessive and uncontrollable with a vigorous digestion, as is often the case especially in the plethoric class, and there is also impairment of the internal secretions, little can be accomplished by any kind of treatment. The prognosis is bad. If the reverse be true, excepting the extremely anemic cases, and if the overindulgence in food and alcoholic beverages can be continuously controlled, the digestion improved with sufficinet out-of-door exercise, the results of a well-regulated diet and practical treatment will be highly satisfactory, and the prognosis good. These two pictures represent the slight and advanced degrees of von Noorden.

Between these two wide extremes varying degrees of intensity will be encountered. Here the prognosis will also depend upon the success attained in meeting and removing the etiological factors.

Treatment.—The treatment of obesity resolves itself in three common principles: overcome as much as possible the anatomical defect; rationally regulate the diet and exercise; improve the defective internal secretions.

When the anatomical deficiency is large, it cannot be overcome and treatment will be of little avail.

The chief principle in the dietetic treatment of obesity consists in reducing the hydrocarbon food elements and alcoholic beverages, and augmenting the protein substances. Theoretically this seems a perfectly easy problem; practically, it becomes a very difficult one, that is, to secure the right adjustment and reduction between the fats and carbohydrates, so that the system will draw upon the excess of fat stored in the system for its caloric energy instead of securing it out of the normally used hydrocarbons, and still enable the system to utilize perfectly and oxidize completely a larger percentage of the protein substances.

In the so-called Banting system, or that devised in 1862 by Mr. Harvey of London, and used with great success in the case of William Banting, animal food was freely allowed, the fat and carbohydrates greatly reduced, the fats very greatly reduced, in fact almost eliminated. In other words he gave his patient

172 grams of proteins,
8 grams of fat,
81 grams of carbohydrates.

261

To oxidize completely these 261 grams requires 346.8 grams of oxygen, and yields 1.112 large calories of heat. Assuming that the lung capacity was normal, there would be a surplus of 403.2 grams of oxygen with which to attack the surplus adipose tissue and excess of proteids, and gain the requisite caloric units of heat required to sustain animal life by oxidation of the excess of adipose tissue. In so far as this is accomplished, the obesity is overcome.

In the Ebstein dietary a little different arrangement of the three is advocated. He lowers the protein elements as well as the fat and carbohydrates, using

102 grams of proteins,
85 grams of fat,
47 grams of carbohydrates.

234

The total amount of food used daily being less than with the Banting system. To completely oxidize these 234 grams requires 437.5 grams of oxygen and it yields 1.401 large calories of heat. This with a normal lung capacity leaves a surplus of 312.4 grams of oxygen with which to attack the surplus adipose tissue and gain the remaining requisite units of heat.

With the Oertel diet a still different arrangement obtains:

183 grams of proteins,
38 grams of fat,
143 grams of carbohydrates.

364

In this instance the total amount of food used is larger than in the other two. To completely oxidize the 364 grams requires 408 grams of oxygen, which if the lung and oxygenating capacity be normal, leaves a surplus of 341.3 grams of oxygen with which to attack the surplus adipose tissue and gain the required heat units.

The Banting diet so far as the oxygen consumed is concerned is the most highly starving. It is the most fat free of all, and leaves the largest amount of oxygen with which to consume the surplus adipose tissue. It, however, contains an excess of proteins as compared with the normal requirement. It yields the smallest caloric force.

The Ebstein diet contains the smallest total amount of food. The proteins and carbohydrates are very much reduced, while the fat remains nearly up to the normal standard. At the same time it requires more oxygen for its complete oxidation than does the Banting system. Therefore it is less of a starvation diet considered from the amount of oxygen consumed.

With the Oertel diet a larger amount of food is used than in either of the other two. Less oxygen is used than with the Ebstein diet, and more than with Banting. In this instance more energy is developed from the food than with either of the other two. There is more oxygen with which to attack the surplus adipose tissue than with Ebstein's diet. There is much more inherent energy developed with which to stimulate the system to accomplish this extra work, both as

regards oxidizing the adipose tissue and utilizing the large amount of proteins than in either of the other two. If this larger amount of proteins can be perfectly transmuted a higher grade of tissue nutrition will be established as the adipose tissue fades away.

The greatly increased energy, as compared with the Banting system, may in a measure offset the larger consumption of oxygen by the Oertel system. So far as the quantity of protein is concerned, the Banting and Oertel systems are more nearly alike. Both use an excess of proteins compared with the normal, which is better than the smaller amount in Ebstein's.

The Banting system made no mention of a reduction of the water or fluids ingested. This is emphasized with the other two, and in fact with all other methods. The reduction in the amount of water taken makes the demand on the part of the system just so much greater for water. Hence the greater the necessity for oxidizing the surplus adipose tissue to secure water, which is one of the end products of fat oxidation. In other words, abstaining from water tends to force fat oxidation.

Very gratifying results have been obtained from all these and similar methods of diet based on the same principles.

In my judgment the fat is too much reduced in the Banting system to give the best results in the majority of cases. In the Ebstein there is too much fat.

To all systems a varying amount of out-of-door exercise must be taken systematically. Needless to say all alcoholic beverages should be excluded.

As already noted, if there is much diminution in the size of the lungs and the aerating capacity of the system, there will be just so much less surplus oxygen with which to oxidize the surplus adipose tissue. This being the case it will be necessary to still further reduce the total quantity of food taken, or to rearrange the three elements of food in such a manner that considerably less oxygen will be required. At best under these conditions it will take longer to accomplish the results. In this class the Ebstein diet would be the best. A diet with less fat than in the Ebstein would be better still. In some instances this anatomical deficiency will make it impossible to overcome the obesity.

Again, if the internal secretions are at fault, this may be the factor that cannot be overcome fully, thus making a cure of obesity impossible. At best it will retard the reduction of the adipose tissue.

There is no special drug that can be classed as having any specific action, unless it be the thyroid extract.

There are many other substances that can be made to force body oxidation and render the individual thin; but they all accomplish it to the detriment of the inherent structure of the animal economy. Therefore they cannot be recommended.

The same is true of the thyroid extract. If given *ad libitum* it will do irreparable damage. Assuming, however, that the endogenous cases of obesity are due to deficient internal secretions, and especially that of the thyroid gland, its use is certainly indicated. Even in those cases it must be used with great care and close watching of its effects.

As there is a possibility that deficient or defective internal secretions, and especially that of the thyroid gland, play a part in the development and maintenance of all forms of obesity, from a purely theoretical standpoint its use to a limited extent may prove of value in all cases. The fractional grain tablets put up by some of the manufacturing chemists makes its administration quite easy of accomplishment in just the dosage required.

Digestive adjuvants, bitter tonics, arsenic, iron, mercury, etc., may all be of value under certain conditions, and must be used as required in each individual case treated.

Hydropathy, massage, and various forms of mechanical exercise have been recommended. They all have in some instances been beneficial in promoting a more active oxidation of the fat and adipose tissue.

Certain mineral waters are highly extolled by some writers, such as Vichy, Kissengen, etc. Alkaline saline waters when they improve the digestive function are of value.

Baths of various kinds have been recommended, and may in a measure augment fat oxidation.

William Henry Porter.

Obstetrics.—See *Labor*.

Obstetrics, History of.—The history of obstetrics is the account of one of the most interesting passages in human development. It is most intimately associated with the history of the reproductive instinct which is in many respects the strongest and most insistent factor in animal life.

The development of the science and art of obstetrics began with the beginning of human intelligence. Among the lower animals the female brings forth her young as best she may, without assistance from her mate, unless it be to protect her from attack by other animals. Sometimes even this defense is wanting. Defective development and physical incapacity mean difficulty and perhaps disaster in the process of parturition both in the lower animals and in man and if we can judge from what is constantly occurring among the domestic animals this is not so very uncommon.

Primitive man must have recognized the occasional need of help during the process of child-bearing, for in so far as there is any primitive man he recognizes it still. At any rate he recognizes the fact that women sometimes die during this experience and at some time in the remote past it must have occurred to some of those who had the spark of love or sympathy that in some instances at least there was something wrong and that human help was needed. It is unlikely that crude and barbarous and rough men should first have offered assistance in such a situation, it was more rational that assistance be given by those who had been through a similar experience. It is therefore probable that the help which is rendered by midwives is the basis of one of the oldest if not the oldest of the human arts.

It is desirable in the consideration of so important a subject as this to pay some regard to chronological sequence. The subject may therefore be subdivided on this basis into seven periods as follows:

1. All that precedes the time of Hippocrates when observations began to be recorded and deductions made therefrom.
2. From the time of Hippocrates, the fifth century B.C., to the Arabian physicians of the ninth century.
3. From the Arabians of the ninth century to their disappearance in the twelfth.
4. The period of relative darkness from the thirteenth century to the time of Ambroise Paré 1550.
5. From Paré to the general knowledge of the obstetric forceps in the seventeenth century.
6. From the general knowledge of the forceps to the use of chloroform during labor in the middle of the nineteenth century.
7. From the use of chloroform to the present time, including the development and applications of antisepsis to obstetrics.

First Period.—When obstetrics or midwifery, which is the same thing, first became an art and was practised as such, we have no means of knowing. It is sufficient at any rate to note that in that ancient book, the Bible, abnormalities in parturition were observed, and that the function of the midwife was recognized more than 4,000 years ago. Thus the birth

of the twins, Pharez and Zarah, is noted in Genesis, and the first recorded instance of spontaneous version is given. "And it came to pass in the time of her travail that twins were in her womb, one put out his hand and the midwife took and bound upon his hand a scarlet thread saying—this came out first. And it came to pass as he drew back his hand that his brother came out, and she said, How hast thou broken forth? this breach be upon thee; therefore his name was called Pharez. And after came out his brother that had the scarlet thread upon his hand, and his name was called Zarah." (Genesis XXXVIII, 27–30.)

The Egyptians of 4,000 and more years ago were a cultured race and lived in cities. The change from a natural or nomadic life meant more or less change in structural anatomy and consequently more or less change, in many instances at least, in the structure of the pelvis.

This was the occasion for the development of the art of the midwife. The Bible declares, that the Hebrew women in Egypt had easier labors than the Egyptians and consequently the midwives had less occasion to give them assistance. "And the King of Egypt called for the midwives and said unto them why have ye done this thing, and have saved the men children alive? And the midwives said unto Pharaoh, Because the Hebrew women are not as the Egyptian women, for they are lively, and are delivered e'er the midwives come in unto them." (Exodus I, 18–19.)

Difficult labor is recorded in the twin birth of Esau and Jacob when the latter presented an arm and is thus an early recorded instance of shoulder presentation. "And when her days to be delivered were fulfilled, behold there were twins in her womb; and the first came out red all over like an hairy garment, and they called his name Esau. And after that came his brother out and his hand took hold on Esau's heel, and his name was called Jacob." (Genesis XXV, 24–26.)

The difficult labor of Rachel is also mentioned, who though encouraged by the surrounding attendants, or midwives, was unable to withstand its severity, and succumbed. "And it came to pass when she was in hard labor that the midwife said unto her—Fear not, thou shalt have this son also. And it came to pass as her soul was in departing (for she died) that she called his name Ben-oni, but his father called him Benjamin." Other interesting facts in the biblical account are that the parturient was delivered upon a stool or obstetrical chair and that women were accustomed to help themselves when in labor, probably by pressing or pulling upon some resisting object. "And he said when ye do the office of a midwife to the Hebrew women and see them upon the stools, if it be a son then ye shall kill him, but if it shall be a daughter then she shall live." (Exodus I, 16.)

The law of Moses prescribed for the purification of women after labor, commanding a period for her recuperation, and her preparation for the normal or unimpregnated condition of her genital organs.

The Talmud recognized the period of pregnancy as 270 to 273 days and that pregnancy could not be determined prior to the fourth month. It anticipated the error of Hippocrates that an eight months' fetus was not viable, and declared that the child floated in the amniotic sac folded up like a scroll. The Talmud also shows that the ancient Hebrews had more or less knowledge of evisceration, cesarean section, and version. In Egypt in addition to the midwives the priests, who were the repositories of so much of the knowledge of the early times, rendered assistance in difficult labors, probably by manual or instrumental procedures; for their experience in the case of the dead made them not unfamiliar with the anatomy of the interior of the body.

Little is known of the obstetrics of ancient India except that it was of a very primitive character. The people of India had some ideas of the development of the fetus *in utero* which were probably gained from the investigation of animals. They thought the embryo fastened itself to the womb in the first month, was egg shaped in the second month, that the head and extremities began to grow in the third month, that the head and trunk took distinct form in the fifth, and that this became more definite in the sixth and seventh months. In the eighth the child became uneasy and was born from the ninth to the twelfth month. The head should always come first the mouth being turned to the mother's spine in prayer and facing earth just before birth took place. In ancient India it is thought there was also knowledge of extraction by podalic version, cesarean section upon the dead, embryotomy, and craniotomy upon the dead child. Obstetrical knowledge in this country was also sufficiently advanced to recognize presentations of the foot, breech, back, side, and breast, the latter with prolapse of the arm, and artificial means had been devised to remedy them. There are even records or traditions that among the ancient Aztecs malpositions of the fetus were observed after the seventh month and were corrected by kneading the abdomen of the mother or by grasping her by the legs and shaking her.

The ancient Japanese practised friction of the abdomen to facilitate labor, performed external version, and determined the existence of pregnancy by certain signs in connection with the pulse, the abdomen, and the breasts.

When we come to the Greeks we reach the fountain of recorded observation in obstetrics as in so many other arts and sciences. Naturally we first invoke *Hippocrates* who lived in the fifth century B.C. and whom we affectionately revere as the father of medicine.

The art of the midwife was a well-recognized and useful one at that time, in fact the mother of Hippocrates himself was a midwife. The priests of Æsculapius had accumulated no inconsiderable fund of knowledge of medicine, including obstetrics, and Hippocrates was indebted to them for much that he placed upon record. But besides this he was an acute observer and made abundant contributions to permanent records from his own experience and reasoning. He could well have said with Socrates that *he* was a midwife and helped nature in giving birth to ideas.

The midwives of his day attended to all the wants of the parturient woman encouraging labor pains by massage of the abdomen, by sternutatories, by making the patient walk about, and even by shaking her if the birth of the child was too long delayed. When the child was born they sang holy songs to greet it. If a woman died undelivered the recognized practice was the immediate performance of cesarean section, and not until then or until a destructive operation on the fetus should be demanded was a man ever called in to assist a parturient woman. The midwives also produced abortion, which was not considered an improper thing if a woman desired it, and they had private asylums for lying-in women and for the treatment of diseases of the female genitals. They evidently made some bad mistakes, for in Aristotle's time, the fourth century B.C., they were forbidden by law to practise in Athens, the law not being repealed until 285 B.C.

Hippocrates taught that a seven months' fetus was viable but an eight months' fetus was not, and this singular observation was handed down almost to our own time. He also advanced the idea which was retained for ages that the head presentation was the only proper one and advised that cephalic version should be performed to convert all other pre-

sentations into the vertical. Though his idea of the mechanism of labor was incorrect and showed imperfect knowledge, it also showed that men had begun to think of measures for overcoming variations from that which they regarded as physiological, and from that point of view it was a most important matter.

He and his followers also advised the manual separation of the placenta when it was retained too long and gave rules for the performance of the destructive operations embryotomy, craniotomy, perforation, extraction with the hook, and amputation of the limbs.

The early Romans did nothing important for obstetric art. Midwives attended women who were in labor but when difficulties came they were accustomed to call upon their goddesses, Lucina, Juno, and Diana for assistance. Midwives also treated diseases of the genital organs and were consulted by the authorities on obstetrical matters which had a legal bearing.

Cesarean section was performed upon women who died undelivered from the time of Numa Pompilius.

Second Period.—This extends from Hippocrates, fifth century B.C. to the Arabian physicians, ninth century A.D.

From the fourth century B.C. to the first century A.D. little or nothing was added to obstetrical knowledge. Then came Galen whose profuse medical writings were based upon those of Hippocrates and became the standard of medical literature for the succeeding thousand years. They added nothing to existing obstetric science, for Galen practised neither obstetrics nor surgery. One curious observation which he made was in regard to the origin of milk in the female breasts. This he considered due to the pressure of the uterus upon the abdominal vessels.

In addition to Galen a group of men arose during the first seven centuries of the Christian Era whose writings have come down to us and show that obstetrics made no little progrees during that period. This was particularly noteworthy in the domain of destructive obstetrics with which men who practised the art were chiefly concerned.

The first of this group was *Celsus* (25 B.C. to 50 A.D.). He described the method of extraction with the hook, decapitation and the expression of the dead fetus. He also described two methods of version, one for the dead fetus and the other for transverse presentations. Four varieties of presentation were recognized by him: (1) the head, which was the only normal one; (2) the thigh; (3) the feet, and (4) the transverse.

Soranus of Ephesus (100 A.D.) is considered the most distinguished obstetrical writer of antiquity. How many of his recommendations were original with him we have no means of knowing, but his writings show that in the brief period which had elapsed since the time of Celsus much information had been acquired in obstetrics, gynecology, and pediatrics. He wrote a book of instruction for midwives which is the first upon this subject of which we have any record.

Among his important observations it is noted that artificial abortion at the third month may result in tetanus, that inversion of the uterus may follow hasty or faulty delivery of the placenta, and that premature rupture of the membranes frequently signifies prolonged and difficult labor. He enumerated the signs of pregnancy and by percussion differentiated uterine mole and other tumors from normal pregnancy.

He also made use of the knee-elbow position in labor and practised both cephalic and podalic version for living children, being the first to recommend the latter of these procedures and to demonstrate thereby that delivery otherwise than by the head was feasible and sometimes desirable. He established a firm basis for obstetric science and his great influence was felt for more than a hundred years, being prolonged by his pupils, Rufus and Moschion.

The writings of *Rufus* were not extensive but he was the first, so far as known, to describe the Fallopian tubes and to note their importance. *Moschion*, (220 A.D.), like his master, wrote a book of instruction for midwives, parts of which only have been preserved. His statements were mostly repetitions of those which had been made by Soranus. He taught that during pregnancy the blood which would have been discharged if menstruation had continued was used for the nourishment of the growing fetus. He described the membranes by which the fetus is enveloped and gave a series of pictures, derived from Soranus, illustrating the position of the fetus *in utero*. In his directions to midwives he refers to the obstetric chair, recommends the dilatation of the os with the fingers, the rupture of the membranes, gives suggestions in regard to the pressure which may be exerted on the abdomen during labor and the removal of the placenta by hand. He advises them to tie the umbilical cord with two ligatures and cut between them with a knife or scissors. He also gives many rules for the care of the new-born baby and determines the period of lactation as eighteen months.

Between the third and the sixth centuries very little was contributed to obstetrical literature. Herophilus of Chalcedon described the changes which take place in the cervix during labor, Oribasius and Dioscorides collected the writings of those who had preceded them, and Tertullian commented on existing methods of perforation and embryotomy.

With the coming of *Aëtius* (501–575) there was a new light in the literary gloom which had lasted for 200 years. This writer industriously collected all that had been previously written on obstetrics and gave out a vast amount of additional and important information which until his time had been inaccessible. He followed Soranus, Moschion, and Rufus in his description of the anatomy of the uterus and the functions which pertain to it. He discussed menstruation, puberty, the signs of pregnancy, and the determination of sex before birth, and he described the fetal membranes, the cord, the development of the embryo, the fetus at maturity, the process of rupture of the membranes, and the phenomena of labor.

As obstacles to labor he mentioned narrow pelvis, obliquity of pelvic position, and polypi, furthermore he called attention to ankylosis of the pubic bones and distention of the rectum and bladder. He also called attention to the fact that dystocia may be due to fault on the part of the child as well as the mother and described a vaginal speculum for investigating the cause of the obstruction. He referred to the crotchet and to artificial delivery by means of two crotchets, thus anticipating for the first time in history the principle and the use of the obstetrical forceps. He advised version for bad cases of head presentation and gave directions and indications for amputating the head and the upper and lower extremities. For extraction after these destructive operations he recommended the use of a sharp hook which he described. Altogether his work is the most comprehensive survey of the entire field of obstetrics that had ever been made and held the same exalted position which the work of Soranus had assumed 400 years previously.

The book of Aëtius was followed by one on obstetrics and gynecology, of considerable scope by *Aspasia*. In this work were included advice to pregnant women regarding the hygiene of pregnancy, directions for artificial abortion and for preventing conception, which were then regarded as perfectly legitimate procedures, and directions for the use of

pessaries which were presumably employed at this early day in cases of prolapsus uteri. Difficulty in labor was regarded as the result of deviations of the uterus, tumors of the cervix, inflammation, premature loss of the amniotic fluid, abscess, obesity, failure of the pubic bones to separate, large size of the fetus and, in twin births, to deficiency of fetal activity. The different varieties of presentation were noted and all except the vertical were still declared to be abnormal.

The procedure and indications for both cephalic and podalic version were delineated. The accoucheur was warned to be cautious in delivery and not to be in haste, and rules were given for the removal of the placenta, for the use of the crotchet, and for destructive operations in general. Thus it will be seen that the accumulated fund of obstetrical knowledge in the sixth century A.D. formed by no means an insignificant equipment and that many of the facts which we now regard as fundamental were understood and established at this early period.

The last writer of this portion of the second period in the development of the science of obstetrics was *Paul of Aegina*. He practised in Egypt and Asia Minor in the seventh century and wrote works comprehending all medical science, much of it being gathered from his own experience. In obstetrics he followed the ideas already enunciated by Aëtius. In addition to a chapter on difficulty in labor he wrote on the diseases peculiar to women, and like the earlier writers he described the use of the crotchet, podalic version, and the destructive operations.

Third Period.—After Paul of Aegina came a period of sterility and darkness, until the Arabs picked up the flickering torch in the ninth century. They did not ignore obstetrics but they made no additions to its literature except as to the use of medicines during pregnancy and parturition. Operative obstetrics was taught by them only to midwives. Among their peculiar claims was their ability to predict pregnancy and the birth of a son from an examination of the urine. Rhazes of Bagdad, of the ninth century, declared he could tell the number of children a primiparous woman would have by the number of wrinkles on her belly. This same Rhazes was the discoverer of the fillet. In the latter stages of Arabian influence there were not a few well-known gynecologists and obstetricians. Among them was *Avicenna* of Ispahan who adhered to some of the obstetric errors of the early Greek writers and in particular to the one that the vertical was the only normal presentation. He advised cephalic version whenever necessary or if this were impracticable, the use of the fillet. This failing he recommended that the head be extracted with the forceps. What form of forceps he used is not known, but probably one which was destructive. If the forceps failed the perforator and crotchet must be used. In the twelfth century *Albucasis* described two varieties of forceps with teeth on their inner surface, the first of them straight, the second curved. They were known as *misdrach* and *almisdrach* and were destructive instruments like all others which had thus far been in use.

With the downfall of the Arabs at the end of the twelfth century came another long period of obstetric gloom illuminated before and afterward by an occasional gleam of light. Thus before this downfall came the foundation of the school of Salerno in the eleventh century, followed by those of Bologna and Paris, the translation of the works of the Arabic writers into the Latin of the middle ages, and an unimportant work on the diseases of women, with a chapter on obstetrics, by Trotula.

Fourth Period.—In the thirteenth and fourteenth centuries there is almost a blank except for the unimportant work on reproduction and birth in the thirteenth century by Albertus Magnus (1193–1282) a Dominican priest. The study of anatomy began to be revived however in this period by DeLuzzi, and that of surgery by Guy de Chauliac. In 1295 Lanfranchi wrote a treatise on the dilatation of the os and about the same time Nicolas Bertucci, the first professional obstetrician in Bologna, advised artificial rupture of the membranes in labor.

In the fifteenth century, the Renaissance had already begun, printing had been discovered, the universities of Prague, Rostock, Leipsic, and Griefswald had been founded, and the Italian gynecologists Petrus Bairut (1500) and Gabriel de Zerbis (1490) were at work.

In 1513 a book by Rösslin entitled A Garden of Roses for Pregnant Women and Midwives was published, and seemed to be demanded on account of the ignorance of midwives as a body. Rösslin resided part of the time at Worms and part of the time at Frankfort and had a very exalted idea of the importance of his book. The art of printing was developing with great rapidity and during the succeeding hundred years this book went through many editions in many languages though it was merely a compilation of what had been written from the time of Hippocrates. Among other things it informs us of the common use of the obstetric chair and of Rösslin's preference for podalic rather than cephalic version.

In 1554 Rueff of Zürich published a book for midwives following many of the principles to be found in the book of Rösslin. Like the Arabic writers he advocated the use of medicines for hastening labor, which process he thought was instituted by the movements of the fetus. He recommended that in delayed labor the genital passage be dilated with the fingers or with instruments and that the placenta be removed by hand if it were not expelled naturally. He gave rules for the management of labor when the position was faulty and also for the delivery of monsters. He described a long, smooth duck-bill forceps for the extraction of the head and on account of this contribution is regarded by Crantz, Stein, and others as the inventor of the obstetric forceps. This was only a destructive instrument, however, and while a step toward the perfected obstetric forceps, it was only a modification of the instruments described centuries before by Aëtius, Paulus, Avicenna, Albucasis, and others.

The first clinical instruction in midwifery was given in the sixteenth century at Padua.

In England in 1518, Lanfranc, the court physician of Henry VIII, obtained a patent for the Royal College of Physicians and from this time obstetrics began to be a subject of some importance in England. The first English work on obstetrics was published by Raynolds in 1565 and was entitled, The Byrthe of Mankinde. It was a translation from the High Dutch work of Eucharius Rodian and underwent further translation into Dutch, French, Spanish, Latin, and other languages. This book repeats the error which was as old as Hippocrates and had been alternately discarded and renewed, that the vertical was the only natural presentation and that all others should be converted to that one. It furthermore erred in stating that when the head presented normally the face and foreparts of the child would face the foreparts of the mother.

Fifth Period.—A real genius in obstetrics next appeared in France in the person of the celebrated *Ambroise Paré* (1510–1590) who was an obstetrician as well as a great surgeon and was honored by Smellie as "the famous restorer and improver of midwifery." There was every reason why obstetrics as well as all other departments of medicine should now make great progress. Letters had revived, the art of printing was diffusing with the greatest rapidity, and the great

anatomists Vesalius, Columbus, and their followers had developed the science of human anatomy and incidentally the anatomy and physiology of the pelvis as had never been done before. Vesalius rectified the errors of Galen and Hippocrates which had been current 2,000 years, he made comparative studies, described the uterus and its neck and the changes which occur during pregnancy. Columbus, the successor of Vesalius at Padua, defined three positions of the fetus *in utero*, the head below, the head above, and the body transverse. Other anatomists of the period who added to the knowledge of the pelvis and its contents were Fallopius and Eustachius, the latter illustrating his discoveries with plates and pictures.

The idea and the purpose of operative midwifery now for the first time became conservative rather than destructive. Paré, although he admitted he did not know what the normal position of the child in labor should be, reintroduced the use of podalic version as a conservative measure, substituting craniotomy only if that were impracticable. In his writings upon obstetrics he advocated cesarean section upon the living. This had already been done in 1531 by Jacob Nufer a sow-gelder, who had sectioned his wife as he was accustomed to section a sow, both mother and child recovering. Paré detailed the management of labor, prescribed the use of sternutatories, when labor was delayed, recommended for the first time that the parturient be laid across the bed during delivery, and described the methods of procedure for the delivery of dead children by craniotomy or the erotchet. He was the first to mention the serious nature of cicatrices of the uterus during labor, the influence of various positions of the fetus upon the progress of labor, and the deleterious effect of uterine inertia and premature loss of the amniotic fluid. He also gave instructions to midwives concerning the care of the new-born.

The school of Paris with which Paré was associated was at this period the foremost in the world and the center of light and leading. Following Paré, surgeons now considered it not beneath their dignity to practise obstetrics. In addition to Paré, in this century, Rousset wrote on cesarean section and reported that he had performed fifteen suceessful operations.

We have seen that the struggle to emancipate the obstetrical art from the hands of midwives was a long and difficult one. The inherent modesty of women, especially when in labor, shrank from and rebelled against the services of any but members of their own sex, and the services of men had hitherto been prineipally limited to the destructive portion of obstetrics. The results of such operations were so often fatal not only to the child but to the mother as well, that the appearance of a man in the lying-in chamber had usually been regarded by the patient as her death warrant. Of course, if men did not have experience with normal labors they would be illy prepared for successful work in labors that were not normal. This fact began to be recognized in the time of Paré and men began to encroach more and more upon the prerogatives and function of the midwives. The problem of obstetrics was not only to deliver women and children but to deliver them successfully under difficult conditions.

The free use of podalic version was a step in the right direction but this even with the aid of the fillet or the vectis was insufficient for the extraction of the fetal head in many cases and the problem could be solved only by the discovery of the obstetric forceps, the most beneficent mechanism that has ever been devised by the wit of man. The germ of this instrument was present in the crotchet and in the double crotchet, with and without teeth, and it is singular that the idea should have waited so long before a destructive was converted into a conservative and life-saving one.

The discovery of the modern obstetric forceps belongs to the Chamberlen family and was kept as a secret by them through four generations.

Peter Chamberlen, the first, practised in London under license of the Barber Surgeons Company between 1598 and 1630. The exact time when he invented the forceps is not known, but it was between 1598 and 1607. His successful use of this instrument gave him prominence before the public and made him very unpopular with the profession. He was accoucheur to the queens of James I and Charles I.

The three generations which succeeded him kept the family secret and waxed rich and important by their skill in making use of it. Naturally enough it was not used with success in all cases but the great Mauriceau had confidence enough in the Chamberlen (Hugh) of his period to entrust him with the work of translating a portion of his book into English.

He also placed in his hands for delivery a woman with a greatly deformed pelvis. Chamberlen failed to deliver her after endeavoring to do so for three hours which shows that his judgment as to the limitations of the instrument was faulty. (See Article *Forceps*.) The secret was sold by the Chamberlen last mentioned to Roonhuysen of Amsterdam in the latter part of the seventeenth century and by the middle of the eighteenth century the instrument was in common use by the profession throughout Europe.

Sixth Period.—In the seventeenth century man-midwives, as obstetricians were called, had become fashionable in France and among them *Mauriceau* was preëminent. His text-book ("Sur les maladies des femmes grosses et de ceux qui sont accouchées") was the best and most complete exposition of obstetrics up to that time. He corrected the idea that the amniotic fluid consisted of menstrual blood or milk, he described the phenomena of normal labor, called attention to placenta previa, described the necessary steps in the performance of version, and corrected the notion that the bones of the pelvis became separated during labor. He was also the first to call attention to tubal pregnancy, to the difficulties which proceed from the umbilical cord, and to epidemic puerperal fever. With regard to the position of the child in the uterus he declared that from the seventh to the eighth month it was in the center of the womb with its head toward the fundus and its face looking forward. The weight of the head and upper portion of the body which were now relatively greater than the lower part, caused the child to drop forward with its face toward the sacrum.

Mauriceau did not believe, as previously had been taught, that the automatic movements of the child aided its delivery, but that the expulsive forces consisted of contractions of the uterus and of the abdominal muscles which naturally acted more forcibly on the back and nates of the child than on the head. Mauriceau had an indistinct idea of the process of rotation within the pelvis, remarking that in footling cases the face of the child should look toward the sacrum and that the child should be turned by hand unless turning had already taken place spontaneously.

France had other obstetricians of eminence and experience in this century including *De la Motte* who gave rules for the performance of version in a narrow pelvis; *Portal* who showed in his treatise in 1685 that version could be done with the aid of one foot and that face presentations were normal; *Philip Peu* also showed that delivery could be accomplished in face presentations without artificial aid.

In England, Willis defined puerperal fever and Needham wrote on the nourishment of the fetus by the placental blood and on the relations between

the mother, the fetus, and the placenta, a very important addition to the physiology of pregnancy.

In Holland during this period *Van Deventer* (1651–1724) who is sometimes known as the father of modern midwifery, flourished. He published an atlas containing plates showing deformities of the pelvis and of the spine and their effects upon labor. This is the first scientific exposition of the subject and his work remained authoritative for 150 years until Michaelis published The Narrow Pelvis (Das enge Becken).

Van Deventer also described the normal gravid condition, the axis of the pelvis, its diagonal diameter, the operation of version and other obstetrical operations. Van Roonhuysen was also of this period and was a champion of the operation of cesarean section which he performed successfully several times, he also described cases of extrauterine pregnancy and of rupture of the uterus. There were several famous midwives of this period who contributed original observations, among them being Justine Siegemundin, Louise Bourgelois, and Jane Sharp, the latter the author of a very influential work entitled Complete Midwives Companion.

Inasmuch as the obstetric forceps had been known and used by not a few obstetricians in England and on the continent since the secret was sold by Hugh Chamberlen in the latter part of the seventeenth century, it seems strange that writers should speak of its rediscovery by Palfyn in the eighteenth. The forceps of Palfyn, as the cut shows (see Fig. 2500, vol. iv.) had parallel blades and was mechanically inferior as a traction instrument to that of Chamberlen. Nevertheless Palfyn presented it as a new invention to the Academy of Science in Paris in 1717. It was criticised severely by De la Motte and seems to have been disregarded until 1723 when the Academy gave to it its official sanction. It does not appear to have had any material influence upon obstetric practice and in 1733 Gifford and Chapman published the account of their instrument, which was apparently the Chamberlen forceps and which they declared was in quite general use by the profession.

From that time on the forceps has been subjected to various modifications. Probably the one which was of greatest importance was the pelvic curve which was added to it by Levret (1747) or as some say by Smellie. Levret added much to the credit of the obstetric art of the eighteenth century. He determined that the axis of the pelvis was a curve, or more correctly followed Van Deventer in this particular, and the deduction naturally followed that the forceps should be curved similarly. Levret called attention to the swelling and partial separation of the cartilages of the pelvis during parturition and while his influence was slight in developing the management of normal labor it was very important in connection with operative obstetrics.

Works on obstetrics from this time onward became numerous. In France an influential work was published by *Mesnard* in 1743. It was the first since the forceps had come into quite general use and was more comprehensive than anything ever published in France up to that time. It described the anatomy and the diseases of the pelvic organs, conception, the hygiene of pregnancy and accouchement. Delivery was described as possible with the patient sitting in the lap of another person, lying upon the back, upon the side, and in the lithotomy position. Various complications during labor were noted, and perforation was considered inadvisable unless the child were dead or dying. Mesnard was the first to recommend the application of the forceps to the after-coming head after version had been performed, delivery by the breech was pronounced normal and proper, and cesarean section was declared to be indicated only in cases, in which the head of the child was too large for safe delivery, or the pelvis very narrow.

Another influential French teacher of this century was *Puzos* who first advised external pressure upon the womb in the treatment of postpartum hemorrhage. (His book was not published until 1759, six years after his death). Other measures which he advised were protection of the perineum during labor, bimanual exploration, podalic version, and friction of the os uteri to bring on labor pains.

Another Frenchman who produced a powerful impression upon the obstetrics of this period was *Baudelocque*. His teaching was much more conservative than that of those who followed Levret and his school. He advocated a series of measurements of the pelvis during pregnancy, advanced the knowledge of the mechanism of labor, and was a pronounced opponent of operative measures, especially the cesarean section, symphysiotomy, and the induction of premature labor.

Camper, a Dutch obstetrician, had advocated symphyseotomy in this century, but it was not actually performed until it was successfully done by Sigault in 1777.

The influence of Germany on obstetrics in this century was less important by far than it was destined to be in the century which followed. *Heister* at Helmstadt was the first German to deliver lectures on obstetrics. *Siebold* performed the first symphyseotomy in Germany (1778), and among others whose names have come down to us as significant and important in their own time and country may be mentioned Stahl, Roederer, Stark, Stein, and Zeller.

Great Britain offers many names which have illuminated the obstetrical history of the eighteenth century. Among them *Manningham* like others of his distinguished contemporaries was both teacher and writer. Like Smellie and Hunter he made use of the manikin in his teaching, and like them also he was very successful in his teaching, showing his pupils how to examine women and how to extract children. He studied the subject of placenta previa, discountenanced the performance of cesarean section, as he believed it was always bound to be fatal, and like Van Deventer advised the depression or fracture of the coccyx as an aid in difficult labors.

Fielding Ould a Dublin obstetrician and obstetric writer was one of the first to describe in detail (1742) in his book the mechanism of labor which was to be further elaborated by his contemporary Smellie, and to culminate in the comprehensive description of Naegele. Ould taught both normal and instrumental midwifery, and was very partial to the practice of version in proper cases. He was apparently, like Hunter, not favorable to the use of forceps and rarely employed it though he taught how the instrument should be used.

Smellie was the greatest obstetrician and obstetric teacher of his time. He was distinctly in favor of instrumental delivery, especially in cases in which the patient was worn out with ineffectual attempts to deliver herself. This applies with particular force to those cases in which the head is arrested, at the pelvic outlet, and the short forceps which he devised, which is in use to this day, is the most valuable contribution which he made to obstetric art. He made use of the manikin in his teaching and in his book on obstetrics (1739) was the first to lay down safe rules for the use of the forceps and for the differentiation by measurements of different varieties of deformed pelvis. His most famous pupil was William Hunter who was not only a great teacher and profound student of obstetrics but for many years was the most distinguished obstetric practitioner in London.

Hunter built an anatomical theater for teaching obstetrics, using the manikin as his model. He worked for thirty years in dissections upon the pregnant uterus, producing a series of plates which have never been excelled. He discovered the decidua reflexa

and thus founded placental anatomy based upon separate fetal and maternal circulation. Unlike his great teacher Smellie he was opposed to the use of the forceps and used to exhibit his own instrument to his students, rusty from disuse.

Charles White was an obstetric writer of this period who achieved the distinction of being the pioneer writer upon antiseptic midwifery. A century was to pass and untold thousands of women to lose their lives from puerperal fever before the suggestions of White bore fruit.

Thomas Denman also gave notice that puerperal fever was communicated by doctors and midwives and among other useful contributions which he made was a theory of normal labor, and a recommendation for the induction of premature labor. He also described spontaneous version in cases in which there was prolapse of the arms of the fetus.

John Aitken recommended exsection of a portion of the bony pelvis in preference to cesarean section. *R. W. Johnson* devised a forceps with pelvic and perineal curves and *John Leake* recommended wrapping the legs with cold wet cloths for the relief of metrorrhagia.

In the United States it is interesting to note that the closing years of the eighteenth century which witnessed our entrance into the family of the nations of the earth also witnessed the beginning of obstetric teaching by *Shippen* in Philadelphia.

The nineteenth century found the science and art of obstetrics well established in all parts of the civilized world. The principles upon which this science rests were well understood and were set forth in the text-books of the different languages. Henceforth there remained, with the exception of anesthesia in labor and the development of the antiseptic theory, only the improvement and modification of the ideas and methods which had been so laboriously wrought out in the previous ages. The nineteenth century, from an obstetrical standpoint was preëminently a period of teaching. No single nation has accomplished this elaboration and there is no nation which has not had a share in it. We cannot do better for this outline than to state briefly what has been proposed or accomplished by the leading obstetricians of each nation.

The obstetrics of Germany during the nineteenth century reached a very commanding position, chiefly owing to the wonderful development of the German universities and the great erudition and skill of the German professors. Included in this category is the great Austrian university at Vienna where the teaching is in the German language, and where the obstetric service at the Allgemeines Kraukenhaus has constantly attracted students from all parts of the world. In the early part of the century its presiding genius was *Boër*, who has been called the ablest obstetrician of his time and who was insistent in regarding the entire performance of labor as a physiological function to be interfered with by the man or woman who happened to be in attendance just as little as possible. He was succeeded by Schmitt, Gustav and Carl Braun, and Spaeth.

At Vienna also about the middle of the century the unhappy *Semmelweiss* preached in vain to deaf and unwilling ears the doctrine of cleanliness in obstetric practice. Notwithstanding the continuous slaughter from puerperal fever in the great Vienna Maternity, and the tracing of it by Semmelweiss to the students and physicians who went from the dissecting-rooms to the lying-in chamber, notwithstanding his demonstrations of the more favorable conditions when the hands of the obstetrician had first been cleansed in a solution of chloride of lime, his expostulations were unheeded. He was looked upon as visionary and a dreamer and not until he had lost his mind in disappointment and chagrin, was the truth of his statements and demonstrations realized. What advantage was it to him that the generation following erected a monument to his memory.

At Prague the obstetric teachings of *Jungmann*, *Kleinwächter*, and others made this an important center for many years. At Munich *Hecker* and *Winkel* drew many students, as did also *Spiegelberg* at Breslau and *Doutrepont*, *Kiwisch*, and *Seanzoni* at Würzburg. At Berlin during this century there was a great company of eminent teachers including *Von Siebold*, *Busch*, *Edouard Martin*, *Schroeder*, and *Gusserow* all of whom had extensive experience in public and private practice and made valued contributions to obstetric literature. There are many other Germans of this period whose names must not be overlooked and which are associated with creditable achievements which have added to the importance of obstetric art and science. *Naegele* stands out as the one who perfected the description of the mechanism of labor and in a certain sense organized the literature of the pathological anatomy of the pelvis by his description of the contracted pelvis. About the same time *Rokitansky* described the spondylolisthetic and the kyphotic pelvis, *Litzmann* the oblique-ovoid, *Stein* and *Michaelis* the osteomalacic, and *Klein* the pelvis spinosa. To pelvic pathology from other nations was contributed the straight narrow pelvis of Robert and the funnel-shaped pelvis of Baudeloeque.

The entire subject of the contracted pelvis has been treated systematically by Michaelis and more recently and more comprehensively by *Waldeyer* in a series of plates and atlases which are of the greatest value to students of pelvic anatomy.

Voluminous histories of obstetrics were published by Osiander and E. C. J. Von Siebold, *Credé* made valuable contributions in his method of pressure upon the uterus to cause its contraction and the expulsion of the placenta, and in his most important recommendation to instil weak (two per cent.) nitrate of silver solution into the conjunctival sac in the new-born to prevent gonorrheal ophthalmia and blindness. *Wenzel* at the beginning of the century gave directions in regard to the induction of premature labor. *Gusserow* described the pernicious anemia of pregnancy. *Braune* published a valuable atlas of frozen sections of the pregnant woman which cleared up many of the problems of intrauterine life and development.

Walcher described the position of exaggerated extension of the legs of the parturient woman to loosen the joints of the pelvis and facilitate the birth of a tightly fitting head either spontaneously or by the aid of the forceps.

One of the most important contributions of the century was the elaboration by *Sänger* of Leipzig of a method for performing cesarean section. Aided as it was by the inestimable cooperation of antisepsis this operation has been taken from the domain of the almost surely fatal procedure, and has been made one of the most practicable and beneficent of all the major operations in surgery. It is now performed hundreds of times every year, the indications for it are clear and distinct, and it is to be feared that because of the facility of its execution it is frequently done by those who should be disqualified by lack of surgical experience, and in many cases also when a similar procedure would answer just as well and perhaps better.

Doederlein in the latter part of the century wrote an important monograph on the relations of the secretions of the vagina to puerperal fever and at a later date wrote also concerning hebotomy, or hebosteotomy, or pubiotomy as it is variously called. This operation consists in dividing the body of the pubic bone in cases in which labor is delayed or its completion prevented by a very large head or a relatively small pelvis. The bone is divided subcutaneously

with a Gigli wire saw and thus affords sufficient room for forceps extraction which would otherwise be impossible. It is a poor substitute for cesarean section as now performed or for symphyscotomy and may result in permanent weakness of the pelvis. Fortunately it has never attained popularity and it is unlikely that it will. To the foregoing category of German obstetricians of light and leading must be added Wigand, Stark, Ritgen, Hohl, Carus, Killian, Fehling, Zweifel, Ahlfeld, and Leopold.

French obstetrics in the nineteenth century occupied an honorable position but it was not preëminent, and, apart from Paris, the schools and hospitals of France were not distinguished as centers for the diffusion of obstetric knowledge. Treatises on obstetrics were written by *Velpeau* who, like his great predecessor Ambroise Parè, was better known as a surgeon, *Cazeaux, Dubois, Depaul, Charpentier, Pinard, Pajot*, and many others. Mayor wrote upon the auscultation of the fetal heart and *Kergaradec* described the entire subject of auscultation in the pregnant woman. *Velpeau*, in addition to this work on obstetrics, also wrote a monograph on the female breasts including the conditions which obtained during pregnancy and lactation, *Baudelocque* contributed to the subject of cephalotripsy and, as already stated, described the funnel-shaped pelvis which goes by his name, and Stoltz added to the literature of premature induced labor. Two remarkable books upon obstetrics in the early part of the century were published by French midwives Mesdames *La Chapelle* and *Boivin*. La Chapelle's was based upon an experience of 40,000 labors and both of them abound in practical information of a very high order. Their works were authoritative among obstetricians and obstetrical writers and were frequently referred to until a recent date.

One of the most valuable contributions to obstetrical art during this century was the work of *Tarnier* in the elaboration of the principle of axis traction for the extraction of the fetal head. The principle was not original with Tarnier, it had already been studied and to a certain degree practised by many of his predecessors but he went over the entire subject with great patience and thoroughness and made many models of forceps before he produced his perfected instrument. Except for the fact that the instrument is somewhat clumsy even in its various modifications, it is a most precious acquisition to the obstetrical armamentarium. Tarnier added further to his reputation by making practical application in obstetrics of the antiseptic theory of Lister (in 1881), advocating the use of carbolic acid solutions for the hands of the obstetrician in the performance of his work.

The nineteenth century gave birth to many brilliant and useful obstetricians in Great Britain. With one marked exception no great discovery can be attributed to the British obstetricians of this period but both as teachers and writers there were many who added luster to the British record. The schools and maternities at Dublin, Edinburgh, and London were important centers and drew many students from other countries. Text-books were written by Churchill, Barnes, Leishman, Playfair, Milne, Galabin, Duncan, Ramsbotham, and others, and useful contributions to obstetric art were very numerous. *Braxton Hicks*, among other valuable contributions, suggested and described combined external and internal version. Barnes devised rubber bags for introduction into the cervix during labor to facilitate dilatation, and this principle has been used in modifications of his idea by Champetier de Ribes in France and Voorhees and Pomeroy in this country. *Ramsbotham* wrote a very good book on obstetrics but his chief claim to distinction seems to have been his insistance upon the purely physiological character of labor and the tendency to interfere with it too frequently, which he denominated meddlesome midwifery.

There is no doubt that many unintelligent and badly equipped men and women who practise or have practised obstetrics have interfered with nature's work too much or too inefficiently. There is seldom any excuse for such obstetricians now-a-days, if they fail to get skilled and intelligent help, and there is far more danger to women who are having prolonged and difficult labors to-day from so-called expectancy and mischievous waiting for nature to finish a task which she is incompetent to finish than there is from meddlesome midwifery, especially since we now have the inestimable boon of antiseptic midwifery which Ramsbotham knew nothing about.

Seventh Period.—The most brilliant and useful obstetric discovery of this century was that of chloroform anesthesia during labor by *Sir James Simpson* of Edinburgh. The anesthetic properties of sulphuric ether had already been announced by the Americans Morton, Jackson, Wells, and Riggs, and Simpson himself had delivered a woman with comparative painlessness by means of this substance. His experiments with chloroform led to its use in preference to ether and it is one of the most important discoveries in the history of obstetrics. It is well worth while to mark this as the beginning of the latest and most important era in obstetric history.

Even more important than Simpson's discovery and its wonderful power of abolishing or at least mitigating the severity of pain during labor, was the application to obstetrics of Lord Lister's great discovery of antisepsis. This was the capstone of the structure started by Holmes, Semmelweiss, and others who had realized the necessity of cleanliness and antisepsis during labor but whose vision was not clear enough to see the rationale upon which they were based. Lord Lister's discovery was not the discovery of an obstetrician nor was it applicable to obstetrics alone, but obstetrical art obtained the full benefit of it and by its means maternity hospitals were delivered from the curse of puerperal fever which had held them in bondage everywhere, while private obstetrics became as free from danger as any form of sickness which has in it the possibility of grave complications.

Italian obstetrics during this century presents only a few names which are well known. Morisani published a text-book and the names of Galbiati, Morisani, and Gigli are associated with the revived operation of symphyseotomy. The sickle-shaped knife of Galbiati was used by Morisani for this operation and the Gigli wire saw was used for this procedure as well as for the operation of pubiotomy and with the same end in view. A powerful dilating instrument for the undilated cervix was devised by Bossi and for a number of years was used somewhat extensively in European maternities. It is a forceful but clumsy instrument and in the hands of one who is inexpert is capable of doing much damage. It would seem to us that its use should be limited to the very exceptional cases in which for some reason or other it may not be possible to avail oneself of Barnes's bags or some of their modifications.

American obstetrics although a new element among scientific forces was able to exert great influence during this century. Philadelphia was the pioneer in obstetrical teaching as in medical education in general, and until the last quarter of the century was easily first as an obstetric center. Since that time the schools of New York, Boston, Baltimore, and Chicago have become prominent and have done excellent work in preparing well-equipped obstetricians. The teachings at Philadelphia of Dewees, Hodge, Meigs, Goodell, Parvin, and many others were not surpassed by any in their breadth and comprehensiveness and in the clearness with which the entire field was elucidated. The text-books of Dewees, Hodge, Parvin, and Lusk were valuable additions to obstetric literature and had much influence in forming the

American obstetric mind of the present day. Not only had didactic teaching in American medical schools reached a high degree of excellence but the maternities which have been established in all the great cities are unsurpassed in all the world in their equipment and in the service which they render to parturient and puerperal women. Early in the century (1808) an American, Dr. *John Stearnes* of New York, introduced the use of ergot in obstetric practice, in 1843 Dr. *Oliver Wendell Holmes* in a noteworthy essay announced the contagious character of puerperal fever and this essay and the work of Semmelweiss a few years later were largely instrumental in the subsequent application of Lister's antiseptic theory to obstetric practice. It was this happy combination which has resulted in the mastery, to a very large degree, of this terrible disease. Marmaduke Wright of Cincinnati (in 1842) suggested a method of combined cephalic version and Davis, Taylor, Hodge, Elliott, Lusk, McLane, and many others have made more or less useful modifications of the obstetric forceps.

The work of contemporaneous American obstetricians is not yet a matter of history. It is interesting to note, however, that in both the science and the art of obstetrics, in text-books and treatises, and in the practical application of the art, American obstetricians are in the front line and are doing as good work as is done anywhere in the world.

Other nations also contributed to obstetric science in the nineteenth century but to a lesser degree than any of those which have been mentioned in the foregoing. Text-books and other contributions were published by Dutch, Swedish, Danish, Polish, Russian, Hungarian, and Spanish obstetricians and in their several languages.

Gynecology.—This sketch would be inexcusably incomplete were mention not made of the influence which obstetrics had in developing the dependent and cognate science of gynecology. Gynecology is by no means a new science as the quotations in the early part of this paper have shown. The speculum, the dressing forceps, the dilator, and various other appliances were all known to the ancients, but from such records as we have it is very improbable that there were very many at any time who were familiar with their use or with the many diseases to which the female pelvic organs are subject.

Modern gynecology may be said to have begun, or to have had its great impetus in connection with the consideration of the subject of ovarian tumor, especially ovarian cyst or ovarian dropsy as it was commonly called. Surgeons and pathologists had frequently said that ovarian tumors could not be successfully removed because of the fatal peritonitis which must necessarily be aroused. McDowell, a young Kentucky surgeon educated at Edinburgh, thought otherwise and in December, 1809, successfully removed a large ovarian cyst from a woman of Danville, Kentucky, who lived for thirty years thereafter. Other American surgeons including Nathan Smith, Dunlap, and the Atlee brothers, took up the subject and performed large numbers of successful operations. In England the work was carried on by Charles Clay, Baker Brown, and others; but while Clay was very successful none of the others were, and most surgeons deemed the operation too dangerous and fatal to be attempted. Any one who attempted the operation did so at the risk of unpopularity and even obloquy The operation was practically dead until Spencer Wells, a British surgeon returned from the Crimean war, undertook the operation along very careful lines, and in what was at that time a huge number of cases obtained remarkable success. From that time on the practicability of the operation when properly performed was assured and it became popularized in all civilized countries. In many of the cases which are now performed it can scarcely be considered an operation of gravity.

The second stage in the development of gynecology came from America and Germany and was purely of obstetric origin. It concerned the treatment of vesicovaginal fistula resulting from prolonged and disastrous labor, and received the attention of Marion Sims in America and Gustav Simon in Germany at about the same time. This injury which had baffled all surgical effort up to this time was also conquered and its conquest not only relieved a multitude of women from a distressing condition but also led to the performance of more careful and intelligent obstetrical work.

Other injuries resulting from parturition, especially the rupture of the perineum and cervix uteri were successfully treated by operations devised by Sims, Emmet, Thomas, and other surgeons.

The treatment of other diseased conditions of the female pelvic organs became more and more developed and as is very often the case when the appetite for such things is stimulated, many worthless and harmful procedures were advocated which have had their day and now happily have become obsolete. The total outcome of effort in the direction of gynecology has, however, been of vast benefit to the human race and it has been of incalculable benefit to practical obstetrics, rectifying its injuries and errors, some of them pardonable, some of them inexcusable, and leading to a more careful and intelligent performance of the work which the accoucheur is called upon to perform. Andrew F. Currier.

Occupational Diseases.—*Definition.*—The occupational diseases arise from harmful substances used in industries and from hazardous conditions of environment associated with a variety of industries, trades, and other occupations. There is also an important group of occupational diseases due to physical, mental, nervous, or muscular strain which is separately described in the article on *Neuroses, Occupational and Professional.*

The occupational diseases are thus caused by: (1) specific toxic substances such as many of the metals, gases, vapors, fumes, strong acids, alkalies, etc., used in the mechanical arts; (2) mechanical irritants such as noxious dusts; (3) extremes of temperature, humidity, air pressure, etc.; and (4) the overuse of nerves and muscles.

These diseases may be (1) acute, causing almost instantaneous death, as by inhaling the fumes of concentrated wood alcohol, nitrous gases, etc.; or (2) chronic, lasting through many years and producing symptoms which, although insidious at first, may lead to fatal issue, or make the system especially susceptible to other diseases such as pneumonia and tuberculosis.

Classification of the occupational diseases is in a transition stage, at present undergoing study by the Census Bureau and other organizations. It presents many inherent difficulties and no system has as yet been generally adopted. The writer has found the following classification (taken from his book on The Occupational Diseases) to form a convenient working basis for study, and it is followed in this article.

I. Diseases due to irritant substances.
  A. Toxic metals and their compounds.
  B. Toxic gases, vapors, and fumes.
  C. Toxic fluids: acids and miscellaneous fluids.
  D. Irritant dusts and fibers.
    (1) Insoluble inorganic dusts.
    (2) Soluble inorganic dusts.
    (3) Organic dusts and fibers.
  E. Germs.
  F. Miscellaneous irritants.

II. Diseases due to harmful environment.
A. Air modifications.
B. Temperature modifications.
C. Light modifications.
D. Electric shock.

III. Miscellaneous occupational diseases, involving more than one hazard. The latter group is best classified by industries, as mining, dyeing, pottery making, etc.

It is also convenient at times to use an anatomical classification, as: Occupational diseases of the blood, the nerves, the eyes, the ears, the skin, the nose and throat, the mouth, the bones and joints, the bladder. The subject is so comprehensive that in the present article it is deemed best to emphasize particularly those diseases which are least often understood or recognized, it being impossible to give full details of all.

I. Diseases Due to Irritant Substances.

A. Diseases Caused by Toxic Metals and Their Compounds.—These substances may enter the body in pure form or in that of their salts or other compounds, either (*a*) as dusts, in solutions, or (*b*), for example in the case of zinc, mercury and lead, they may be volatilized and be inhaled as fumes. Some of them, as lead, may be taken into the body in either of four forms, viz., as pure metal particles, as a mixed dust, in solution, or as a fume. Others, such as iron or steel, may act merely as mechanical irritants, injuring the bronchial mucosa by their sharp particles. The mode of entrance into the body is mainly through inhalation into the nose or mouth, when the irritant is either aspirated into the deeper respiratory passages or mixed with saliva and swallowed. With the exception of mercury and silver, it is doubtful whether any of the heavy metals are capable of exerting toxic action through cutaneous absorption when in solution.

Apart from mechanical irritation, when inhaled in solid form (in which case the action of the metals is usually non-specific), many of them, if inhaled or swallowed, are absorbed and exercise specific and definitely selective action upon certain parts of the body, notably upon the nervous system, arteries, and kidneys, but in some cases upon the mucous membranes and bones.

Among all the heavy metals those exerting the most deleterious effect are mercury, arsenic, and lead, and the latter, owing to its ready solubility in the fluids of the body as well as to the great number of industries in which it is employed, furnishes by far the largest number of examples of metal poisoning.

In the great majority of instances the poisoning due to heavy metals is insidious and extremely chronic, both as to mode of onset and duration. But when inhaled in the form of fumes, the dose of the poison being large, and its absorption being readily accomplished, very acute symptoms are produced, which in some instances may prove fatal within a few hours, as, for example, when in lead smelting dense fumes are accidentally inhaled. Such instances, however, are comparatively rare. It thus appears that the action is usually cumulative and considerable quantities of such metals as lead, arsenic, or silver may be stored in the body tissues. After absorption, the metals gradually leave the body through the medium of the kidneys, and in so doing may give rise to chronic nephritis. In the case of lead, traces of the metal may be obtained in the perspiration.

Specific Action of the Metals.—Antimony compounds if inhaled as dust cause inflammation of the nose, pharynx, and bronchi with stomach disorder, diarrhea, and colic. In the more serious cases the circulation suffers and faintness, palpitation, and low blood pressure occur with albuminuria. As type metal contains fifteen to twenty per cent. of antimony, Strumpf and Zabel of Strassburg hold the view that much of the poisoning of typesetters, usually attributed to lead, is in reality due to antimony. Cases of chronic poisoning occur with headache, vertigo, peripheral neuralgia, muscular fatigue and sexual weakness. Blood examination reveals leucopenia and eosinophilia.

Arsenic poisoning will be elsewhere described in this work.

Brass being a compound of zinc and copper, it is believed that the acute symptoms caused by inhaling fumes of molten brass are due to zinc vapor, as copper is practically inert. Brass dust, if inhaled, tends to cause bronchial irritation and possibly pneumonokoniosis, but as this dust is usually mingled with that of emery sand or other dusts developed in grinding, buffing, etc., it is difficult to isolate its influence. "Brass-molder's fever" or "brass-founder's ague" is the name given to a peculiar group of symptoms which come on after a day's work and usually disappear after drinking hot milk and spending a few hours in bed. They consist of languor, hard chills, perspiration, headache, vomiting, and cramps in the extremities. Flatulent dyspepsia is common. Workmen soon acquire immunity against such attacks. George M. Kober states that fully seventy-five per cent. of new workmen have these "brass chills." In the writer's work on Occupational Diseases are reported several cases of chronic brass poisoning, in one of which there was endarteritis obliterans. Sand-blasting of brass castings is a most injurious occupation where the workmen are not protected by adequate screens, masks, etc.

Bronze workers complain of headache, rhinitis, conjunctivitis, indigestion, and anemia. In many bronze industries varnishes, acids, buffing powders, etc., play a prominent part in producing symptoms, and the same is true of brass.

Chromic acid manufacture and the use of chrome pigments for dyeing, etc., may give rise to two important symptoms: obstinate perforating ulcers of the hand, known as "chrome holes," and chronic ulcerative rhinitis resulting quite often in perforation of the nasal septum toward its anterior portion. Congestion of the fauces and loosening of the teeth with frequent vomiting was observed in one of the cases in the writer's clinic.

Cobalt is said to be capable of producing sarcoma of the bronchial glands, but as in mining and smelting processes it is associated with many other metals, it is difficult to isolate its effects.

Copper miners and smelters sometimes acquire intestinal cramps, diarrhea, vertigo, and an uncertain gait. A green-blue line forms at the margins of the gums and the hair may be colored green. Probably many of the symptoms attributed to copper are due to associated metals with which it is found.

Gold is practically non-toxic, but in making the many articles of jewelry and adornment for which it is used, there is the hazard of plumbism from solder, and in gilding processes, benzene, potassium cyanide, and other injurious substances are employed.

Iron and steel are non-toxic, but their dusts may be highly irritant to the lungs, causing chronic bronchitis and fibroid phthisis. The "knife-grinder's phthisis" or pneumonokoniosis is well known. The smelting of iron and steel is accompanied by hazards to the eyes from excessive heat and light, hazards from overheating and subsequent chilling of the body, and inhalation of furnace gases of several types, especially carbon monoxide. The sand-blasting of iron and steel castings is most hazardous for the respiratory mucosa.

Lead.—There are more than 150 industries in which lead poisoning constitutes an essential hazard, and the topic is so important that it is elsewhere discussed in this work.

Manganese dust when inhaled may cause serious and rarely fatal poisoning. It gives rise to weakness, drowsiness, night sweats, cramps and rheumatic pains

in the legs, edema of the ankles, salivation, intention tremor of the muscles of the face and head, and a pseudo-ataxic gait. Nine cases were described by L. Casamajor in 1913. In one fatal case there were lesions of the cerebral ganglia.

Mercury poisoning is elsewhere described in this work. It occurs principally in quicksilver mining making felt hats, incandescent lights, mirrors, thermometers and barometers, and in gilding and bronzing processes.

Nickel is not poisonous when pure, but its ore often contains arsenic, and nickel carbonyl may be toxic.

Platinum was formerly used in making photographic paper, and in Illinois in 1911 eight cases of poisoning by it were found. It gives rise to coryza, an irritant cough, and bronchitis. Handling platinum paper may cause painful, bleeding fissures of the skin.

Silver poisoning or argyrosis occurs in the mirror-making and silver-plating industries. The skin and all the visible mucosa become colored a peculiar bluish-purple hue. Even the ear drums may become pigmented. Bohemian glass workers who use silver to coat glass pearls may acquire argyrosis. So may the makers of silver-leaf booklets. The metal may be inhaled or swallowed as dust, or enter the system in solution. To some extent also it may penetrate into the skin.

Tin is non-toxic, but in tin plating the metal is dissolved in sulphuric acid and the acid fumes are injurious, as elsewhere described.

Zinc is used in many industries but the hazards usually are those of associated substances used for solvents, as alloys, etc. Zinc smelters may acquire asthma and are prone to tuberculosis. Its influence in the so-called "brass chills" is described under "Brass" in this article.

B. Diseases Caused by Toxic Gases, Vapors and Fumes.—The volatile poisons, when inhaled, act injuriously both locally on the mucous membranes and systemically through absorption. Their effects may be acute and serious, or almost immediately fatal, or chronic, operating through periods of weeks or months. These injuries, moreover, may be either (*a*) general or (*b*) specific.

(*a*) *General injuries*, that is, those which may be produced by any of the volatile poisons, arise in part from replacement of the inspired oxygen of the air by the poisonous gas or fume, in part from irritation of the epithelium and nerves of the respiratory mucosa, a factor which is often augmented by the excessive temperature at which the gas or fume is inhaled, as in smelting and certain chemical manufacturing processes. Thus arise coryza, conjunctivitis, pharyngitis, laryngitis, tracheitis, and bronchitis, all of which may be either acute or chronic.

(*b*) *Specific effects* are produced by the peculiarities of the poison, varying from the highly corrosive action of strongly acid or alkaline fumes to the insidious action of certain gases which, like carbon monoxide and dioxide, may possess no irritable property at the time of inhalation, acting only after absorption by the blood. This absorption in many cases takes place with great rapidity, resulting in rapid hemolysis and varying degrees of anemia. In addition some vapors, as those of the nitrogen compounds, act as vasodilators.

Further effects of the toxic gases, vapors, and fumes may be manifest in the nervous and digestive systems. Among the former, vertigo, headache, visual disturbances, tremors, paralyses, coma, and convulsions are met with, and among the latter, nausea, vomiting, abdominal cramps, and diarrhea are sometimes observed. In certain groups of chronic cases cerebral symptoms ensue, such as amnesia, mental confusion, and despondency. At least three of the toxic fumes in their chronic effects give rise to necrosis of bones and cartilages.

The fate of the toxic gases, vapors, and fumes after absorption is to be eliminated by the lungs, or in lesser degree by the urine (as in the case of turpentine vapor, hydrocyanic acid gas, and sulphureted hydrogen).

Specific Action of the Toxic Gases, Vapors, and Fumes.—Acetaldehyde, developed in vinegar making and used in silvering mirrors, etc., is extremely volatile and quite irritating to the bronchial mucosa, upon absorption through which it weakens and quickens the pulse and induces sweating. The vapor easily causes conjunctivitis.

Acrolcin, a pungent highly malodorous fluid, is met with in fat and bone rendering factories, tallow and soap factories, varnish boiling, and in making oilcloth and linoleum. Its vapor, when inhaled, causes prickling and constriction of the throat, conjunctivitis, coryza, and bronchitis.

Ammonia is used in many industries, as in tanning, cleaning, refrigeration plants, soda and artificial fertilizer works, etc. Its highly irritant vapor may cause painful vesicular or pseudo-membranous conjunctivitis with lacrymation, and photophobia. When inhaled the vapor causes spasm of the glottis so suddenly that it does not have opportunity to enter far into the lungs; nevertheless, it produces cyanosis, dyspnea and asphyxia. The buccal and pharyngeal mucosa becomes deeply congested. There are burning pain and a choking sensation in the throat. Sneezing and dry cough may be followed by bronchitis. The pulse is quick and feeble and there may be vomiting. The victim commonly recovers, but if not, death is preceded by edema of the larynx and glottis, extreme air hunger and coma. The vapor is very irritating in a strength of one-thousandth part per hundred of air.

Ammonium chloride, or sal ammoniac, is used, among other things, for galvanizing. Its fumes when inhaled give rise to irritation of the larynx, dyspnea, cyanosis, and sometimes to fatal edema of the lungs. Amyl acetate is an ingredient of "zapone," and as such is employed in lacquering metal ware, jewelry, etc. It is also used in preparing oilcloth and patent leather. Its vapor when inhaled affects the circulation and nervous system. It causes such symptoms as headache, vertigo, numbness, palpitation and vomiting.

Amyl alcohol is used in making fruit essences, anilin dyes, etc. Inhalation of its vapor causes vertigo, tinnitus, headache, reduction in blood pressure, and vomiting.

Anilin acts upon the circulation after inhalation, but it also may cause toxic symptoms on absorption from the skin. This substance and its compounds are widely used for coloring. In Elberfeld among 5,000 employees in anilin works as many as 260 cases of anilinism have occurred in a year. Anilin is liable to poison cotton-mill workers both as a vapor and through dust.

(*a*) Mild acute cases of poisoning present headache, vertigo, orbital pain, weakness, a dull expression, retarded speech, and a gait resembling that of drunkenness. The lips and fingers are deeply cyanosed and much darkly pigmented urine is voided. Recovery soon takes place in the fresh air.

(*b*) Severe acute cases occur after saturation of the workman's clothing or inhalation of considerable vapor. The heart action becomes very feeble, respiration is slow, there are vomiting, cough, tremors, and convulsions. The visible mucous membranes look black, the pupils are narrow at first, and the breath reeks of anilin. There is hemolysis and the blood spectrum shows the bands of methemoglobin. Attacks may begin suddenly, the workman staggering and falling while at work, or he may go home and develop symptoms only after many hours. Intense strangury and passage of blood-colored urine may be observed. Despite the severity of the symptoms, recovery is the rule, but the patient must be kept

awake, or, as in opium poisoning, he may lapse again into coma. In other cases the victim dies in coma or convulsions.

(*c*) Chronic anilin poisoning, is characterized by anemia, bronchitis, and nervous symptoms, such as disturbances of sensation, motility, and dulness of mind. Locally pustular eczema appears on the hands, scrotum and elsewhere. Carcinoma of the bladder and testes occurs sometimes. In Germany in 1904 in eighteen anilin works twenty-eight such cases were found, and in 1910 four more. Vomiting also occurs.

Arseniureted hydrogen is a direct blood poison when inhaled, dissolving the red corpuscles and causing such symptoms as hematuria, pain in the back, jaundice, hematemesis, chills, dyspnea, fainting, and congestion of the liver and spleen. These effects may prove fatal.

Benzene or *benzol* is used in a variety of industries as for cleaning, scouring, the making of nitrobenzol, phenol, anilin, etc.

(*a*) Acute poisoning results from inhaling a large quantity of the vapor in a confined space. The pulse becomes rapid and irregular; vertigo, vomiting, faintness, great muscular prostration, perspiration, and cyanosis ensue. The pupils become dilated and hallucinations are followed by delirium, paralyses, and convulsions. The erythrocytes are fragmented and methemoglobin appears. In fatal cases there is generalized visceral hyperemia.

(*b*) Chronic poisoning causes gradual derangement of digestion and of the nervous system. Vertigo, tinnitus, and headache with tendency to fainting are complained of. There are tremors of the upper limbs and sometimes epileptiform seizures. Two fatal cases with hemorrhagic purpura occurred in Baden. The morbid anatomy in fatal cases shows fatty degeneration of the blood-vessels, kidneys, and liver. Two fatal cases occurred recently in Baltimore in girls in a canning factory who sealed the cans with a cement of rubber dissolved in benzol. Benzol possesses the unique property, among similar poisons of causing leucopenia, which has led to its therapeutic use in leukemia. It is, however, a dangerous remedy and may cause albuminuria and other serious symptoms.

Bromine vapor, evolved in chemical and drug manufactures, may cause a serious train of symptoms, such as choking, hoarseness, dyspnea, bronchitis, muscular prostration, convulsions, and coma. The buccal mucosa is discolored brown by it. It may cause immediate fatal spasm of the glottis. Fortunately this form of poisoning is rare. In milder, chronic cases prurigo and other skin eruptions occur with palpitation, dyspepsia, and bronchitis.

Carbon bisulphide is extensively used in vulcanizing rubber, making waterproofing materials, extraction of fats, and in textile industries. The vapor is toxic in proportion of 0.5 part per 1,000 of air. (*a*) Acute poisoning causes fullness of the head, vertigo and visual disorder. The victim acts as if drunken, becoming loquacious and following the suggestions of hallucinations. The temperature of the body is subnormal, the pupils fail to react, perspiration is increased and vomiting, dyspnea and palpitation are, further symptoms. Anesthesia with absent reflexes and convulsions may be observed and there is an odor as of rotten eggs in the breath. A few fatal cases with coma are reported, but usually the symptoms, although grave, are recovered from.

(*b*) Chronic poisoning produces curious psychic disturbances with periods of excitement and depression. Mental alienation, outbursts of temper and hysterical laughter, with exaggerated muscular and cutaneous excitability, are followed by nervousness and a pseudo tabetic state, with insomnia and serious disorders of digestion. Paraplegia and muscular contractures and atrophy, with facial spasm, have been recorded. The ocular symptoms include paralysis of accommodation, epiphora, atrophy, and pallor of the optic disc. Atrophy of the testes, dysmenorrhea, and melanoderma have been observed. The patient may pass into a state of chronic dementia.

Carbon dioxide affects particularly workers in mines, deep wells and cellars, tunnels, peat bogs, and sewers. Ten deaths have lately occurred among workmen in foreign sewers from this gas. In many industries also it may be toxic, being developed in beer vats, wine presses, lime kilns, sugar and starch refineries, etc., as a result of fermentation. In making aerated waters and in gas and smelting works it is present. In acute cases the victim becomes suddenly unconscious, cyanosed, and dyspneic with a feeble quick pulse, and he may die of asphyxia. Chronic cases present anemia, drowsiness, vertigo, and indigestion.

Carbon monoxide and illuminating gas constitute very common sources of poisoning, the former abounding in mines, foundries, coke furnaces, etc. The monoxid constitutes the chief poison of illuminating gas, especially of water gas of which it constitutes from twenty to thirty volumes per cent.

(*a*) Acute intoxication from these gases. The symptoms consist of frontal headache, dyspnea, muscular prostration, and possibly coma or a state of tetanus that may prove fatal. In a series of ninety cases of illuminating gas poisoning reported by the writer, leucocytosis was repeatedly observed. In eighteen of these cases the count was above 18,000 and the maximum count observed was 52,000.

In the comatose cases the body temperature usually was elevated from a day or two to a week, the maximum being 107° F. in a fatal case and 104.2° F. in non-fatal cases. The pulse varies from 120 to 140. Tremor, subsultus, convulsions, rigidity, increased reflexes and nystagmus were symptoms occasionally observed. The face is red and the blood contains methemoglobin. Rare cases are reported of sequelæ such as multiple neuritis, leptomeningitis, mania, and dementia. Pneumonia is a common sequel and is often fatal. In several of the writer's cases in which there were autopsies softening of the lenticular nucleus was found.

(*b*) Chronic poisoning presents anemia, dyspepsia, headache, a subnormal temperature, and, in serious cases, insomnia, amnesia, hallucinations and delirium of persecution.

Carbureted hydrogen encountered in mines contributes to the toxic effect of other gases, causing asphyxia and hemolysis.

Chlorine and the *chlorine compounds*. Chlorine is one of the most irritant of the gases in any strength above one-fifth part per 100,000 of air (Lehmann).

(*a*) In acute poisoning there is intense suffocation with cyanosis and a feeble pulse. Lewin reported seven deaths from this gas, two among chemists. Prompt reflex closure of the glottis may save the victim from deeper inhalation of the irritant.

(*b*) In chronic poisoning bronchitis and asthma occur with anemia and malnutrition. Chloride of lime locally irritates the skin causing pruritus, eczema, and ulcers. "Chloracne" is a peculiar eruption caused by working in chlorine salts. Salt workers suffer from nasal catarrh and Müller has reported forty-five cases of perforation of the nasal septum among 165 workers in salt mines and mills.

Diazomethane, used in methylizing causes bronchial irritation and ulceration with muscular prostration.

Dimethyl sulphate used in making perfumery causes local cutaneous sloughs, and when its vapor is inhaled, there arises ulcerative bronchitis, followed in some cases by aspiration pneumonia. Convulsions and coma may ensue. The gas may cause conjunctivitis, and corneal edema and opacity.

Dimethyl sulphate is used in preparing perfumery. Locally, it may give rise to ulceration of the skin. Its vapors may cause lacrymation, photophobia,

and corneal edema with opacity. When inhaled it produces ulcerative bronchitis which may be followed by inhalation pneumonia. There are pains in the thorax with paralyses, convulsions, and possibly fatal coma. Cases of this type of poisoning are rare, but a few have been reported in foreign countries.

Essences, extracts, and *essential oils,* such as those of spikenard, lavender, and rosemary, may prove more or less irritating when their vapors are inhaled, causing vertigo, tinnitus, and dyspepsia. The eyes and skin may be irritated. Essence of vanilla, similarly, when its vapor is inhaled in quantity may cause muscle pains and cramps, neuralgia, headache, and vesical irritation. Perfumery makers may suffer from a papular eruption of exposed parts of the skin, as well as general pruritus, coryza, and conjunctivitis. Some workers do not become immune to these irritations and must perforce discontinue the employment.

Ether is used extensively as a solvent and in making a certain type of smokeless powder and W. G. Hudson reports that the workmen become in time weak and anemic and have to change their work at least temporarily.

Methylated ether, when inhaled, gives rise to headache, nausea, drowsiness, and weakness. C. T. Graham-Rogers has reported seven cases of this type of poisoning acquired in making incandescent mantles.

Ethyl nitrite vapor, on inhalation, causes temporary cyanosis and dyspnea, which, however, are recovered from in the open air.

Formaldehyde used in dyeing, embalming, disinfection, etc., causes, when its vapor is inhaled, prickling in the nose and eyes, lacrymation, bronchitis, and ulceration of the respiratory passages. The writer saw an undertaker with a protracted generalized maculopapular eruption due to embalming with this substance. Such cases are not uncommon.

Gasoline vapor, inhaled in a confined space may cause vertigo and fainting with nausea, and, exceptionally, coma.

Naphtha Fumes.—Acute poisoning, when large quantities are inhaled resemble those of benzene poisoning above described. Chronic poisoning produces chronic bronchitis, tinnitus, vertigo, and dullness. The vapor also may cause acne of the hands, arms, and face. Wart-like papillomata may develop on the hands and nose.

Hydracyanic acid and the *cyanides.* These substances are used or developed in many industries, such as photography, making coal gas, soda, and fulminate of mercury, electroplating, etc. (*a*) Acute poisoning from large doses may cause instant death. Lesser doses cause pallor, vertigo, syncope, and sweats. The breath and urine smell like bitter almonds. The nose and throat are irritated. (*b*) Chronic poisoning results in vomiting, reduced blood pressure and muscular weakness.

Iodine vapor gives rise to a sort of intoxication called "iodine fever," resembling a general catarrhal or influenzal attack. In chronic cases of poisoning there are disorders of digestion, malnutrition, erythema, acne, blebs and atrophy of the testes.

Methyl alcohol or *wood alcohol* much used as a solvent for varnishes, when its fumes are inhaled may cause instant death, or in lesser dosage, cramps, vomiting, coryza, headache, prostration, rigors, dyspnea, restlessness, and insomnia. The pupils are dilated and immobile. Granular degeneration in the retinal ganglion cells and swelling of the optic nerve may cause permanent blindness (L. Pick). S. E. Jelliffe has reported two cases of chronic poisoning with hyperesthesia and paresthesia of the upper extremities, combined with muscular weakness.

Nitrobenzol and *dinitrobenzol* when inhaled cause throbbing headache, vertigo, vomiting, dyspnea, lessened blood pressure and weakness with cyanosis. Fatal coma may ensue. In chronic cases there is persistent cyanosis with prickling in the mouth and pharynx. The blood spectrum shows the band of free hematin and a specific Filehne's band. The pulse is slow. Transient coma and convulsions have been observed. Dinitrobenzol causes amblyopia, scotoma, and retinal venous hyperemia. The skin and buccal mucosa become brownish yellow. The urine is yellow and may contain the unaltered poison. Ten fatal cases resembling severe catarrhal icterus have been recorded by Schroeder and Strassmann.

Phosphorus poisoning, which formerly occurred chiefly in the match industry, owing to recent Congressional legislation is now rare. The necrosis of the jaw which it causes is elsewhere described in this work.

Ferrosilicon is not in itself poisonous, but when it becomes saturated with water arsenicureted hydrogen gas is evolved, poisoning by which is above described.

Sulphur and Sulphurous Acid.—Sulphur dust causes catarrh of the upper air tracts. Sulphurous acid fumes cause violent laryngeal spasm, cough, and dyspnea. Other symptoms are hemoptysis, bronchitis, pain in the eyes and conjunctivitis. Gastrointestinal disorder may be followed by anemia.

Sulphureted Hydrogen. (*a*) Acute poisoning exhibits general muscular paralysis, convulsions, coma, feeble pulse and respiration, and cyanosis. Death may ensue from apnea.

(*b*) Chronic poisoning results in headache, vomiting and a peculiar heaviness of the stomach that workmen call "the lead." Weakness and cachexia follow.

Turpentine fumes irritate the eyes, and cause vomiting, diarrhea, laryngeal spasm, bronchitis, acute nephritis, strangury, hemoglobinuria, vertigo, a quick pulse, nervous irritability, depression and emaciation. Among sixty-two turpentine workers Hayhurst found fourteen with organic renal lesions.

C. Diseases Caused by Acids, Alkalies, and Various Toxic Fluids, Such as Dyes, Petroleum, and Similar Products.—The action of these substances is in the main local and corrosive, although when concentrated some may give off irritant fumes. Hence they affect chiefly the skin, but in handling may be spattered into the eyes or mouth, giving rise to hyperemia and congestion or inflammation.

The bare hands and arms of the workman, being immersed in acid or alkaline solutions or wetted with other irritant fluids, afford naturally the principal site of injury, but often the face is affected through spattering, while leaning over a tub of dyestuff, for instance. The skin of the penis and scrotum too, is sometimes affected by conveying the irritant substance on the hands during micturition. When the clothing becomes saturated in a moist or steam atmosphere impregnated with the irritant substance, the skin of a large portion of the body may, be affected with hyperemia, sudamina, dermatitis eczema, or diffuse ulceration. The lesions of the hands, which are the most definite, consist essentially of chronic eczema, ulceration, fissures, and eczematoid dermatitis. The effects of the irritants which are more or less specific, are greatly intensified by the conditions under which work is done, as by prolonged maceration of the hands in hot or acid fluids, pressure and friction with the hands, the rubbing into the sores of various kinds of dirt, machine oil, etc. Although some of the irritants under discussion cause thickening and hardening of the skin, with many of them the opposite effect ensues and a cumulative irritation results in very chronic and intractable sores which often incapacitate the workman for months at a time, and show an unfortunate tendency to prompt recurrence when he resumes work.

Specific Action of Various Toxic Fluids.—The fumes of mineral acids produce very acute symptoms. Death may result almost immediately from suffocation with spasm and edema of the larynx and in-

tense bronchial irritation. Less intense poisoning results in cough, choking sensation, and bronchorrhea. In more serious cases pulmonary edema develops after a few hours with intense suffocative dyspnea which may prove fatal, be followed by pneumonia, or terminate favorably. W. G. Hudson, after experimental study of acid-fume inhalations, concludes that although some of the acid is absorbed into the blood, the direct caustic irritation of the respiratory mucosa constitutes the essential danger. Long-continued inhalation of weak acid fumes causes marked erosion of the teeth, and indigestion. Acid fumes are evolved in the manufacture of acids, in the dipping of metals into acid solutions for burnishing; in many dyeing and bleaching processes and a great number of miscellaneous industries.

Carbolic acid in contact with the hands may cause a serious degree of eczema. Poisoning by its fumes is rare. It gives rise to nausea, vomiting, salivation, dysphagia, and, exceptionally, a chronic nephritis. Workmen long exposed may emaciate and present what is known as "carbolic marasmus."

Hydrochloric acid besides causing erosions and eczema when handled in solution, may give rise through its fumes to conjunctivitis, rhinitis, and bronchitis. Concentrated fumes may cause death with dyspnea, hemoptysis, and coma. Long-continued inhalation of mild fumes may give rise to ulcers in the nose and mouth, erosion of the teeth, gastrointestinal disorder, anemia, and emaciation.

Hydrofluoric acid is used in bleaching such materials as cane and tallow, in etching glass, porcelain decoration, etc. It especially injures the eyes, its fumes causing edema of the lids, and occasionally ophthalmia and ulcerative keratitis. They may cause coryza, bronchitis, and bronchopneumonia. The acid in contact with the skin is also intensely irritant, so that periostitis may result from quite superficial acid burns and the blebs with cutaneous ulcers which develop are painful and very intractable. Dr. Laura H. Brauson has reported a case of acute poisoning through absorption from cut fingers. The body temperature rose to 105° F. and local periostitis and synovitis with edema affected the fingers. These results followed the application of not over three minims of the acid, and it was eight weeks before complete recovery from the local lesions resulted.

Nitric and Nitrous Acids, Nitrous Gases.—Although not strictly in accordance with classification, owing to similarity of action it is convenient to consider these substances together. Nitrous poisoning is both acute and chronic, the former being much the more common.

(*a*) In the acute type there is hyperemia of the skin or dermatitis with conjunctivitis, dyspepsia, and colic. The throat feels choked, there is more or less dyspnea and dry cough. In more serious cases capillary bronchitis develops, with great anxiety and restlessness, cyanosis, and intense dyspnea. There is copious watery sputum. Vomiting, delirium, and convulsions may precede a fatal termination. In the Gunnison tunnel in 1911 a premature blast liberating fumes of nitrogen tetroxide overwhelmed thirteen men, nine of whom died in a few days from acute pulmonary inflammation.

(*b*) Chronic nitrous poisoning gives rise to chronic bronchial catarrh, slight dyspnea, anemia, and dizziness. Kobert has reported finding erosions and perforation of the nasal septum in workers in a nitric acid factory.

Osmic acid irritates the skin and its fumes cause coryza and bronchitis.

Picric acid used in the manufacture of explosives and in chemical manufactures, colors the skin yellow by contact.

As a dust the acid causes sneezing and increased nasal secretion; there is bronchitis with anorexia and anemia. Conjunctivitis is also produced.

Sulphuric acid is used in bleaching, sugar refining, and starch making, burnishing metals, fertilizer making, petroleum distillation, and a variety of other industries. Its fumes cause rhinitis, acute or chronic bronchitis, and sometims bronchopneumonia. Spattered on the skin it is very painful and produces a brownish-white eschar with edema. Absorption after extensive sulphuric acid burns has caused duodenal ulceration followed by stupor and death.

Chinin is a by-product of petroleum which causes a desquamative eczema of the face, hands, and sometimes of the whole body.

Chinon used in dyeing processes causes keratitis and bronzing of the skin.

Metol is used in photography. The doctors Karasek reported thirty-one cases of poisoning by it in Chicago. It gives rise to erythema which may be very extensive and result in serious ulceration of the skin.

Nitroglycerin is used mainly in the manufacture of nitrocellulose and dynamite, of which latter more than 250,000,000 pounds are produced annually in the United States. Nitroglycerin is more readily absorbed into the system than almost any other poison being taken in through the skin, alimentary canal, and respiratory system. Some persons absorb it so readily that merely shaking hands with a workman who has been handling giant powder may produce fulness and throbbing in the head, with reduced blood pressure—the "nitroglycerin head" as workmen call it. Miners using blasting powder may carry home sufficient partially consumed powder fumes in their clothing to poison members of their family. On the other hand, the workmen themselves in time acquire a certain degree of immunity against the poison. Further symptoms of acute poisoning are congestion of the vessels of the face, injection of the conjunctivæ, tinnitus, vertigo, nausea, vomiting, and fainting. Temporary blindness may occur. The urine is increased and is pale and of low specific gravity. The heart action is at first quickened, then slowed. In the more serious cases of poisoning by inhalation or otherwise there may be paralyses in the muscles of the extremities, head and eyes. Respiration is slow and deep, and the victim complains of dyspnea. In cases where the workmen have been caught in explosions there may be tremors, syncope and fatal coma. In other cases the imprisoned miner becomes frantic from pains in the head, and as C. E. Laws describes the condition he "runs about shouting and striking his head against obstacles." This observer further describes cases of chronic poisoning with dyspnea, tachycardia, tremors, dyspepsia, and neuralgia.

Paraffin is used for water-proofing, electric insulation. When melted, its vapors cause headache, vertigo, nausea, vomiting, gastric and intestinal pains, diarrhea, dyspnea, muscular prostration and sweats. In contact with the skin, the sebaceous glands especially are irritated and cases of epithelioma in paraffin workers have been reported by several clinicians. A petroleum by-product paraphenylendiamin after prolonged inhalation may cause hematuria. As an ingredient of hair-dye it is highly irritant.

Petroleum or coal oil may cause acute or chronic poisoning among workmen at the wells, especially in certain foreign countries where mechanical processes are better developed. (*a*) In the acute type or "petroleum intoxication" the legs become suddenly weak and there is marked dyspnea. A workman entering a non-ventilated reservoir may suddenly fall in coma and die of asphyxia. Korjenewsky describes the case of a man who after a day's work in a petroleum well was attacked by hemoptysis, hematemesis, melena, and delirium followed by death the next day. Even coma from petroleum poisoning is not necessarily fatal, and in mildly toxic cases the workmen sometimes experience a feeling of mild elation in their intoxication.

(*b*) Chronic petroleum poisoning results in vertigo, headache, cough, dyspnea, nervousness, hallucinations, amnesia, and attacks of syncope. In contact with the skin petroleum may cause ulcers and papillomata.

Phenylhydrazin, a by-product derived in making antipyrin from anilin, may cause burning and pruritus of the skin with a vesicular eruption. If absorbed it causes granular degeneration of the red blood corpuscles, indigestion and diarrhea.

Pyridin, used in making denatured alcohol is thus employed in wood polishing, hat-making, gilding, etc. It's vapor gives rise to choking, hoarseness and laryngitis. There may be cerebral symptoms, as vertigo and headache with tremors, weakness of the limbs, dyspnea and convulsions. Upon the hands it causes eczema. Very few toxic cases, however, are recorded.

Tar and Pitch.—The fumes of these substances cause cerebral symptoms, such as headache, tinnitus and vertigo, also dark colored urine, dyspepsia, diarrhea, asthma, bronchitis and angina. In grave cases of poisoning there may be muscle cramps, paresis, hyperesthesia, and mental depression or exaltation. There may be suppurative otitis. Locally "tar itch" or a general pruritus affects the body from contact with clothing saturated with tar fumes. The skin becomes brown and a scaly psoriasis-like eruption may appear. Conjunctivitis is common and nasal or buccal ulcers may be observed. Handling railroad ties treated with tar or creosote has been known to cause dermatitis and pustular eczema on the face and hands. Many other fluid substances are irritant to the skin and mucous membranes as used in manufactures, but in the above list are included the commonest and most important sources of industrial poisoning occurring under this heading.

D. Diseases Caused by Irritant Dusts and Fibers.—The mode of action of these substances may be classified as follows:

(1) Through mechanical obstruction of the air passages, as illustrated by the dust in grain elevators, cement works, etc.

(2) Through laceration of the respiratory mucosa by means of sharp hard particles, as in the case of steel, emery, procelain or stone dust as developed in grinding and polishing with buffing wheels.

(3) Through conveyance of soluble toxic material, as for example the dust of lead filings, chromic acid, etc.

(4) Through conveyance of germs into the lungs, as for example when the inhalation of dust from contaminated fur or feathers gives rise to pulmonary abscess.

(5) Through irritation of the skin, choking the sweat and sebaceous gland ducts, and chafing the epithelium, thus causing pruritus, erythema, and eczema. Mixed with sweat and lodging in the deeper folds of the skin, dust may exceptionally cause ulceration, or even epithelioma, as in the "chimney-sweep's cancer" of the scrotum.

(6) Through irritation of the eyes, causing conjunctivitis, lacrymation, and corneal or conjunctival ulceration.

(7) Through inhalation into the mouth and subsequent swallowing. In this manner most of the cases of lead poisoning occur, among those who work in paint dust, etc. Most cases of arsenic poisoning also have such origin.

Many dusts do not penetrate very deeply into the lungs, but the hard, heavy, fine dusts, as those of silica, emery, and steel, may do so, and in addition to causing a chronic bronchitis (which is at first protective by virtue of the tenacious mucous secretion), eventually give rise to pneumonoconiosis. In the case of coal miners, after death, deposits of minute particles of carbon have been found in the bronchial and other lymphatic glands and even in the liver where they have been conveyed by phagocytes.

In general the action of dusts may be said to be less specific than that of most of the irritants, for the effect of all the non-toxic dusts is mechanical and hence fairly uniform. Rhinitis and bronchitis, both acute and chronic, constitute the most common diseases due to such dusts, with a tendency after protracted exposure to favor the development of asthma and emphysema. All the dusts, however, and particularly those which give rise to fibroid phthisis, tend to lower the resisting power of the lungs against tuberculosis, hence the mortality, from pulmonary tuberculosis among pottery and china scourers, emery grinders and those subject to similar hazards is exceptionally high.

Specific Effects of Various Ducts.—For convenience of description the dusts may be grouped as follows: (1) Insoluble inorganic dusts. (2) Soluble inorganic dusts (3) Organic dusts and fibers. (4) Insoluble inorganic dusts.

Asphalt.—The melting pots of this substance give off irritating fumes which may cause conjunctivitis and bronchitis. The dust of dried asphalt as ground by street traffic is more or less irritating to the respiratory mucosa. Workers in asphalt may suffer from a generalized dermatitis imparting a yellowish color to the skin. Cases of this sort have been reported by Weyl.

Cement.—Grinding and mixing cement is one of the most dusty occupations which to some extent is controlled by ventillating and other appliances. Thus the packing in sacks and barrels is sometimes done by machinery. In this country the cement manufacturers maintain that this form of dust is non-irritating, but foreign literature contains many references to cases of serious irritation of the bronchi and conjunctivæ. The dust is liable to cake in the nose, the incrustations causing ulceration and sometimes perforation. "Cement itch" is the name commonly given to the pruritis caused by the dust mingling with the perspiration and the hands of the workmen may be affected by chronic eczema.

Diamonds and other precious stones while being cut may give off sharp fine dust. This dust in itself is probably rarely inhaled in injurious quantity but the emery and sand used in polishing may cause bronchial irritation and pneumonoconiosis. The jewels are often imbedded for cutting in a leaden matrix, and in jewelry making solder is applied wih a blowpipe, hence occasional cases of lead poisoning have been recorded among jewelry makers.

Emery.—The manufacture of emery grindstones and emery paper, as well as their use in grinding evolves much sharp hard dust which is highly irritating to the mucous membranes of the conjunctivæ, nose and bronchi. Röpke found among twenty-three men employed in emery milling, that all had nasopharyngeal catarrh, fifteen had atrophic mucous membranes, seven had otitis media, and one a perforated nasal septum.

Glass Making.—Glass grinding and polishing gives rise to very harmful dust particles. Glass mixing involves exposure to such dusts as those of sand, flint, quartz, limestone, soda, potash, etc., as well as to toxic metals used for coloring, such as lead and zinc oxides, arsenic, etc. In glass-blowing and casting there is exposure to great heat and both excessive heat and light may irritate the eyes, causing "glass-blowers cataract." Glass-blowers, contrary to popular belief, are not especially prone to emphysema, but the grinders may acquire bronchitis and pulmonary fibrosis which predispose to tuberculosis. Mineral wool, consisting of fine shreds of glass, is particularly irritating when its dust is inhaled.

Meersehaum or sepriolite grinders and polishers are subject to more or less injurious dust inhalation.

Metal filings constitute a considerable source of dust inhalation, especially those of iron, steel, and

brass. Steel grinding, as in cutlery making and many similar industries, constitutes a fertile source of cases of chronic bronchitis, asthma, and fibroid phthisis.

Stones and Earths.—Carbon.—These substances in fine dust figure in many industries as respiratory irritants. Such for example, are the making and using of grinding and polishing materials, like corundum, sandpaper, etc., the making and handling of bricks, tiles, terracotta, flint, granite, silica, limestone, marble, etc. Especially exposed to such irritants are stonecutters and polishers, rock drillers, *et al.* In Germany stonecutters and quarrymen present in their death-rate eighty-six per cent. of pulmonary diseases. In Massachusetts forty-one per cent. of the deaths among stonecutters have been found due to tuberculosis and twelve per cent. to other types of pulmonary disease. In general the tuberculosis mortality of stone and marble cutters is five times greater than that of farmers. A most injurious occupation is that of sandblasting of metal castings, and the cleaning of stone buildings by sandblast. Although the workmen wear protective masks, much dust filters through and is inhaled. Carbon, dust as represented by coal screenings, etc., is less hard and on the whole less irritating than the dusts above mentioned, nevertheless stokers and coal heavers inhale it in such quantities that particles may be conveyed to the bronchial glands and even to the liver, through the agency of phagocytes.

(2) *Soluble Inorganic Dusts.*—Many dusts on being inhaled or swallowed, on coming in contact with mucus or the digestive fluids pass into solution and are absorbed into the system. Such for example, are the dusts of lime, gypsum, plaster-of-Paris, phosphates, and certain metals or salts of metals such as brass, arsenic, zinc, lead, silver, and mercury. In so far as they exert specific action their effects are described elsewhere in this article.

Oxalic acid is used for polishing brass and copper, bleaching straw, and in dyeing and chemical cleaning works. It is a serious cardiac poison, causing intense cyanosis, paralyses and occasionally convulsions. In solution in contact with the nails, it makes them blue and brittle.

Ultramarine is composed of various finely ground substances, as kaolin, charcoal, sulphur, and soda. Sulphuric acid is used in making some forms of it. Workmen employed in packing the powder, suffer, according to Röpke, from nasal and bronchial catarrh. The nasal septum may be perforated.

(3) *Organic Dusts and Fibers.—Acridin* used in dyeing consists of nitrogen with carbon and hydrogen. It forms acicular crystals which when scattered as dust cause excessive pruritus, dermatitis, conjunctivitis, coryza, obstinate sneezing and tracheitis. Dyers are the type of workmen subject to this form of poison.

Ashes and Street Dusts.—Ashcart men and street sweepers perhaps owing to their out-door life suffer less from bronchial irritation and tuberculosis than might be supposed. In New York City this matter has been investigated by Drs. John Rogers, A. Bleiman, and other physicians. Among 5,800 men examined less than two per cent. had incipient tuberculosis. Ash dust is sterile, but street dust is a mixture containing such substances as paving material, as brick, asphalt, concrete, flint rock, macadam, sand, earth, wood, dust from building materials, house sweepings, passing ashcarts, iron rust, soot, tar, automobile oil, powdered excrement of horses and dogs, and dried sputum. Ashmen and garbage collectors have to lift heavy barrels and may acquire hernias from strain. Street cleaners in summer are subject to insolation, and both classes of workmen may acquire injuries to the eye from sharp spicula of silica or other forms of ash.

Carpet cleaners inhale dust which contains all manner of dirt, and may thus inhale germs of influenza, pneumonia or tuberculosis, but notwithstanding the industry has not attracted attention as being particularly unhealthful.

Cotton.—In ginning cotton much dust of earth and sand besides the organic fiber is blown about. Employees complain of dryness of the nose and throat and may have nasal catarrh and epistaxis. Röpke found that almost all of eighteen cotton wool cleaners had erosions of the Schneiderian membrane. Cotton spinning and weaving as well as buffing with rag wheels fill the air with fiber dust. William Stainsby investigating 1,500 New Jersey operatives in cotton mills found twenty-two cases of pulmonary diseases and fifteen of throat diseases. Dysmenorrhea is common among the women operatives who have long work hours on their feet, often on floors jarred by machinery. Cotton and flax dust seem more harmful upon the whole than wool dust. In the morning cough of cotton weavers with bronchitis, fibers of cotton may be detected. If drawn into the alveoli the fibers cause dyspnea and asthma, associated with anemia. But the "cotton-mill anemia" of the South has been shown by C. W. Stiles to be due to uncinariasis. In Lancashire, England, a few years ago, one person in five who died of tuberculosis was a weaver.

Feathers.—Feather dust conveys much dirt to the lungs, together with bacteria. In feather dyeing toxic arsenical and chromate pigments may be used. Purulent bronchitis and pulmonary abscess are among the pulmonary diseases occasionally recorded among feather dressers.

Felt is made from finely cut rabbit, hare or other fur. The fine hair dust is a respiratory irritant, moreover, the fur is treated with a nitrate of mercury solution and mercury may subsequently be vaporized under heating processes and inhaled.

Flax and hemp dust may be mixed with natural dirt, machine oil and chemicals used in macerating or bleaching the fibers. Fiber-beating liberates such dust and in subsequent maceration sulphuric acid and ammoniated sulphur fumes may be evolved. Flax and hemp beaters acquire "beater's fever," with malaise, headache, neuralgias, and catarrh of the upper respiratory passages. Dryness of the nasal mucosa occurs with loss of sense of smell and epistaxis. Otitis media occurs and eczema of the hands and forearms. French writers describe a chronic flax-workers' poisoning with bronzing of the skin, dulness, hesitating gait, and a peculiar odor like hasheesh in the urine.

Fur.—Fur, like feather dust, conveys much dirt. Besides the risk of bronchial irritation from inhalation of such dust, the fur may be infected by specific germs. Anthrax is sometimes communicated through this agency, and the writer examined two of a series of six cases of eczema impetiginodes which arose from infected fur in a felt hat factory in New Jersey. Staphylococcus aureus was isolated from the purulent eruption. The disease began behind the ears and spread over the scalp, limbs, and serotum. The blebs became sanguineous and purulent. A further risk for the health of furriers consists in the handling of toxic dyestuffs and a variety of substances employed for curing the fur such as lime, nitrate of mercury, and sulphide of arsenic.

Grain and flour dusts beget nasal and bronchial catarrh, particularly among those working in the grain-polishing rooms. Meal and flour dust in the nose forms crusts which may cause ulceration and atrophic rhinitis. Eczema of the external auditory canal and otitis media also are observed. Hirt found that millers and grain elevator men suffer largely from respiratory diseases whereof twenty per cent. are pneumonia and more than ten per cent. tuberculosis. Atelectasis may be caused by the caking of flour or meal dust in the lesser bronchi. "Miller's asthma" produces sputum in which the sharp epidermal layers of grain are found. The New York State Bureau of Labor Report for 1906 showed a mortality

among millers from pneumonia double that of ordinary occupations.

Horn, Bone, and Shell.—Besides the use of these materials in button making, elsewhere described, they are much used for knife handles, combs, hairpins, and many other articles, in the polishing of which coal ashes, pumice stone, and other substances are employed. The articles also are dipped in glacial acetic acid which may cause eczema of the hands and irritate the eyes and bronchi by its fumes. The pointing of teeth of celluloid and tortoise shell combs gives rise to similar dust hazards to those of horn.

Horsehair and Other Hair.—In the carding, cleaning, and manufacturing processes of hair and in upholstering, and brush making dust may be inhaled consisting of fine hairs, epithelium, and sometimes particles of dried flesh. Pustules and carbuncles may attack upholsterers and paint-brush makers. Hair dust causes, when inhaled, sneezing, epistaxis, ulceration of the nasal mucosa, and asthma. Some persons are especially susceptible to this form of dust in whom it begets attacks resembling "hay asthma." A patient of the writer who had had an upholsterer's bronchitis for fifteen years finally acquired tuberculosis and pneumothorax.

Jute dust irritates the eyes, ears, skin, hair, and lungs. In rope making, cord and sack making, the workmen (or often workwomen) may suffer from conjunctivitis, eczema of the scalp, deafness from choking of the external auditory canal with dust, plugging of the nasal cavities, bronchitis, and asthma. Huberden found furunculosis in jute workers and Röpke reported cases of polypoid degeneration of the nasal mucosa. The tarring of hempen ropes may cause eczema of the hands.

Rags and Paper Making.—Handling, sorting, and cutting rags for paper making is a dusty trade, and despite fumigation is not without hazard from infection. Offelmann studied 4,875 rag paper makers and found that fully one-half become ill during the year with some ailment, usually pulmonary in character. Rarely actinomycosis or "wool-sorter's disease" has been conveyed through rag sorting. Dohnal found in Germany, thirteen cases in five years. The dust of baled rags may equal one-fourth the weight of the bale, and its inhalation may occasion bronchitis, bronchorrhea, and gastric catarrh. In paper making from rags they are macerated and bleached with hydrochloric or sulphuric acids, lime chloride, etc. The workmen may have to stand all day exposed to wet and cold, or in an atmosphere of steam. In making fancy wall papers, chrome and bronze or other toxic pigments may be used, but arsenical pigments have largely been superseded by anilines. Velour tapestry paper making distributes fine wool dust. Wood pulp paper making liberates sulphurous acid fumes, and new workmen complain of nasal and bronchial catarrh, but as in many other industries of the sort, appear soon to acquire more or less immunity.

Straw and broom dust is mingled with much general dust. In the manufacture of straw hats sulphuric acid is a bleaching agent and lead chromate or other toxic pigments may be used. But there are no records that the industry is particularly harmful.

Sugar refining is a process in which the workman is subjected to a temperature which sometimes reaches 95° F. with a relative humidity of 96 (G. M. Price). The residue of molasses dirt often contains germs and mites which give rise to dermatitis and pruritus. The stirrers of molasses have been known to acquire a staphylococcus aureus lymphangitis and furunculosis.

Tobacco Sorting and Manufacture.—Tobacco dust and tobacco vapor derived from the moistened leaves, steaming the leaves on hot trays, sorting and packing cigars, handling cut tobacco, are all unwholesome occupations unless very carefully conducted. Beginners at the work, especially if they are children or young girls complain of insomnia, muscular weakness and nervousness, palpitation, pharyngitis, cough, nausea, vomiting, and diarrhea. Conjunctivitis is common and anemia may follow, with emaciation. Adults may suffer from vertigo, faintness, nausea, vomiting, and diarrhea. Tachycardia and anemia may follow. Amblyopia may be present, with other visual disorders. Women may have dysmenorrhea and are prone to abort. Nicotine has been found in amniotic fluid (Ruef and Stolz). Pierraccini of Milan found forty-five per cent. of premature births among tobacco-working mothers. In the lungs of tobacco workers patches of pigment and brown induration have been found. By no means all tobacco workers suffer from this extensive series of symptoms, but many have some of them, especially on beginning work. They may become immune after a few weeks, or be obliged to change the occupation if the more serious symptoms develop.

Wood-working.—In addition to the moderate bronchial irritation which may arise from inhalation of fine sawdust, there are a variety of woods, mostly from the tropics, which contain alkaloidal or other specific poisons. In cabinet making, veneering, etc., where these woods have to be finely sawed and scraped or polished, their dust may produce toxic symptoms. This applies to such as teakwood, boxwood, ebony, satinwood, African rosewood, and the American redwood and sequoia. For example, working in boxwood may cause smarting and burning in the eyes, vertigo, and severe coryza or bronchitis followed sometimes by jaundice, asthma, and sweats; the heart action is slow and there is muscular weakness. Sequoia dust is capable of causing analogous symptoms. Cokus wood holds an oil which may cause papular eczema of the lips and ears or even the face. Cocabola is another imported hard-wood valued for handles of agricultural tools. Its dust causes conjunctivitis and dermatitis. Some workmen cannot work it at all. Satinwood causes urticaria of the hands. Indian rosewood may cause edema of the face and hands. Sawyers of ebony and teak, highly resinous woods, may acquire erythema multiforme, acne, and dermatitis. Tagazasa, a Japanese wood, when sandpapered may cause conjunctivitis and dermatitis with punctate brown discoloration. This wood contains a substance resembling chrysarobic acid.

Woodworkers are also subject to the toxic effects of inhalations of substances used in polishing, varnishing, etc., such as wood alcohol, turpentine, benzene, etc., substances which affect the circulation and respiration causing acute poisoning. Sandpaper and emery paper used for finishing add to the dust hazards. Sternberg of Vienna refers to typical chest deformities in cabinet makers who maintain constrained attitudes at their work-benches. Floor scrapers may acquire patellar bursitis. Noisy sawmills may give rise to deafness. Blum has described cases of poisoning from chrome pigments used in coloring canes and umbrella sticks.

Wool.—Wool sorting and cleaning is dusty work which may beget acute and chronic bronchial catarrh. Hydrochloric and sulphuric acids are used in part of the cleansing process, the fumes of which given off from the vats are very irritating. In New York State several cases of anthrax have been reported among weavers of woolen rugs and carpets. Wool spinning and carding is less likely to be harmful than similar processes conducted with cotton and jute.

E. Germ Diseases of Occupational Origin.—These diseases, elsewhere described, are here mentioned by title only, for completeness of classification. They include: ankylostomiasis among miners; anthrax among wool sorters, furriers, and tanners; the foot-and-mouth disease among cattle herders and dairymen; glanders and farcy among stablemen,

and septicemia, particularly among makers of fertilizers, workers in fat rendering, etc., where serious infection through abrasions may follow handling dead animal matter.

F. Miscellaneous Irritants.—These are met with in several industries difficult otherwise to classify.

Linseed Oil.—In making this oil sulphuric acid is used and heat up to 125° F. is employed.

Oilcloth and Linoleum.—Linoleum is made with linseed or cottonseed oil, resin and ground cork spread on cloth. Pigments which may contain lead or chrome salts may be added. Hardening is favored by addition of zinc, lead, or manganese preparations. In the process toxic fumes of various sorts are evolved. Among the workmen cases are recorded of purulent bronchitis, rhinitis, conjunctivitis, and pulmonary hemorrhage.

Rubber.—In the making of rubber goods, such as overshoes, such substances are used for polishing and varnishing as naphtha, benzene, wood alcohol, mercury solutions and acids, all of which may give rise to irritating or poisonous fumes. In the rubber industry, also, carbon bisulphide is employed as a solvent, the extremely toxic effects of which are detailed under that heading.

II. Diseases due to Harmful Environment.

These comprise modifications in air pressure and air composition, and modifications in surrounding temperature and light.

Compressed-air Illness.—This disorder to which tunnel and caisson workers are subjected is always serious and sometimes fatal. In all underground work such as tunnelling, laying deep foundations for bridges, "skyscrapers" etc., in which water is likely to enter the excavations it must be forced back and kept out by compressed air which carries a pressure of thirty to forty-five or rarely sixty pounds per square inch or from two to four times the normal. Men entering the caissons and tunnels in which this atmosphere exists absorb a greatly increased quantity of atmospheric air which is promptly liberated again from the lungs when they return to normal atmospheric pressure. In 1900 three German experimenters, von Schrötter, Mager, and Heller demonstrated a local ischemia in the spinal cord which is due to air-bubbles, mainly composed of nitrogen which lag behind in the capillaries when the compressed air is escaping from the circulation. Their work has been experimentally confirmed and elaborated by Leonard Hill. The nitrogen bubbles produce the effect of capillary emboli, from which arise a train of spinal cord symptoms which the workmen call the "bends" from the doubling up of the body with pain. These symptoms do not arise while the workman is under compression, but appear soon after he returns to normal atmospheric air and are proportioned in severity to the celerity with which decompression is conducted. The symptoms, which vary somewhat in different cases, consist of intense pains in the back and limbs, paraplegia, vertigo, unconsciousness, and collapse with constriction of the chest and dyspnea, called by the workmen the "chokes." The writer has seen several cases with complete anuria. Either recovery or death may result in a few hours, or the patient may remain paralyzed for weeks and finally recover, or may be disabled permanently. Boycott and Damant of the British Navy showed experimentally that under compressed air fat animals retain more nitrogen than lean animals and Haldane showed that "fat dissolves about six times as much nitrogen as blood." Obviously therefore only lean, muscular, non-alcoholic men should run the risks of caisson work.

In addition to the risks of air compression workers in tunnels are subject to inhalation of fumes from explosives, such as nitrous and other gases as well as irritant smoke, dampness, and sudden temperature changes.

Prevention of compressed-air illness consists in slow decompression either by a nearly uniform rate, taking fully twenty-five minutes to decompress from an atmosphere of forty to fifty pounds, or by Haldane's "stage decompression," consisting of rapid decompression down to half the maximum pressure to which the workman has been subjected, followed by a slower more uniform rate. Treatment of the symptoms of compressed-air illness demands an immediate recompression of the victim in a special air lock, whereby further escape of the air which he has absorbed is checked. He is then very gradually decompressed. Further he is given hot bland drinks, a hot bath and is wrapped in warm dry clothing. Morphine may be necessary to relieve pain, and a diuretic may be required. E. L. Keays of the writer's clinic had the exceptional opportunity of studying 3,692 examples of compressed-air illness occurring among the 10,000 workmen employed in constructing the railroad tunnels under the East River at New York. Many of the cases were mild, but among the others were twenty deaths.

Divers are employed largely for sponge gathering at depths down to 200 feet or more beneath the water surface. They are also occupied in naval work, building bridge foundations, exploring and raising wrecks, etc. They suffer from symptoms essentially similar to those of the caisson and tunnel workers—symptoms which have the same cause in the formation of nitrogen emboli. They suffer more from vitiated air, as the volume received through the "scaphander," or diving apparatus, is relatively small. They also suffer from disturbances of the circulation in the legs because of the tightness with which their clothing is fastened. The duration of their labor must naturally depend upon the depth at which they work; thus a diver may work for an hour at ten to fifteen fathoms depth, but only a minute at thirty fathoms. In caissons, on the contrary, he may work for two or three hours at a shift.

Air concussion arising from blasts, boiler explosions, firing of heavy guns, etc., frequently causes rupture of one or both membranæ tympani, and labyrinthine injury may ensue. The victim may be stunned to unconsciousness. Prolonged results may be such as tinnitus, headache, and more or less deafness.

Rarefied air is encountered in the ascent of lofty mountains and in balloon and aviation ascensions. Under these conditions, the pulse and respiration may become rapid and feeble. Chills, vertigo, nausea, tinnitus aurium, headache, urgency for micturition occur. Hemorrhages may take place from the nose and bronchi. These symptoms, however, are usually promptly recovered from, and it is a curious fact that aviators who fly to great heights do not more frequently suffer from them.

Air concussion as met with in explosions in mines, big-gun firing, etc., may rupture the ear drums, causing hemorrhage, and sometimes labyrinthine disease may follow, although permanent deafness seldom follows.

B. Temperature Modifications—Excessive Heat and Moisture, Extreme Cold.—Glassblowers, stokers, foundrymen, flax-spinners, tanners, bakers, canners, pottery makers, and employees in many other industries are exposed to great variations of temperature which predispose to bronchitis and nephritis. The heat may be dry, as in kilns and in stoking, or moist, as in dye works, tanneries, laundries, etc. Insolation affects chiefly roofers, stokers, layers of asphalt pavement, foundrymen, *et al.* Extreme heat may give rise to dermatitis and may injure the eyes, especially when accompanied by excessive light as in pouring molten metal.

Extreme cold is met with in the cold storage industry in which it may give rise to bronchitis, check perspiration, and overtax the kidneys.

C. Light Modifications.—Apart from the injurious effects of faulty or inadequate lighting of workshops, etc., the eyes may be strained by reflected moving light, as in polishing shiny metal articles. Light from molten metals is accompanied by temperatures ranging up to 3,200° F. All temperatures above 2,000° F., with light, are liable to injure the eyes permanently, causing retinal hyperesthesia, conjunctivitis and sometimes retinitis and ophthalmia. "Glassblower's cataract" is a long known occupational eye lesion. Electric-arc welding involves temperatures up to 7,000° F. or higher, with most intense light. The workman must stand behind an asbestos screen, wear protective gloves, and protect the eyes with goggles made with a half-dozen alternating layers of blue and red glass. Testing incandescent electric light bulbs is another occupation liable to result in serious eye-strain.

III. Miscellaneous Occupational Diseases.

Under this group are included a variety of diseases which, because of the variety of hazards comprised in the single industry or from special conditions, are difficult to classify more definitely. It is necessarily a large and constantly increasing group, but the more important members of it will be briefly summarized as follows:

Mining.—Miners in general are subject to considerable dust inhalation, but contrary to popular belief, the tuberculosis mortality among coal miners is not disproportionately high. The so-called "miner's phthisis" or anthracosis is a progressive fibrosis of the lungs, chiefly involving the apices, due to constant irritation by inhaled particles of carbon dust. Coal miners often present bluish discoloration of the skin of the face and hands due to tattooing by imbedded particles of carbon blown in by explosives. Miner's nystagmus is an oscillation of the eyeballs caused by picking at overhead coal seams with the head held in an unnatural position. The symptom usually passes away after periods of prolonged rest. Owing to improved methods of mining it is at present much less often observed than formerly. Stokers and coal screeners suffer from the evils of dust inhalation. In addition to the ordinary hazards of poor ventilation, in mines in which explosives are used their fumes, especially those of nitroglycerin and dynamite, disturb the respiration and circulation. Tinnitus, vertigo, and chronic deafness may result from the detonations. Men who work in damp hot mines on emerging into the outer air in winter frequently suffer from bronchitis and rheumatism. The workers in lead, arsenic, mercury, and sulphur mines may be affected by these specific poisons, and suffer from neuritis, palsy, anemia, etc. Cases of ankylostomiasis have been observed in a very few mines in this country, naturally only where accumulated filth polluted the floor of the mines. Exceptionally dysentery has been spread in a similar manner.

Masons, Plasterers, and Concrete Mixers.—These workmen are exposed to cold, dampness, and inhalation of such irritant dusts as those of bricks, tiles, lime, gypsum, and cement. They suffer, in consequence, from rhinitis, conjunctivitis, and chronic bronchitis. Statistics show that among masons thirty-three per cent. suffer from respiratory diseases, about one-third of the cases being tuberculous. Mortar mixers deal with fine sand and may acquire pulmonary fibrosis. Rheumatism is common among masons and cases of lumbago and sciatica have been traced to their frequent stooping in laying bricks. Masons and plasterers often suffer from cutaneous irritation of the hands from the grinding into the folds of the skin of cement, plaster of Paris, etc. As a result, blisters or infected pustules form; there are fissures and ulcers between the fingers or over the knuckles and chronic eczema is associated with such lesions.

Roofers may acquire eczema from handling tar, plumbism from soldering metal roofs, and insolation from exposure to summer heat. Bruno Bosse observed partial paralysis with tremors of the legs in men who worked on steeply inclined roofs.

Pottery, china, and porcelain manufacture presents the hazards of exposure to damp in the clay-mixing rooms, extreme heat in the firing ovens, lead poisoning from dipping various articles into solutions of lead glaze, the mixing of paints or pigments where the articles are to be colored, the inhalation of coal gas in the drying rooms, and the inhalation of a variety of dusts while buffing or scouring, or in the original mixing processes. Among these noxious dusts are kaolin, flint, charcoal, feldspar, silica, white and red lead, galena, cobalt, and other mineral pigments. Owing mainly to these dusts and especially the hazards of poisoning by fluid lead glaze, and scouring the glaze after firing, the pottery industry originally ranked as one of the most harmful, particularly in England and France. Arlidge found that more than twenty years ago the mortality among potters from respiratory diseases was almost double that of workmen in other trades, and as many women and children were employed, who are especially susceptible to plumbism, very many cases of lead poisoning resulted among them, including many of the worst types such as lead encephalopathy. Of recent years, however, following legislative control of the special hazards of the pottery industry and better understanding of their nature, evil results are very much less common. The scouring is now conducted in many cases in front of exhaust ducts, or inside of closed cabinets into which the hands are passed through canvas apertures so that the dangerous lead dust is aspirated away from the workman's face. Substitutes for lead in the glaze have been tried but have not generally been found as satisfactory.

Brick and Tile Making.—In these industries the hazards are similar to those of pottery making. In the clay beds and baking ovens the workmen are exposed to irritant dusts or to constant wetting and overheating. Among the dusts besides pulverized clay, are those of iron filings and other coloring materials used, and the lead of glazed tiles. The writer saw a serious case of plumbism in a man employed in unloading glazed tiles from a barge. Women are considerably employed in this form of glazing industry.

Fertilizers.—Both bone and mineral fertilizers in the making expose the workman to the inhalation of dusts and acid fumes. The grinding of basic slag develops highly irritating dust. The addition of potassium nitrate to fertilizer mixtures with acid superphosphate develops both nitrous and nitric acid, the fumes of which may give rise to serious vasomotor disturbance, suffocative bronchitis and even pulmonary edema. In some mixtures hydrofluoric acid is liberated which is one of the most dangerous of respiratory irritants. The dusts of the fertilizers are liable to give rise to bronchitis, asthma, and, in the case of basic slag, to fibroid phthisis.

Dyers.—In the dyeing industry many poisonous materials are used in coloring, bleaching and as mordants, such, for example, as ammonia, mineral acids, naphtha, gasoline, chloride of lime, and other bleaches; metal salts, such as those of copper, arsenic, and chromium; the anilines; wood alcohol, and a variety of wood or bark extracts, some of which are quite harmful. In addition to the effects of these specific poisons the workman frequently is obliged to inhale hot steam and fumes and is exposed to constant wetting of the body. Among the ailments common to dyers, therefore, are bronchitis, rheumatism, anemia, and digestive disorders. The hands and arms, constantly dipped into the vats or employed in squeezing

the dye from cloths, yarn, etc., are affected by serious chronic eczema and dermatitis. The fluids also may be spattered into the eyes or face, causing much local irritation. One of the writer's patients, a dyer of ostrich feathers, who had inhaled much arsenic and oxalic acid, acquired a bronchial hemorrhage.

Electroplating, in addition to the hazard of poisoning by red lead, subjects the workman to dermatosis of the hands and forearms from irritation of the powdered lime in oil used in finishing and the sour beer used in "scratch brushing." The process of electroplating employed while producing phonograph records is so delicate that protective gloves cannot well be used, and the workmen have their hands wet with dilute sulphuric acid which in a few weeks may cause an incapacitating degree of dermatitis with burning pain and itching.

Lithographers, lithotransfer workers, and engravers are subject to myopia. They also make use of various irritating acids, and the mortality from tuberculosis among them is high. The confining sedentary work leads to anemia and dyspepsia. Lithotransfer work involves considerable risk from lead poisoning.

Chemical Manufactures.—In the making of chemicals the workmen are exposed to varied hazards, the principal ones being elsewhere described under special metal poisonings, acid poisonings, etc. German statistics of the industries of production of chemicals show that eighty-eight per cent. of the men employed are injuriously affected in one way or another, including mainly irritations of the respiratory mucosa and skin.

Jewelry Industry.—The inhalation of metal dusts in this occupation constitutes a negligible hazard, for neither gold, silver, nor platinum dusts are toxic in any degree, moreover, these dusts are valuable and are usually well collected by a proper system of exhaust or aspirating ducts. The fumes of lead solder may, however, be inhaled and those of the stronger mineral acids used in coloring, gilding, and refining processes may prove injurious. Working with small bright pieces of metal as well as precious stones is trying to the eyes and William Stainsby who made an intensive investigation of nearly 3,000 jewelers in New Jersey found not a few who were finally obliged to abandon the trade on account of defective vision induced by it.

Tanning and Leather Dressing.—Workmen in these industries suffer from frequent colds, bronchitis, emphysema, and pneumonia. They are exposed to cold and wet in lifting bundles of hides into and out of the tanning vats, as well as to fumes of lime, turpentine, naphtha, and similar irritants used in curing, japanning, and dyeing leather. The writer met with a case of arsenical neuritis in a leather dresser, the arsenic being used in curing. The foul-smelling fumes derived from oil and fat in the skins often give rise to gastric catarrh. Various cutaneous lesions arise from contact with lime and tanning extract solutions, and muscular or skeletal deformities may be produced by faulty postures while at work, lifting heavy bundles of hides, etc. Tanners who handle imported raw hides or skins exceptionally may acquire anthrax infection. In England in five years there were eighty-six such cases reported of which twenty-one were fatal. A few cases occur in this country from time to time. Malignant pustule and lymphangitis may develop from handling infected hides.

Factory and Hand Shoemaking.—Shoemaking by machinery involves much subdivision of the industry. The scraping, trimming, and polishing of leather develop much organic dust mingled with that of dyestuffs and preservatives employed in tanning. Sitting at machines for hours in cramped positions may develop anemia and dysmenorrhea in the women workers, as well as vesical disorders. The "lasters" who make constant pressure over the abdomen may acquire visceroptosis. In polishing emery, sand, or glass, paper wheels are used, and in rivet making brass filings give rise to dust, all of which processes may give rise to bronchial irritation.

In hand shoemaking a typical postural deformity occurs with round shoulders, a flat chest and depression of the lower half of the sternum from pressure over the last. "Shoemaker's cramp" is a form of tetany of the hands and wrists, with changes in electric reactions. Frankel-Hochwart reported 179 such cases from Vienna. Constant peg hammering over the knee may give rise to fibrous swelling. Injuries to the soiled fingers may result in infection. The writer saw an Italian shoemaker who lost a finger thus infected.

Glovemaking implies maceration of the skins, the use of dyestuffs, and such powders as those of alum, pumice, and anilin. Thus chrome sores may occur as well as other forms of cutaneous irritation. Cases of plumbism have been reported from use of white lead, or Kremsen white, in making white gloves.

Button Making.—In making "pearl" buttons, round discs are punched out of iridescent muscle and clam shells, the edges of which must be smoothed on emery wheels, thereby evolving much dust which consists largely of calcium carbonate. Subsequent processes consist of drilling, polishing with chemicals, and buffing wheels. "Vegetable ivory" or the "ivory nut" grown in Colombia is also much used. Composition buttons are made with various mixtures of gums, amber, feldspar, silica, mica, calcium carbonate, celluloid, etc. Wood and bone are also used. Altogether this industry is one of the dustiest, and the girls and women employed suffer from rhinitis, conjunctivitis, bronchitis, and sometimes develop fibroid phthisis. Ludwig Teleky of Vienna found that among 150 button makers, more than one-third had pulmonary or bronchial disease. The latter may be of very purulent type. This investigator also described thirty-one cases of osteitis of the diaphyses of the long bones with periostitis, pain, soreness, and fever. Gussenbauer attributes this peculiar disease to conchiolin, an organic poison derived from the muscle shells. The buffing wheels being controlled by a foot pedal, its constant use may beget flat-foot.

Calico Printing.—This industry involves exposure to heat and humidity in dyeing and steaming processes, besides exposure to the effects of many chemicals including cyanides, quicklime, fuchsin, anilin, chlorine, chromates, arsenic, antimony, lead, and a number of the organic and inorganic acids. Shearing, brushing, and singeing over coke ovens are further processes which evolve much dust as well as the possibility of carbon monoxide poisoning from the coke fires. The hazards of the industry, besides a number of specific poisonings from the chemicals used, include rheumatism, bronchitis, anemia, gastrointestinal disorders, and a great variety of skin lesions. Fatal cases of anilin poisoning have been reported in the industry.

Lace Dressing involves bleaching, or dyeing and drying in rooms sometimes at a temperature as high as 140° F. The occupation is only hazardous through working in superheated rooms and going out into a cold atmosphere afterward.

Garment Workers.—An intensive investigation of this industry has lately been conducted in the writer's clinic in the Cornell University Medical College in New York City, and also in New York by W. Scherechewsky of the United States Public Health Service and by George M. Price. The hazards are mainly

those of dust inhalation, chronic gas poisoning from the use of gas stoves for heating irons, strains from posture in machine work, and neurasthenia from the strain of piece work and "speeding up" in the busy season. The various diseases found among the workers are due rather to defective hygiene than to any inherent harm in the industry itself, and consist mainly of anemia, digestive, menstrual, and neurasthenic disorders with a tendency to development of tuberculosis common to conditions of poor ventilation, overcrowding, and confining work. Of recent years, owing both to education and legislation controlling the "sweat-shop" evils, the hazards of the industry have been greatly reduced.

Laundresses who are exposed to wet and steam suffer from chronic rheumatism, bronchitis, constipation, dyspepsia, and dysmenorrhea. Chlorosis is common among the young girls employed in the heated machine ironing rooms. Among the older women flat-foot and varicose ulcers are not uncommon.

Slaughtering involves exposure to damp and cold, with consequent tendency to bronchial catarrh. Infected wounds are common from handling sharp knives, and Dr. Fordyce of New York has reported rare cases of localized tuberculosis of the fingers.

Canning.—This industry, being a seasonal one, involves irregular work under considerable pressure. Infected fingers are common from cuts acquired in peeling fruits and vegetables, and the men employed in soldering the cans are exposed to lead poisoning. The women occupied in the wash rooms often work for hours in wet skirts with the hands constantly immersed in cold water, from which conditions rheumatism and dysmenorrhea may result.

Bakers, grain and flour millers work in very dusty rooms. In entering the ovens bakers are exposed to great heat and to the inhalation of carbonic acid gas developed by the yeast fermentation, and the cheaper ovens may emit carbon monoxide gas as well. The hazards of the occupation, however, are mainly those of poor hygiene in general and can scarcely be rated as specific.

Miscellaneous Foodstuffs.—The preparation of mustard, peppers, and spices may give rise to rhinitis and conjunctival irritation. In making vinegar, fumes of acetic acid may cause nasal catarrh. In making starch sugar, sulphuric acid is used, the fumes of which are irritating. Tea testing occasionally gives rise to the nervousness and insomnia of theine poisoning, and the writer has met with functional glycosuria from chocolate tasting, in testing the quality of the product.

Telephone operators, owing to the extreme concentration of their work, are liable to neurasthenia, and cases of diminution of acuteness of hearing, vertigo, and middle-ear disease have occasionally been known to develop among them. In this country, however, owing to the excellent care taken of the more than 50,000 working girls and the admirable hygiene enforced by the telephone companies, very little serious illness of any kind results among them.

Barbers occasionally acquire eczema of the hands from the constant handling of hair-dyes and oils. They also are subject to flat-foot.

Gardeners are exposed to rheumatism and bronchial affections from working in cold damp ground, and from the careless handling of insecticides, arsenic poisoning has rarely been observed. Cases of tetanus from soil infection through abrasions of the skin have been reported. A variety of primrose (Primula obconica) grown in Holland and sometimes imported to this country may give rise to acute rhinitis when handled, and to violent urticaria or dermatitis resembling that caused by poison ivy (Rhus toxicodendron).

Blacksmiths and horseshoers who work over hot furnaces, like stokers are exposed to alternate overheating and chilling and sometimes in consequence develop chronic nephritis, chronic rheumatism, and bronchitis.

Drivers have long been rated as having an unhealthful occupation, and according to Arlidge, their tuberculosis mortality is rated at 359 as compared with 220 in other occupations combined. They often work in cold stables and are also exposed to inhalation of much street dust. Hence their work renders them liable to attacks of bronchitis, influenza, and pneumonia in somewhat unusual degree.

Firemen encounter the hazards of extreme heat, wetting, and cold in winter. They are subject to exceedingly irritating inhalations not only of hot smoke but frequently of such fumes as those of ammonia, burning rubber, and a variety of chemical substances which may be stored in warehouses. They suffer often from acute bronchitis, pneumonia, and pulmonary edema with immediate asphyxia.

The subject of treatment of the occupational diseases is elsewhere discussed in this work under the various titles. W. Gilman Thompson.

Ochee Spring.—Providence County, Rhode Island. Post-office.—Johnston.

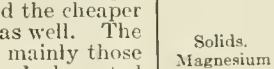
The Ochee Spring is not properly a health resort, although there are many visitors in pleasant weather. There are a number of springs in the neighborhood, but only one is improved at the present time. In the most severe droughts the water from the Ochee Spring bubbles up clear and sparkling. The following analysis was made by Prof. John H. Appleton, of Brown University:

One United State Gallon Contains:

Solids.	Grains.
Magnesium carbonate	1.13
Calcium carbonate	3.20
Calcium sulphate	0.44
Potassium sulphate	0.88
Sodium sulphate	0.41
Sodium chloride	0.57
Iron oxide and alumina	0.75
Insoluble mineral matter	0.58
Organic and volatile matter	0.97
Undetermined	0.15
Total	9.08

This water is pure and wholesome, and is said to act as a mild cathartic and diuretic when used continuously. It has been accorded a considerable reputation as an auxiliary in the treatment of kidney, liver, and stomach troubles. The water is used commercially. Emma E. Walker.

Ochronose.—In many cases of alcaptonuria the cartilages and bones may assume a brown or black color due to the presence of a substance, ochronose,



It is presumably closely related to the melanins and homogentisic acid. F. P. U.

Ochronosis.—This is a rare condition in which the cartilages (and sometimes other tissues, such as the loose connective tissues, smooth and striated muscle fibers, and epithelial cells) are found to have undergone a pathological pigmentation; in other words, it is a form of melanotic pigmentation. This pigmentation is supposed to be produced by a sub-

Table Giving Particulars of All the Reported Cases of Ochronosis.

Case.	Author and Reference.	Sex and Age.	Color of Skin.	Other Parts Colored.	Urine Color and Reactions.	Other Diseases.	Length of Illness.	Microscopical Details.
1	Virchow: Virchow's Archiv, 1866, Band xxvii., p. 212.	M., 67.	No description, presumably unaltered.	All cartilages.	Clear; no account of reaction.	Aneurysm, ascites, hydrothorax, and arthritis deformans.	?	Brown coloration of ground substance; granular pigmentation of cartilage cells.
2	Boström; Virchow's Festschrift, Band ii., 1891, p. 177.	F., 44.	No reference.	Cartilages ebony black; also spots on valves and endocardium of heart (brownish gray).	No reference.	Strangulated umbilical hernia.	?	Pigment generally distributed in ground substance or cartilages; granular in cells.
3	Hansemann: Berliner klinische Wochenschrift, 1892, Band xxix., p. 660.	M., 41.	No alteration.	Cartilages of ribs, sternoclaviculars, intervertebrals, etc., inky black.	Black; no reduction of copper; no homogentisic acid. *Not alkaptonuria* (Langstein).	General edema and aneurysm of the left ventricle.	18 years.	Details given in Langstein: Hofmeister's Beiträge, Band iv., p. 145, on Urine; also Zdarek: ibid., p. 378.
4	Heile: Virchow's Archiv, 1900, Band clx., p. 148.	F., 36.	No alteration.	Cartilages of ribs jet black; cartilages of larynx and trachea only colored in periphery.	No notes.	Peritonitis and ruptured tubal pregnancy.	?	Fine granular pigment in ground substance.
5	Ibid.	F., 62.	No alteration.	All cartilages.	No change.	Chronic ulcer of leg and mitral-valve disease.	Many years.	Same as above.
6	Hecker and Wolf: Festschrift des 50 Jahr. Best.d. Stadt Krankenhaus zu Dresden, 1899, p. 325.	M., 73.	A dun ash color, brownish in places.	Patch on sclerotics; all cartilages; dura mater in spots.	Brown, becoming black on standing; no sugar or albumin. *Not alkatonuria.*	General arteriosclerosis, softening of cerebellum, myocarditis, stenosis and inefficiency of aortic valves, arthritis deformans, and osteomalacia.	Melanuria 11 years.	General pigmentation of ground substance of cartilage; granular also in patches; granular in dura mater.
7	Albrecht: Zeitschrift für Heilkunde, 1902, Band xxiii., p. 366.	M., 47.	During life pale (*blass*). Post-mortem, no marked pigmentation.	Rib cartilages; chordæ tendineæ of the heart.	Dark, reduces copper; all reactions of alkaptonuria except homogentisic acid ? *Alkaptonuria.*	Pulmonary tubercle.	?	Microscopy nil.
8	Osler: The Lancet, Jan. 2, 1904. p. 10.	M., 57. Living.	Coal-black on the nose and cheeks; patches on sclerotics; ears blue black.	Spots on the back of the hands.	Clear when passed, becoming black on standing. *Alkaptonuria.*	Anemia; weak, irregular heart; and Heberden's nodules.	More than 10 years.	Still living (Jan., 1906).
9	Ibid.	M., 49. Brother of Case 8.	Normal; patches on sclerotics.	Ears showed blue black through the skin; no postmortem.	*Alkaptonuria.*	Died from pneumonia.	—	None.
10	Ogden: Zeitschrift für physiologische Chemie, 1895.	? Living.	—	Pearly gray inside concha.	*Alkaptonuria.*	?	?	
11	Pope: The Lancet, Jan. 6, 1906. p. 24.	F., 47.	Face brown; patches on sclerotics.	Rib cartilages blue black; ears blue; inside of lips black patches.	Black. *Not alkaptonuria or true melanuria.*	Chornic ulcer of leg, phthisis, and sclerosis of adrenals.	Five years.	Fine granular pigment in cartilages; pigment in the white elastic tissue in the skin but not in rete Malpighii.

TABLE GIVING PARTICULARS OF ALL THE REPORTED CASES OF OCHRONOSIS.—(*Continued.*)

Case.	Author and Reference.	Sex and Age.	Color of Skin.	Other Parts Colored.	Urine Color and Reactions.	Other Diseases.	Length of Illness.	Microscopical Details.
12	Pick: Case presented at Meeting of Berl. med. Society, Mar. 14, 1906. Dtsch. med. Wch. Vereinsbeil., No. 13, 1906, p. 524; Berl. klin Woch., No. 17, 1906.	F., 77.	Bronze-skin complexion. Not brown throughout, but partly bluish. Hands and ears steel blue. Brown spots in both palpebral fissures.	Pigmentation not limited to cartilages, but also found in heart-valves, vessels of lymph glands, etc. No special findings in other organs. Sole of the foot and toes free from pigmentation.	Urine free from albumin and sugar.	Chronic varicose veins of legs with ulceration. Thickening (mild elephantiasis) of feet. Chronic arthritic changes of fingers of both hands.	Discoloration of ears began 16 years ago. Change in face, eyes, and hands came on gradually in last 4 years.	Pigment not invariably diffuse, but also granular. Free from iron; soluble in alkali; related to melanins.
13	Poulsen. Beitr. z. path. Anat. u. z. allg. Path., 1910, xlviii., 346.	F., 63	Radial surface of forearm, a few small dark brown spots. Otherwise unaltered.	Scleræ, brown spots; concha, blue gray; tendons, black, especially at insertions; bones, brownish gray; joint capsules and ligaments, brownish black spotted and black; perichondrium, brownish black spotted; cartilages of air passages, brownish black spotted; intervertebral discs, coal black; costal cartilages, coal black; kidneys, black spots and streaks; heart and blood-vessels, black spots.	Alkaptonuria (?) (As patient was first examined by Poulsen at autopsy, diagnosis of alkaptonuria was made from history of periodic dark color of urine, darker on standing).	Arthritis deformans; uterine fibromata; diffuse lobar pneumonia; fibrous adhesive peritonitis; strangulated hernia; polypi of colon and rectum. (Death from pneumonia following operation for hernia.)	14 years.	The pigmentation in the ground substance and in the cells and their capsules varied in distribution, being brown or brownish yellow, diffuse or granular.
14	Ibid.	F., 63	Brownish around face and neck.	Scleræ, brown spots; cartilage of ears blue black; costal cartilages, black brown; joint cartilages, brownish yellow or smoke colored; intervertebral discs, brown or brown spotted; cartilages of air passages, especially trachea, brown.	Normal.	Leg ulcer, (treated with carbolic water); polypus (carcinoma?) of duodenum; multiple hepatic abscesses; fibrous peritonitis; fibrous perisplenitis; granular atrophy of kidney; double fibrous adhesive pleurisy; emphysaema of lungs; endocarditis.	21 years.	Ground substance of cartilages pigmented; cells and their capsules sometimes pigmented, sometimes not, and varying in degree when pigmented. Pigmentation diffuse.
15	Ibid.	F., 55	Skin dark, earth colored; lips, blue spots; thenar and hypothenar areas faintly blue.	Nose, blue; scleræ, brown spots; ears, steel blue.	Acid; murky; dark brown, becoming darker on standing. Contained phenol and its derivatives in large quantities. ("Carbolic urine.")	Leg ulcer, (treated with carbolic solution); syphilis in youth.	22 years.	Still living.
16	Ibid.	F., 56	Normal in color.	Nose, faintly blue; ear cartilages, blue-gray.	Alkaptonuria; occasional traces of albumin and indican; markedly acid, very dark sometimes gave a precipitate.	Arthritis deformans.	3 years (?)	Still living.

TABLE GIVING PARTICULARS OF ALL THE REPORTED CASES OF OCHRONOSIS.—(*Continued.*)

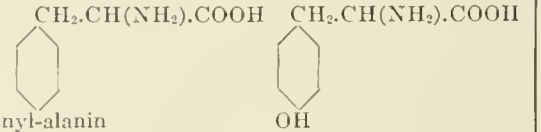
Case.	Author and Reference.	Sex and Age.	Color of Skin.	Other Parts Colored.	Urine Color and Reactions.	Other Diseases.	Length of Illness.	Microscopical Details.
17	Ibid.	M., 44	Normal in color.	Scleræ, brown spots; ear cartilages, grayish blue.	Yellow, not becoming darker on standing; acid; a little murky (urine examined in hospital, when patient was not being treated with carbolic solution).	Ulcer of leg (treated with carbolic solution); gout fever; stiffness of joints.	8 years.	Still living.
18	Ibid.	F., 49	Normal in color.	Scleræ, brown spots; cartilages of ears, blackish blue.	Alkaptonuria, (probably congenital).	Arthritis deformans.	25 years.	Still living.
19	Ibid.	M., 35	No abnormal pigmentation, except in axillæ and genito-femoral furrows (due to greenish perspiration).	Cartilages of ears blue gray.	Alkaptonuria.	Appendicitis.	15 years, or more.	Still living.
20	Ibid.	M., 68	Brown spots on face, back and hands; axillæ and genito-femoral furrows, bluish (from greenish-blue perspiration.)	Scleræ, brown-black spots; ear cartilages, bluish-black.	Alkaptonuria, (probably hereditary.)	Arthritis deformans; gout.	40 years.	Still living.
21	Ibid.	M., 61. (Brother of case 20.)	Skin, brownish.	Scleræ, diffuse brown with blue brown spots; ear cartilages, blue gray; nose, blue gray.	Alkaptonuria; always dark.	Arthritis deformans.	23 years (?)	Still living.
22	Wagner: Beitr. z. Kenntnis der Ochronose, Diss. Freiburg i. B. 1904. Über Ochronose, Z. f. kl. Med. Bd. 65, H. 1–2, 1908.	—	—	Scleræ, blackish gray; all cartilages examined, black as coal; tendons, brown or black; bones of cranium, brown spots; aorta, other large vessels, mitral valves, black spots; kidneys, black dots in cortex, brownish streaks in papillæ (pigment visible with naked eye); lungs, interstitial tissue, pigmented.	Alkaptonuria.	Arthritis deformans.	—	Ground substance and cells of rib cartilages, sometimes diffuse, sometimes granular.
23	Ibid.	—	—	Costal cartilages, black as ink; shoulder, hip- and knee-joints, blackish; intervertebral discs, black or gray; thyroid cartilage, black or grayish-black spots; perichondrium, faintly pigmented; cranial bones brown gray; heart and some of large vessels pigmented; kidneys, liver, spleen, slightly pigmented.	Alkaptonuria.	Arthritis deformans.	—	Same as 22.

Table Giving Particulars of All the Reported Cases of Ochronosis.—(*Continued.*)

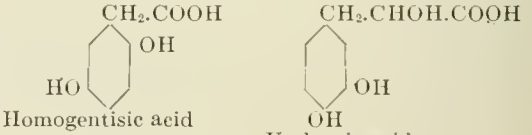
Case.	Author and Reference.	Sex and Age.	Color of Skin.	Other Parts Colored.	Urine Color and Reactions.	Other Diseases.	Length of Illness.	Microscopical Details.
24	Græffner: Demonstration von einem Ochronosiker, Berl. kl. W., H. 33, 1907. Ref. Berl. med. Ges.	—	Yellow brown.	Scleræ, black; tarsal cartilages, dark colored; nasal septum, grayish-blue streaks; ear cartilages, grayish blue.	Normal (?).	Ulcer of leg (treated with carbolic solution).	15 years.	Still living.
25	Gross and Allard: Untersuchungen über Alkaptonurie, Z. f. kl. Med. Bd. 64, H. 3–4, 1907. Alkaptonurie und Ochronose, Deutsche med. Wochenschr., 1908.	—	No visible pigmentation.	Ears, in life not pigmented; post-mortem, cartilages, black; nose, post-mortem, black; nails slightly pigmented; costal cartilages, black; larger joint cartilages, black; perichondrium, pigmented; tendons, at insertions, black, otherwise, smoke gray; hollow bones, brown; flat bones, dark brown; aorta, black spots; kidneys, only microscopic pigmentation; dentine of dental roots, ochre yellow.	Alcaptonuria.	Arthritis deformans.	—	Ground substance snd now and then cells of costal cartilages, diffuse pigment; bone tissue, diffuse pigment.

stance similar to, and very closely related to, melanin; and is said to be due to the action of the enzyme tyrosinase on tyrosin and phenyl-alanin. Ochronosis has also been observed after a prolonged administration of phenol, as well as in connection with disorders of the suprarenals. The ochronotic pigmentation may affect external parts, such as the hands, ears, sclera, skin of the face with inner surface of the lips, to a marked extent. These pigmentations constitute a clinical sign of ochronosis, so that the disease may be diagnosed during the life of the patient. The pigment may be excreted by the urine, which then becomes dark on being exposed to the air; in these cases pigmented casts may also be found in the urine. Such casts are considered by Pick as pathognomonic of ochronosis.

The question of the relation of ochronosis to alcaptonuria has been debated; but the two conditions are not necessarily associated, and either can occur without the other; Garrod thinks that alcaptonuria may be a cause, but not the only cause, of ochronosis. Still, the possibility of a relation between these two conditions (even if not a causal relation) must be allowed, particularly when we notice the constitution of uroleucic acid and homogentisic acid (to which alcaptonuria is due), and compare the same with the constitution of tyrosin and phenyl-alanin, which are supposed to be the causative factors of ochronosis.



Phenyl-alanin Tyrosin



Homogentisic acid Uroleucic acid

Nardi has studied the occurrence of beginning ochronosis in the cartilages, especially those of the knee, in normal adult individuals up to eighty-five years of age. Every one of these cases came to autopsy from other causes; and pigmentation was positively demonstrated in fifteen out of fifty cases.

Upon the basis of his investigations, Nardi (*Archivio di Biologia*, Florence, lix., 1905, 496) arrives at the following conclusions: (1) The articular cartilages of adults frequently present pigmentations, which are as a rule of hematogenous origin. (2) The ochronotic pigment, besides being found in the cartilages, was also in the intima of the arteries, where it existed in large amount and in diffuse form, because the conditions and circumstances favoring its deposit had been present for a long time. (3) The fatty degeneration of the cartilage cells cannot be regarded as a change which specially favors the deposit of the ochronotic pigment, although in a general way the fats are known to have a marked affinity for the pigments. (4) It is possible, by means of repeated injections of homogeneous blood into the joints of animals such as rabbits, to produce in the cartilages a pigment possessing all the properties of the ochronotic pigment.

A complete *résumé* of the cases and literature up to the present time will be found in the accompanying table, which is based on one published in the *Lancet* of

January 6, 1906 and on Poulsen's article in the *Beiträge zur pathologischen Anatomie und zur allgemeinen Pathologie*, 1910, xlviii, 346.

R. J. E. Scott.

Oconee White Sulphur Springs.—Hall County, Georgia. Post-office.—Gainesville. Hotel and cottages.

Location, six miles from Gainesville and two miles from White Sulphur Station, on the Southern Railroad. Automobile meets all trains.

This is one of the most attractive watering-places of the South. Situated in the foothills of the Blue Ridge Mountains, at an altitude of nearly 1300 feet, the air is pure and cool, and the resort is surrounded by charming walks and drives. Long before the war Southerners of wealth and fashion gathered there annually. Recently, many improvements have been made. The old buildings have been torn down and a large, well-appointed hotel and handsome cottages have been erected. The excellent and liberal management has kept the place popular, and it now numbers among its guests visitors from far and near. The hotel table is supplied from its own farms.

The following analysis of White Sulphur Spring water has been made by S. W. McCallie:

In Grams per U. S. Gallon.

Lithium chloride	Trace.
Potassium chloride	0.512
Sodium chloride	0.103
Sodium sulphate	0.229
Sodium phosphate	Trace
Sodium arsenate	Trace
Sodium carbonate	3.507
Magnesium carbonate	0.685
Calcium carbonate	2.333
Aluminum sulphate	0.078
Ferrous carbonate	0.135
Silica	1.283
Total solids	8.865
Free carbon dioxide	3.161

The spring is protected by cement walls and an attractive pavilion.

The waters are said to be valuable in rheumatic troubles, dyspepsia, and diseases of the blood. There are also bathing conveniences, including shower and plunge baths and a large swimming pool.

Various amusements are provided for the guests.

Emma E. Walker.

Odontoma.—This term has been applied in a general sense to a great variety of tumors arising in connection with the teeth—from the tooth follicle, the dentine, the cement, the enamel, the tissue about the tooth, or from the tooth structure as a whole. Different names have been applied to these growths by various authors, and at present the classification of these tumors is in a confused state. The majority of the observations are rather old, very little study having been made recently of this subject. By most writers the term *odontoma* is limited to those growths which arise at an early period of development of the tooth before the formation of the dentine. Those developing during later life from the dentine, cement, or enamel of the mature tooth are classed as *odontinoids*. These are further divided into *dentinoids*, arising from the dentine; *emailloids*, arising from the enamel; *dental osteoma*, arising from the cement.

The *true odontomata* are rare; they arise from a complete tooth germ, and for the greater part form soft growths corresponding to the stage of development of the tooth, and presenting such varied appearances as to justify the diagnosis of myxoma, cystoma, sarcoma, or fibroma. Dentine may develop later in the tumor, the growth becoming hard, and, after complete dentification, being stationary in development. Enamel structures also are found in the odontoma, and the early stages of this neoplasm correspond to those of the adamantinoma, but the differentiation proceeds farther. Odontoblasts appear and these may eventually form calcifying dentine; emailloblasts occur and form enamel, while in the final stage of development cement is formed. Since no papilla projects into the tooth germ epithelial body, the various lamellæ are formed in a reverse order to that of the normal. Odontomata are found most frequently in the lower jaw, in the region of the molars, particularly near the angle of the jaw. They arise either as independent neoplasms or as atypical appendages to the molars. Very commonly a misplaced molar is found beneath the odontoma, so that the latter may be interpreted as a disturbance of development of a tooth germ giving rise to a neoplastic growth preventing the eruption of the posterior molar. Occasionally odontomata may reach such a size as to cause erosion of the jaw bone. They may be single or multiple. They are usually irregular or nodular; after dentification they resemble dentine in structure. The *odontinoids* are usually very small and unimportant excrescences of the teeth, which are more of the nature of inflammatory hyperplasias (*exostoses*) than of true tumors, and are found in pathological conditions of the teeth, particularly in association with diseased roots. *Dentinoids* are very common in the premolars and molars as disturbances of development, appearing as small masses of atypical dentine in the pulp tissue of the root canals, and probably arise from misplaced odontoblasts rather than originating in inflammatory processes. In caries of the teeth there may arise from the exposed pulp masses of granulation tissue of a polypoid character, the so-called *pulp-polyps* or *pulp-granulomata*.

Closely related to the odontoma is the *adamantinoma* or *adenoma adamantinum* arising from *rests* of the enamel organ. They form solid epithelial tumors located centrally in the jaw bone, but also occur as rare teratoid tumors in the pharyngeal vault or in the base of the skull, particularly in the hypophysis region. The microscopic picture is that of a branching network of epithelial cords and masses, the center of the latter being formed of stellate cells resembling the enamel organ. Intercellular processes are usually very well defined ("prickle cells"). In the center of the cell masses atypical enamel is developed, and calcification may occur. Through liquefaction of the central cell masses and dilatation of the spaces, *multilocular cystomata* are sometimes developed. The adamantinoma may also undergo carcinomatous change (*adamantinocarcinoma*).

The *cystic tumors* found in the jaw are sometimes included with the odontomata, but by other writers are placed in a class by themselves. Three forms of these cysts occur: *follicular* and *periosteal cysts* and the *multilocular cystoma*. The *follicular cysts* appear usually as monolocular, rarely multilocular, cysts, having a wall lined by squamous or cylindrical epithelium. With the exception of those arising from the wisdom teeth they develop at an early age, often becoming manifest during the second dentition, and grow slowly, taking several years to reach an important size. They arise from the cystic degeneration of a normal tooth follicle, or from supernumerary follicles or anlage. In the cyst cavities there are occasionally found one or more imperfectly developed teeth. The crowns of these teeth are directed toward the cyst cavity. The contents of the cyst are usually serous, slightly brownish, and usually rich in cholesterin crystals. At the location of the cyst there is usually an absence of the corresponding tooth, which speaks for the origin of the cyst from a misplaced and imperfectly developed tooth anlage, the epithelial sheath becoming developed

into a cyst. The *periostcal cysts* arise chiefly as a result of chronic inflammatory processes affecting the roots; they are termed accordingly *peridental, periodontal, subperiosteal,* or *root cysts.* A portion of these formations arise from collections of pus beneath the periosteum; others take their origin from granulation tissue growing about the roots. The inner side of the granuloma is lined with epithelium derived from the remains of the epithelium of the cement. The granulation tissue may become converted into a firm fibrous capsule forming the cyst wall, the root of the tooth projecting into the cavity of the cyst. Proliferation of the epithelium lining the cyst may lead to appearances similar to those of dermoid cysts. More frequently the cysts contain a clear, mucoid, or thick brown fluid. They occur most frequently in the upper jaw. Carcinoma may take its rise from the epithelium of the cyst wall. The *multilocular cystomata* of the jaw are very rare tumors, taking their rise from the follicle, epithelial proliferations from the follicle forming alveolar or gland-like structures which become cystic. The cyst walls are usually very thin. The growths may reach a large size, and cause great destruction of the jaw bone. Though seldom becoming carcinomatous, the cysts cause great enlargement and atrophy of the bone, the bony layer over the cysts being sometimes as thin as paper, or in other cases the bone may entirely disappear, leaving the cyst covered only by periosteum.

Sutton ("Tumors Innocent and Malignant") defines the odontoma as a tumor composed of dental tissues in varying proportions and different stages of development, arising from tooth germs or from teeth still in the process of growth. He classes them, according to the part of the tooth germ concerned in their formation, as follows: (1) *Epithelial Odontoma,* from the enamel organ; (2) *Follicular Odontoma;* (3) *Fibrous Odontoma;* (4) *Cementoma;* (5) *Compound Follicular Odontoma,* all from the tooth follicle; (6) *Radicular Odontoma,* from the papilla; (7) *Composite Odontoma* from the whole germ. For a description of these varieties and for illustrations of cases the reader is referred to this work.

ALDRED SCOTT WARTHIN.

O'Dwyer, Joseph.—Born at Cleveland, Ohio, on Oct. 12, 1841. His early life was spent in Canada and he was graduated in arts from McGill University in Montreal. He then went to New York where he studied medicine, receiving his doctor's degree from the College of Physicians and Surgeons in that city. For a number of years he was an inspector of the Board of Health, and during his service he saw a great deal of such diseases as Asiatic cholera, typhoid fever, diphtheria, etc. In 1882 he settled in New York City as a general practitioner, but devoted himself mainly to diseases of children. In the same year he made his first experiments in the introduction of tubes into the larynx in cases of diphtheria ("intubation"). At first, these attempts were not very successful, but he accomplished one thing of decided importance: he demonstrated the fact that the larynx can tolerate for hours at a time the presence of a tube sufficiently large to permit the passage of both air and mucus. In the course of the following three years he effected material improvements in intubation, thus rendering it an acceptable adjunct to the methods of treatment universally employed in diphtheria. He died on Jan. 7, 1898. A. H. B.

Oertel, Max Joseph.—Born at Dillingen, in Bavaria, on March 20, 1835. He studied medicine in Munich and received his doctor's degree in 1863. For four years he was one of Prof. Pfeuffer's clinical assistants; and then he took lessons from Johann Nepomuk Czermak of Prague in the use of the laryngoscope. After which he gave systematic instruction in Munich in this special department. In 1876 he was made Professor Extraordinary of Laryngology, a position which he held up to the time of his death on July 19, 1897.

Oertel was the first person to give instruction in laryngoscopy in southern Germany; and, both by his teaching and by his numerous contributions to current medical literature, he did his full share toward strengthening and building up this special department of medical knowledge. Of his published writings on laryngological topics the following deserve to receive special mention: "Ueber Geschwülste im Kehlkopf, etc.," 1868; "Ueber Diphtherie," in von Ziemssen's Cyclopedia of the Practice of Medicine," vol. ii., 1875; and "Ueber den laryngologischen Unterricht," Leipzig, 1878.

In 1884 Oertel published a book ("Therapie der Kreislaufstörungen," etc.) which brought him a great deal of well-deserved celebrity, and which showed that he was by no means a narrow-minded specialist. In this treatise he expounded, for the first time, in a scientific and thorough fashion, the method of treating certain fatty and other affections of the heart by dietetic measures, by carefully graded physical exercise, etc.; and he further emphasized the importance of this method by publishing a small popular treatise that bore the title: "Terraincurorte." Pagel, from whose biographical sketch of Oertel, the present account is derived, speaks of the latter's handling of this subject as marking an important period in the history of medicine. A. H. B.

Œsophagostomum.—A genus of round worms in which the mouth is small and surrounded by six papillæ. In East Africa *Œ. brumpti* has been found in cysts in the colon. See *Nematoda.* A. S. P.

Œstridæ.—The family containing the botflies and warbles. The larvæ live parasitically in various parts of the body, such as the stomach (horse), subcutaneous tissue (cow), and nasal sinus (sheep). There are on record many cases of the occurrence of these larvæ as occasional parasites of man. See *Insects, parasitic.* A. S. P.

Œstrus.—A genus of botflies. The larva of *Œ. ovis* is the sheep botfly, or head maggot. It is found in all parts of the world. The flies deposit living maggots which when in man cause frontal headaches, nasal or throat catarrh, sometimes even blindness. See *Insects, parasitic.* A. S. P.

Oils.—An oil is an organic substance which is unctuous to the touch and which when dropped on glazed paper renders it translucent. Oils are mixtures and may be derived from mineral, vegetable, or animal sources. *Mineral* oils are mixtures of hydrocarbons, such as petroleum. *Vegetable* oils are derived from various parts of plants; some from the stem, some from the seeds, some from the flowers, and some from the leaves. *Vegetable* oils are often classified as: (1) *non-drying* or *greasy* oils, which remain liquid and greasy on exposure to the air (such as olive oil); and (2) *drying* oils which dry and become hard on exposure to the air (such as oil of turpentine). This difference of behavior on exposure to air is due to the fact that oil of turpentine is an unsaturated organic compound and is thus capable of taking up oxygen from the air, while olive oil does not combine with the atmospheric oxygen.

Oils may be classified as (1) *volatile*, *ethereal*, or *essential* oils; and (2) *non-volatile*, or *fixed* oils. Some of the non-volatile oils are derived from the vegetable kingdom and some from the animal kingdom. The chief medicinal oils will be found in the article Olea.

R. J. E. Scott.

Ojai Valley, Southern California.—This little valley, said to be one of the most beautiful spots in Southern California, is situated in Ventura County, about sixty miles northwest of Los Angeles, and about fifteen miles from the coast. It has an average elevation of from 900 to 1,200 feet, the upper part of the valley being the highest.

It is from six to eight miles in length, and from two to four miles wide. It is "entirely surrounded by the San Rafael and Santa Inez ranges, which rise on the east to a height of 6,000 feet. It is thus well sheltered from harsh winds and partly also from the sea fogs" (Solly).

Nordhoff is the principal town with a population of eight hundred or more, and is the terminus of a branch railroad from San Buena Ventura. The soil consists of gravel and loam with a subsoil of clay. The upper Ojai is noted for its orchards, while the lower Ojai is devoted to beans and grain. Fruits of various kinds also thrive here. The opportunities for camping and shooting are abundant, deer, quail, and other small game being plentiful. The horseback rides are very attractive in this "country of beautiful views."

The following table, compiled from data given by Solly ("Medical Climatology"), will indicate the character of the climate:

Climate of Ojai Valley, Taken at or Near Nordhoff.

	Jan.	Feb.	March.	April	May	Dec.	Winter	Spring	Year.
Temperature for 1892.							1893	1893	1893
Average (degrees F.) mean	52°	53°	54°	56°	62°	50°	51°	54°	58°
							1895	1895	1895
Average mean	...	...	...	...	...	...	52	57	
Maximum for 1892	78	79	85	82	100	77	85	95	
Minimum for 1892	27	...	28	31	34	25	26	32	
Humidity: Mean relative (January and February)	...	...	...	...	...	...	66%	65%	
Fogs, mornings	...	...	...	...	...	...	4	28	
Rainfall, inches	...	...	...	...	...	...	12.82	9.23	27.84
Rainy days	...	...	...	...	...	...	14	8	

During the year 1894 there were over 300 bright sunny days.

The climate, it will be seen, is a very mild, equable one in the winter and spring with a comparatively dry air, and slight rainfall: There are occasional high winds with sand storms, in brief, it represents the well-known characteristics of the Southern California climate for resorts situated some distance from the sea, and, in addition, the modifications produced by the peculiar situation of the valley, shut in as it is by mountains. It is to be borne in mind, however, that the summers are hot, the average temperature ranging from 90° F. to 95° F.

This climate is said to be especially favorable for asthmatics, and is also to be recommended for cases of pulmonary tuberculosis, chronic bronchitis, chronic diarrhea, and nephritis.

The accommodations are only moderate. According to Solly there are pleasant boarding-houses and cottages. Such a locality as the Ojai Valley is rather suited to those who are well enough to take up a permanent residence there, and occupy themselves with the various pursuits of an outdoor life.

Edward O. Otis.

Ojo Caliente.—Taos County, New Mexico.

Post-Office.—Ojo Caliente. Hotel.

Access.—Take Denver and Rio Grande Railroad to Barranca Station; thence eleven miles by stage to springs.

These celebrated hot springs are located at an elevation of about a mile above the sea level in the region of the ancient cliff dwellers, twenty-five miles west of Taos and fifty miles north of Santa Fé. There is now a commodious hotel at the resort. The surrounding country is broken and mountainous, and the climate of the usual delightful New Mexico variety. The hottest summer day recorded at the springs in recent times was 93° F., and the coldest winter day 20° F. The resort is kept open all the year round. The springs are fifteen in number, and vary in temperature from 90° F. to 122° F. Their flow has not been measured, but it is estimated by Anthony F. Joseph, the proprietor, at about 4200 gallons hourly.

An analysis of these waters shows a total of 288.09 parts in 100,000 divided as follows:

Sodium carbonate	196.95
Iron carbonate	20.12
Arsenic	10.08
Magnesium carbonate	6.10
Silicic acid	4.10
Calcium carbonate	4.20
Sodium chloride	40.03
Lithium carbonate	1.22
Potassium sulphate	5.29

Hypothetical combinations, parts in 1,000,000 of the waters of the Thermal Spring (New Spring) at Ojo Caliente:

Lithium chloride	20.9
Potassium chloride	59.9
Sodium chloride	305.5
Potassium iodide	Trace?
Sodium arsenate	Trace.
Sodium borate	5.4
Sodium nitrate	Trace.
Sodium sulphate	223.3
Sodium carbonate	1846.9
Ammonium carbonate	Trace.
Calcium phosphate	0 3
Calcium fluoride	10.7
Calcium carbonate	43.0
Strontium carbonate	2.4
Barium carbonate	Trace.
Magnesium carbonate	33.2
Silica	60.2
Iron oxide	1.6
Alumina	0.5
Carbon dioxide	775.6
	3389.4

The waters here have a great reputation in the treatment of advanced syphilis, chronic induration of the lymphatic glands, gout, rheumatism, neuralgia, malaria, mercurial poisoning, Bright's disease, scrofula, catarrh, diseases of women, eczema, locomotor ataxia, and paralysis.

Emma E. Walker.

Old Age.—Introduction.—The day is past when old age was looked upon as a pathological state of maturity, when the term was accepted as a diagnosis and a cause for death. There are discomforts associated with advanced life as there are discomforts associated with childhood, but no one would consider the debility of the child, its inability to speak,

to walk, to reason, to chew meat, diseases. These conditions are natural, normal, physiological at that period of life, though unnatural, abnormal, pathological, later. In like manner we must look upon the infirmities and debilities that accompany old age. If we look upon senility as a physiological entity in the same manner as we look upon childhood we will realize that many of the conditions that are now treated as diseases are pathological only when compared with the physiological state of maturity. Occurring in the aged they are normal and physiological, they cannot be prevented or removed, although some of the discomforts associated with them can be relieved. Functions may be stimulated but excessive stimulation of a degenerating organ hastens its degeneration. Disease in the aged is a pathological process in a normally degenerating organ or tissue, not such a process as occurs in maturity complicated by degenerations. The cure of a disease in the aged is a return to the norm of senility, not a return to the normal state of maturity. These are the underlying principles of geriatrics, the branch of medicine dealing with old age and its diseases.

Ageing.—The essential factor in ageing is a progressive degeneration of the tissues with gradually diminishing functional capacity, the functions maintaining harmonious relations with each other. In the process of ageing the intellectual faculties become weaker, muscle tonicity and nervous activity diminish, breathing becomes slower and more shallow, the heart reaches the limit of its functional capacity and then breaks down, assimilation becomes more difficult, elimination is diminished, the whole organism wastes and becomes enfeebled until there is complete cessation of functional activity in physiological death. This is, however, very rare. Death in the aged is usually due to some pathological process in one or more organs while other organs and tissues are still able to carry on their functions.

The normal cycle of life can be divided into three periods, development, maturity, and decline. The first is fairly regular in length, the heart, lungs, and brain reaching their maximum growth about the thirtieth year. It is probable that skeletal growth would continue to about the thirtieth year if the compression of the intervertebral discs through the weight of the body when in the erect position, did not cause spinal curves. Where this compression is removed as in bedridden patients there is an increase in length between the twentieth and thirtieth year and even later. The period of development is broken about the middle by a critical period called puberty.

The period of maturity should last about thirty years and a person in good health who has not hastened this period through "fast" living, does not present subjective or objective manifestations of ageing before the close of the sixth decade. There are many circumstances beside disease which may hasten this period or cause local degenerations similar to the senile degenerations. The smoke and dust-laden atmosphere of manufacturing cities causes a more rapid pneumonoconiosis with impaired aeration and pulmonary degeneration, than the clearer atmosphere of the seashore, the mountains, and the country. Intense commercial activity causes more rapid cerebral and cardiac breakdown. Insufficient sleep prevents complete repair. Perversions in feeding, irrational recreations, unhygienic surroundings, neglect of the person, all hasten or shorten the period of maturity and leave foci for disease or more rapid degeneration of tissue. If such causes for precocious senility can be avoided the usual manifestations of ageing do not appear until about the sixtieth year. The period of maturity is broken about the middle by a critical period called the menopause in the female and the critical period in the male. The period of decline should last about as long as each of the other two periods and in the normally ageing individual there is a critical period analogous to the critical periods in maturity and development, about the seventieth or seventy-fifth year. This senile climacteric is followed by a general breakdown. There are many notable exceptions, notable only because they are exceptions. There are rare instances of abnormal length of life. These are comparable to the rare instances of giants in growth.

Causes of Ageing.—Numerous theories have been advanced to account for ageing but none is free from unanswerable objections. The principal theories will be given briefly.

The *wear and tear* or *mechanical* theory assumes that the body wears out like old machinery. This is clearly untenable as the waste and repair through metabolic activity is totally unlike the wear from friction and exposure and mechanical repair.

The *histopathologieal* theory of Demange assumes that the constant friction of the blood against the endothelium of the vasa vasorum in time irritates and inflames these fine vessels, the endothelial cells swell whereby the caliber of the vessels becomes diminished, less blood flows through them and the main vessels being insufficiently nourished, degenerate. The tonicity of the vessels being impaired the blood current is slowed, the tissues receive insufficient nutrition and they degenerate.

The *histomechanical* theory of Thoma assumes that the ceaseless activity of the heart and blood-vessels gradually weakens the elastic fibers of the vessels and they lose their tonicity. The vessels dilate and the current is slowed, the tissues are insufficiently nourished and they degenerate.

The *autointoxication* theory of Metchnikoff assumes that toxic products of intestinal decomposition are absorbed from the intestines, these toxins irritate the lining membrane of the blood-vessels causing inflammation and degeneration and they also cause degeneration of the tissues.

Metchnikoff's *phagocyte* theory, based upon his discovery of neurophags which destroy brain tissue, assumes that phagocytes destroy certain tissues faster than they can be repaired.

Defective elimination theory assumes that the leucomaines and other waste products of metabolism are not completely eliminated, they are stored, and being carried in the blood, act as toxins, causing degeneration of the blood-vessels and tissues.

Theory of *unstable metabolism* assumes that there is a constant change in the salt content of the blood, that abnormal diosmosis is thereby caused and the circulation is interfered with.

Husnot's theory assumes that there is hyperactivity of the suprarenal glands causing arteriosclerosis and consequent tissue degeneration.

Horsley's theory assumes that ageing is due to degeneration of the thyroid gland. This theory is based upon the fancied similarity between myxedema and senility. It does not explain the cause of the degeneration of the thyroid.

Lorand's theory is similar to Horsley's theory but Lorand includes other ductless glands.

Naunyn's *inherent repair defect* theory assumes that there is an inherent defect in the organism to repair waste in tissues while waste is going on. This applies especially to the blood-vessels in which there is ceaseless activity and in which in course of time there is diminished tonicity which the organism cannot repair. This is a complement to Thoma's theory.

Weakened heat regulation theory, also advanced by Naunyn, assumes that the heat-regulating centers gradually become weakened. In maturity the surface loss of heat causes internal loss of heat which is restored through increased muscular activity, this causing waste which is replaced by food furnishing

material for combustion and repair. As the heat-regulating centers become weakened the loss of heat does not arouse the same stimulus for muscular activity, less food is taken, a lower body temperature makes metabolism more difficult, repair is imperfect, and tissues degenerate and waste.

Durand-Fardel's theory assumed that there was a vital principle in the living organism which had a limited duration. He believed that in animal as in some forms of plant life when the organism had completed its purpose in the plan of nature to reproduce the species there was no further object in its perpetuation and heteroplastic processes took the place of the former anabolic processes, this leading to such functional changes that the harmonious relations between the functions were interfered with and finally ceased.

Muhlmann's theory assumed that every living tissue in its growth creates conditions which interfere with its nutrition.

Canstatt's cell theory, the first theory of senescence which ascribed the senile change to a change in the cells, assumed that cells had a definite period of existence and their death was so much molecular death which was not replaced. An elaboration of this theory has recently been advanced by *Boy-Teissier*.

Minot's cell theory assumes nutritional changes in the cells whereby the protoplasm is increased and the nucleus shrinks. As the nucleus governs the growth and regeneration of the cell its degeneration interferes with the regeneration of new cells.

Nascher's cell theory assumes that there is a constant evolution in cell life; that newer cells differ from their predecessors; that at one stage of this evolution the cells are in the most perfect condition for their purpose in the organism; that the tissues which they form are then best adapted for their functions; that later cells are less perfectly fitted for their purpose and they reproduce cells still more imperfect; that fewer and more imperfect cells are thus produced and finally the cells are so poorly fitted for their purpose that the tissues which they form can no longer carry on their functions.

Defective aeration theory assumes that the constant inhalation of dust which is not entirely expelled by coughing and expectoration, causes a pneumonoconiosis which in time interferes with the free access of air to the lungs, and the blood is consequently imperfectly aerated. Its carrying capacity of nutrition to the tissues and waste from the tissues is lessened and tissues degenerate. This is accepted as a contributing cause of ageing but not as the basic cause.

Any of the many causes for arteriosclerosis, atheroma, cardiac hypertrophy, autointoxication, indeed anything which tends to depress the organism, reduce its vital resistance, or interfere with the circulation or metabolism may be a contributing cause of senescence. It is probable that many of the factors advanced as basic causes are really contributing causes. It may be that several conditions are capable of producing the senile changes or that several conditions are necessary to initiate or continue the processes. Deficient nutrition and impaired pabulum will cause degeneration of tissue, but tissue starvation in earlier life can usually be overcome while the tissue starvation of senescence is permanent and progressive. The absolute idiot shows the same senile changes as occur in the normal individual. It is evident that these changes do not depend upon metabolic activity nor upon the nutritive medium but upon some property of the tissue itself. The theory of tissue cell evolution offers a rational explanation for the senile changes and the diversity in time, extent, location, and character of such changes.

Normal Senile Changes.—The process of senescence causes anatomical and physiological changes in every organ and tissue of the body but there is no regularity in order, time, extent, or rate of such changes, the changes are not always the same in the same tissues nor does the extent of the anatomical changes and the functional impairment always correspond. Walsh of Philadelphia has demonstrated that there is a progressive increase in connective-tissue fibers between the apices of the pyramids of the kidney beginning at birth and this increase continues throughout life. The infant inhales dust with the first breath and lays the foundation for the senile pneumonoconiosis and emphysema, the extent of which will depend upon the character and amount of dust in the air. Excessive muscular activity in youth causes cardiac hypertrophy, the blood sent with greater force through the blood-vessels causes earlier and more rapid loss of tonicity of the vessels with earlier arteriosclerosis and general tissue degeneration. Inactive voluntary muscle fiber undergoes fatty degeneration while active voluntary muscle fibers waste. Glandular structures waste through atrophy of glandular substance while hyperplastic fibrous tissue compresses the gland cells and sometimes the blood-vessels as well, thereby depriving the gland of nutrition. The secretions are generally diminished and sometimes altered in character. While the general tendency of the senile processes is to cause atrophy, diminished secretions, and lessened functional activity, there are some marked exceptions to this rule. The prostate gland is more often hypertrophied than atrophied, hypertrichosis is quite common, bromidrosis is frequently found in the aged, cardiac hypertrophy is the rule, and there is probably a hyperactivity of the adrenals and of the lymphatic system. The hypertrophy of the heart is a compensatory condition to overcome the increased resistance when the caliber of the blood-vessels is diminished or to overcome the lessened elasticity of the vessels when the tonicity of the muscular fibers is lost. The cavities become equally enlarged, the aortic orifice is usually dilated through the dilatation of the aorta, the valves become thin and flabby and later they shrivel or are bound down. Diminished nutrition through degenerated coronaries causes myofibrosis with weakening of the force of the heart. As the tonicity of the vessels diminishes and their caliber decreases the heart must exert greater force to maintain the circulation and when the limit of its functional capacity is reached the next effort causes loss of tonicity of the heart muscle, the organ dilates and compensation is lost. In rare cases there is no hypertrophy, hyperplastic fibrous tissue compresses the heart, it becomes smaller, denser, harder, and darker and the condition of brown atrophy is produced. This is a true senile degeneration.

The changes in the arteries are atheroma, fibrosis, and calcification. Atheroma is a fatty degeneration which later undergoes calcification. It is a question whether atheroma is really a senile degeneration or a pathological condition due to endothelial irritation. This irritation may be produced by deleterious matter carried in the blood in autointoxication, and if we accept the autointoxication theory of senescence we must accept atheroma as a senile degeneration. In most senile cases there is loss of tonicity of the muscular fibers, these waste and are replaced by connective-tissue fibers, there is later a hyperplasia of this fibrous tissue and degeneration of the endothelial coat. The loss of tonicity permits a dilatation of the vessel; this is later overcome by the increase in connective tissue and thickening of the endothelial cells. The flow of blood through the contracted vessels is diminished and the tissues are insufficiently nourished.

The endothelial walls of the capillaries and the vasa vasorum degenerate, they become thickened, the caliber of these fine vessels is lessened and a smaller amount of blood passes through them. Veins become dilated through loss of elastic fibers, and they

become overdistended with a slowly flowing current. This condition of venosity is most marked in the lower limbs.

In the blood no change in composition has been demonstrated except a diminution in the watery element and a consequent relative increase in the salt content. The blood in old age is denser and more viscid and it coagulates more readily. When we consider that aeration is imperfect owing to the changes in the lungs, that there are profound changes in the spleen and marrow which would affect the production of blood cells, that the elimination of waste products is diminished and that an excess of such waste products of metabolism as well as reabsorbed products of intestinal decomposition are carried in the blood, we must assume that there are blood changes that neither the microscope nor the test-tube has so far revealed.

The lungs in the aged are atrophied. Owing to the constant inhalation of dust the lung is darker and heavier than in maturity, the bronchioles and air vesicles contain dust deposits, which diminish the aerating surface of the lungs, the walls of the air vesicles become thin and finally break, adjoining vesicles coalesce producing senile emphysema. The amount of CO_2 expired, which in maturity is about 1,340 cubic inches per hour, falls to about 1,000 cubic inches at 60 and may fall to 700 cubic inches in extreme old age. In extreme old age when the atrophy is very great, the lungs lie close to the vertebral column, the upper lobes sink and lie in front of the lower lobes, and sometimes the lower right lobe overlaps the upper lobe posteriorly. The pleura becomes dry, lusterless, opaque, and adherent.

The upper part of the bronchi and the trachea become rigid and are sometimes covered with calcareous incrustations.

The stomach becomes dilated through atony and waste of the muscular fibers, the mucous membrane becomes thin and pale, the glands atrophy and the secretions diminish, the amount of hydrochloric acid is considerably lessened and there is probably some change in the character of the gastric juices. There is generally a gastroptosis. Gastric digestion is slow, food sometimes remaining from five to eight hours in the stomach without producing distress. There is sometimes atony of the pyloric sphincter. In the intestines there is atony due to waste of muscle fiber, the small intestines become thin, the villi atrophy, the valvulæ conniventes become smoothed out and the intestinal secretions are diminished. The large intestines dilate and the descending colon may form a pouch. As a result of these changes the aged are usually constipated or if they have a daily stool the feces contain the débris of food taken two or three days before. The feces are generally dry, dark, small in amount and while containing a large proportion of decomposing or decomposed matter it has little of the decomposition odor. Glandular organs generally atrophy. The liver becomes harder, paler, the cells are smaller, there is a proliferation of connective-tissue fibers, the surface becomes granular and the capsule becomes cloudy and adherent to the organ. In cases where there is impeded circulation or weakened heart action there is passive congestion of the liver and the organ becomes dark. The gall-bladder is generally thickened and filled with a thick, heavy bile containing a larger proportion of cholesterin than in maturity. Cholesterin stones are quite frequently found upon autopsy, which gave no evidence of their existence during life. The gall duct is thickened and the amount of bile is diminished.

The spleen is greatly atrophied the waste being greater than in any other organ. The hyperplastic fibers not alone compress the gland cells, they frequently compress blood-vessels, depriving large portions of the organ of nutrition.

The pancreas undergoes changes similar to the changes in other glandular organs but in some cases the pancreas undergoes fatty degeneration without diminution in size. The kidneys atrophy, become hard, pale, granular, the glomeruli, loops, and tubes atrophy and become sclerosed, the parenchyma is compressed by bands of fibrous tissue, and the organ presents the appearance of the kidney in interstitial nephritis. In the normal senile kidney the increase in connective tissue is uniform; in the nephritic condition the increase is in those portions undergoing pathological degeneration. Failure to differentiate between the senile contracted kidney in which the fibrous hyperplasia is general and the nephritic kidney in which it is scattered or localized, is responsible for the frequent reports of findings of interstitial nephritis at autopsies in cases which gave no evidence of the disease during life. The ureters undergo fibrosis and become stiff and dilated. The changes in the bladder are atrophy and dilatation due to waste of muscular fibers with proliferation of connective-tissue fibers, these forming bands in the walls of the organ. The thinner walls bulge out between these bands forming pockets in which small quantities of urine accumulate. Late in life these bands contract, diminishing the capacity of the organ. The mucous membrane atrophies and the glands waste, the sphincter muscle loses its tone and permits dribbling while in about one-third of all males the prostate becomes enlarged causing partial retention of urine. The changes in the bladder and prostate are among the most frequent and the most annoying of all the changes due to ageing.

The prostate is hypertrophied in about one-third and atrophied in about ten per cent. of all cases. In some cases this hypertrophy is due to fatty infiltration, in some there are fibrous tumors in the gland, sometimes there is an increase in glandular substance, occasionally there is an increase in the muscular tissue. No satisfactory explanation has been given for this anomaly in senile involution.

The urine in old age is generally diminished in amount, the salts are diminished, the urea content is considerably reduced, the calcium elimination is diminished and the urine generally contains a large amount of indican.

The brain atrophies and degenerates. The waste is confined to the cerebrum, mainly to the cortex. The brain becomes denser, darker, the pia mater is thickened, there is an increase of fluid and a decrease of fat, the connective-tissue fibers are increased and the cortex frequently contains amyloid bodies. The cells atrophy and the nerve fibers become thin. Atheromatous changes in the blood-vessels are found more frequently in the brain than in any other organ and in many cases there are spots of miliary aneurysm causing softening.

The cord undergoes changes similar to the brain. There is a general decrease in volume of nervous tissue, waste of ganglionic cells with deposit of pigment granules, an increase of cerebrospinal fluid, thickening of the meninges and occasionally there are amyloid bodies around the central canal. The atheromatous arteries appear beaded and a zone of sclerosis sometimes presses upon the cord or nerves causing waste at the point of compression, with functional impairment of the part supplied. The changes in the nerves are similar to the changes in the cord but they appear late and proceed slowly. In the peripheral nerves parenchymatous changes begin in the terminals and proceed toward the center. No changes have been found in the tactile terminals to account for the hyperesthesia, pruritus, formication, and other sensory defects frequently found in the aged. Anesthesia is usually associated with mental impairment.

No changes have been demonstrated in the optic

nerve or retina but the lens becomes hardened and the muscles of accommodation become weakened. The arcus senilis, a grayish deposit of fat cells frequently found around the cornea of aged persons, is not a senile change and is occasionally seen in the young. In the nose the Schneiderian membrane atrophies and there is often marked waste of mucous membrane and glands. No change has been found in the taste bulbs.

In the ear no change has been demonstrated in the auditory nerves although hearing is greatly restricted in the aged. In some cases the drum is thickened, in others it is thin or may be perforated. A peculiar feature is found in aged persons who have been long subjected to loud and shrill noises as saw grinders, locomotive engineers, etc. They become deaf early and they have a marked hypertrichosis in the ears.

The senile changes in the skin are varied and include atrophy, hypertrophy, pigmentation, anemia, congestion, and changes in texture. In some localities it is soft and smooth, in other places it is rough, wrinkled, loose, and flabby. The subcutaneous fat, derma, elastic fibers, and glands atrophy, the areolar tissue becomes fibrillated and the connective tissue becomes loose. Deficient surface circulation causes the skin to feel cold and in parts not exposed to sunlight it is pale or presents patches of passive hyperemia. The perspiration is diminished but in localities subject to attrition as the axilla, the groin, and between the toes, there is usually bromidrosis. The hair bulbs atrophy and the hair falls out. Alopecia and canities though usual accompaniments of old age seem to be due to other causes than ageing for they are frequently found in maturity and are subject to hereditary influences to a more marked degree than any other condition found in the aged. Hypertrichosis occurs in several locations, notably the eyebrows, the nose, ears, and on the upper lip and chin of women. In the male, hypertrichosis sometimes occurs on the back of the hands and on the toes.

Cartilage changes include atrophy, fibrosis, calcification, and ossification. Articular cartilages become dry, fibrillated and waste. The epiglottis undergoes fibrosis; most other cartilages ossify or calcify.

Ligaments contract and harden. The Ligamentum Nuchæ is an exception to this rule as it frequently becomes longer and less rigid than in maturity. The capsular ligaments may through contraction and hardening cause anchylosis, a condition almost invariably mistaken for rheumatic arthritis.

Bones lose organic matter and the inorganic matter being proportionately increased the bone becomes brittle. Osteoporosis occurs in short bones, in the epiphyses of long bones and in the diploe of flat bones. Late in life there is a resorption of the entire bone substance. The bone marrow becomes thick, yellowish and contains a larger proportion of fat than in maturity. One of the earliest manifestations of ageing is the deposit of fat in the abdominal wall. Late in life this fat is absorbed. The bone changes are most marked in the skull, chest, pelvis, and femurs, the most pronounced change occurring in the lower maxilla. The alveolar process atrophies, the condyles waste, making the notches larger, the angles become more obtuse and there is a gradual resorption of the entire bone until it assumes an infantile type. The neck of the femurs become gradually depressed until they form a right angle with the shaft. The pelvic changes include waste of bone and a flattening of the pelvis through the downward pressure upon the sacrum and the upward pressure of the femurs upon the acetabuli. In the chest the ribs calcify and lose their resilience, the costal cartilages ossify, the sternum becomes rigid, and the vertebræ waste. In addition to these changes the intervertebral discs calcify and become compressed, the compression being greatest where the discs are thinnest, anteriorly in the dorsal region and posteriorly in the cervical and lumbar regions. As a result of this uneven compression the dorsal curvature is exaggerated, the articular relations between the ribs and spinal column are altered, and owing to the changes in the ribs and costal cartilages the chest wall becomes rigid and flattened at the sides. The rigid chest walls interfere with the expansion of the lungs and thus become a contributing cause to senescence. The compression of the intervertebral discs is due to the downward pressure of the body when in the erect position. Space does not permit an elaboration of the influence of the erect position upon senescence. It could be shown that many conditions due to the erect position such as the increased spinal curves which affect the respiration and consequently the aeration of the blood, the visceral ptoses, the formation of compensatory and adventitious bands, the slowed return circulation from the lower limbs due to gravity, etc., all contribute to the anatomical and physiological changes which form the process of senescence.

We find in the aged functional changes due directly to the anatomical changes in the functionating organs, indirectly through changes in some other organ as urinary retention through a hypertrophied prostate, impaired expansibility of the lungs through rigid chest walls, intestinal stasis through enteroptosis caused by flaccid abdominal walls and diaphragm, etc. Functional and anatomical changes are also influenced by the mode of life, occupation, climate, and environment. The senile kyphosis is more marked in the male as the weight of the clothes rest upon the shoulders and he carries weights, while the weight of the woman's clothes is borne mostly by the hips, and she wears corsets which retard the dorsal curvature. It is marked in women who carry heavy weights on the head. Pneumonoconiosis is pronounced in dwellers of smoky cities, slight in seamen. The impairment of the organs of special sense begins earlier and proceeds more rapidly in the city than in the country, and the same applies to the degeneration of the heart, blood-vessels, and kidneys. Mental impairment, degeneration of the skin, glandular organs, and the intestines appear earlier in the country. Some of these can be traced to other causes than senescence, as the chronic constipation of the farmer who neglects his bowels in winter if the closets are some distance from the house. For the same reason there is usually an early dilatation of the bladder.

The early manifestations of ageing are varied and obscure. The individual may notice shortness of breath which he calls asthma; or a stiffening of the joints (arthrosclerosis) which he thinks is rheumatism; or he finds that he gets tired after a few hours work and he says, malaria. It may be diminished virility or forgetfulness, or he may notice that he becomes confused after prolonged mental work, or that he needs glasses. The early objective manifestations are likewise indefinite. It may be an accumulation of fat upon the abdomen, graying of the hair at the temples or falling out of the hair, a tendency to stoop, to make shorter and slower steps, to avoid exertion; wrinkles upon the forehead or the drawn lines in the face that indicate the waste of muscle, or the mental condition may attract attention. In some cases the earliest evidences of ageing are found upon examination when a hardened xiphoid cartilage, or high blood pressure with a hypertrophied heart and without kidney impairment, are found. Failing memory, especially for names and dates, usually appears early, sometimes during the fifth decade. Other signs of mental decadence usually appear late and the manifestations of physical decadence are always more pronounced than of mental decadence. Among the early signs of mental impairment beside weakened memory are lessened interest in the events of the day, in hobbies and pastimes which the individual formerly enjoyed,

weakened sensuous impressions without weakened senses, and lessened control over the emotions. Matter that he reads does not make so vivid an impression upon him as formerly and he may be obliged to read a part several times to grasp its import. Catchy airs which he could formerly recall at will now are forgotten as soon as heard. If interrupted while speaking he forgets where he left off or he forgets the subject altogether. Gradually it requires stronger and stronger sensuous acts to make and leave an impression on the mind; a louder sound, a brighter flash of light, a greater shock, sharper food, stronger odors. On the emotional side he weeps, laughs, fears, exults over trivialities, develops exaggerated ideas of his importance, is easily depressed by slight opposition or apparent neglect; he loses ambition and hope, while life assumes a value inconceivable to the young. As the mental faculties become weaker he becomes apathetic or morose and in extreme cases these proceed to melancholia and complete dementia. It may be pointed out that there are many exceptions, many old persons who are active, cheerful, mentally alert, who take an active interest in life and in the affairs of the day. In most of these cases it will be found that the mental faculties are concentrated upon one subject or have been directed into one channel while in other directions they are weak. Some will under extraordinary stimulus exhibit extraordinary mental power but when the stimulus ceases the mind relapses into a condition of brain fag, dulness, and weakness. Cases of old persons who are able to accommodate themselves to modern thought and conditions, adopt new styles and fashions, exhibit the ambitious spirit of maturity and comport themselves as young persons, are very rare.

Pathological Conditions.—There are many senile conditions which while normal at that period of life still cause distress and require medical attention. In some cases the degenerations appear earlier, proceed more rapidly, are more extensive or give more distress than normal. These conditions can be grouped together as *Primary Senile Diseases*. Arteriosclerosis, arthrosclerosis, senile emphysema, senile dementia, are examples of this group. A second group of diseases arises from the senile degenerations. These *Secondary Senile Diseases* are pathological conditions due to some disease cause. Apoplexy, senile (atrophic) bronchitis, senile trifacial neuralgia, senile gangrene, senile cataract, are examples of this group. A third group occurs most frequently in middle or advanced life and appears to be in some way associated with the senile processes. Carcinoma, gout, diabetes, paralysis agitans, are typical examples of this group of *Preferential Diseases of Old Age*.

A fourth group comprises diseases which may occur at any time of life but occurring in the aged they present marked pathological or clinical differences from the diseases as they appear in earlier life. These are classed as *Modified Diseases of Old Age*.

This group includes various dermatoses, neuroses, and psychoses, senile pneumonia, senile gastritis, pleurisy, cystitis, etc. There is finally a group of diseases which may appear in the aged, which does not differ from the diseases as they appear in earlier life. These *Diseases Uninfluenced by Age*, include the infectious diseases, acute inflammations, etc.

Inaccuracies in nomenclature are responsible for many misconceptions concerning the diseases of old age. The term Cardiovascular Disease is used as though it represented a clinical or pathological entity yet physicians describe various conditions under this term. Atheroma is used interchangeably with arteriosclerosis although it is a fatty degeneration and in the early stage there is softening and not hardening of the vessel. A frequent source of error in dealing with senile conditions is the failure to differentiate between the normal senile changes and pathological conditions which they simulate. Thus arthrosclerosis is frequently mistaken for rheumatic arthritis; the gastric crisis of abdominal arteriosclerosis may be mistaken for cancer or tabes; the trace of albumin in the urine may raise the suspicion of nephritis, especially when associated with physical weakness, irritability, high blood pressure, and other concomitants of interstitial nephritis. In the aged it is necessary to trace each symptom to its source before we can determine its relation to the suspected disease. Symptoms are frequently so obscure as to be uninterpretable or unnoticed and it often happens that the symptoms of a grave disease are masked by the manifestations of ageing. In the senile pneumonia there may be chilliness but no chill, the typical panting respiration may be replaced by shallow breathing, the rapid rate of breathing being overlooked on account of its shallowness, there may be no pain and the cough and expectoration may be ascribed to an old bronchitis. The temperature may not exceed 101° and the patient may give no subjective symptoms pointing to the lungs. In this disease the symptoms are usually mild while the condition is grave, and pulmonary edema or cardiac exhaustion occurs before the gravity of the disease is suspected.

Many of the ordinary symptoms and signs which in earlier life suggest and are associated with certain diseases are unreliable in the aged. The pulse is worthless for diagnosis if there is arteriosclerosis anywhere between the heart and the wrist. Temperature is an unreliable index as the body temperature is generally lower in the aged, there may be a difference of two degrees between the mouth and the rectum and in the mouth at different times. Typical temperature curves such as appear in typhoid fever and malaria are rarely found in the aged, the rise in temperature in acute diseases proceeds more slowly and does not rise as high as in earlier life and a sudden drop is always of grave import. Pain is an unreliable symptom and may be absent in diseases usually associated with pain, as peritonitis, pneumonia, appendicitis, while many aged persons will exaggerate pain or complain of pain where it does not exist to obtain sympathy or avoid a painful examination. The blood pressure is another uncertain diagnostic guide, as arteriosclerosis and contracted kidney, the principal causes of high systolic pressure, are found in almost every senile case. A fairly accurate estimate of the normal systolic pressure in the aged is the age plus 100 in millimeters. A lower systolic pressure with the heart strong and regular indicates slow arterial degeneration. If the pressure is higher it points to marked arteriosclerosis or kidney degeneration. The tendon reflexes are uncertain guides in diagnosis. In over eighty per cent. of cases between the ages of sixty-five and ninety-three the foot reflexes were absent, the knee reflex was increased in thirty-two per cent. and absent in twenty per cent.

The skeletal changes and flaccid diaphragm and abdominal walls cause changes in position of the viscera which may lead to error. Gastroptosis and enteroptosis are usual, the liver is occasionally so low that its upper border may be felt, the heart is generally lower while the lower border of the lungs is found much higher than in maturity. The heart will lie higher and may be displaced when the stomach and transverse colon are distended with gas, and owing to the waste of the intercostal muscles the apex beat is more pronounced.

Vomiting is rare in old age even in diseases in which it is a prominent symptom in maturity. Diarrhea is almost always due to some fault in the food or feeding and constipation or delayed defecation is the rule in the aged.

A serious source of error is the mental condition of the aged making the history and subjective symptoms as given by the patient unreliable, while those who have the care of the aged frequently lose patience with their charges and ascribe the petty complaints to whims, imagination, or attempt to obtain sympathy. Aged persons are sometimes afraid to complain in the presence of their care takers and it may be necessary to question them alone to get any kind of a history from them. Errors in diagnosis lead to errors in treatment. Another source of error in treatment is our ignorance of the action of drugs and other therapeutic agents upon degenerating tissue. We have not even an empirical knowledge of such action and consequently use drugs as we do in maturity, perhaps reducing the dose without reason or rule. A moment's reflection will show that drugs that are given to stimulate functions must be given in constantly increasing doses while sedative drugs should be given in the smallest possible dose that will have an effect. Owing to slowed assimilation drugs that are not rapidly eliminated are liable to produce cumulative effects. For this reason arsenic, a most valuable tonic in the debility of the aged, must be given cautiously and the treatment must be frequently interrupted. If rapid action is required the drug must be given hypodermically or intravenously. There is some change in metabolism and assimilation for some drugs which are readily assimilated in earlier life are rejected in old age. Iron, for example, is generally rejected even when there is a low hemoglobin content while calcium is retained in excess. The most assimilable iron product is hemoglobin or hemogallol.

Many drugs exhibit in the aged powerful secondary or incidental effects which are undesirable and may be positively injurious. Belladonna, a valuable respiratory stimulant, at the same time diminishes secretions which are already diminished through atrophy of the glands, and it weakens and may completely paralyze unstriped muscle fiber, thereby diminishing peristalsis and relaxing sphincter muscles. The danger from opium and its preparations in the aged lies in its paralyzing effect upon the respiratory centers. This is overcome by combining it with belladonna or one of its preparations but here again we must remember that opium or morphine given per os is more rapidly absorbed than the belladonna or atrophia, and the opium or morphine may destroy the patient by paralyzing the respiratory centers before the other has begun to act.

When given hypodermically they act together. Chloral hydrate and the coal-tar products are powerful cardiac depressants and must be combined with cardiac stimulants. Here again the rapidity of action must be considered. The frequent reports of disastrous effects of coal-tar products when combined with caffeine are traceable to the more rapid action of the coal-tar product. Carbonate of ammonia should be used with this class of drugs. Digitalis "the most valuable drug in the pharmacopœia" is a powerful vasoconstrictor, making it a dangerous drug in arteriosclerosis. Where this exists strophanthus should be used instead. Both are slow in action and both may exhibit cumulative effects. The diuretic action of digitalis is much less marked in the aged.

Drug action is also influenced by the mode of administration. Gelatin-coated pills frequently pass through the bowels unchanged, especially if the coating is old and the mass is hard. Salts given in solution are readily absorbed while hours or days pass before the action of insoluble salts like calomel or bismuth subnitrate is recognized. Drugs used for local application by inunction must be combined with an animal base, like lanoline or sweet butter. The mineral bases are not absorbed by the senile skin. The marked benefits aged patients derive at the medicinal springs are due rather to the strict regimen, change in the accustomed routine, and the mental stimulation through change of scene, enforced activity, and faith in the beneficial effect than in any peculiar merit in the waters themselves; for the same waters taken at home do not have the same effect. The senile degenerations create vicious circles which increase until every organ and tissue is involved in one or more of these circles. Thus the weakened muscular fibers of the descending colon permits a dilatation of the part in which feces accumulate, further dilating the pouch thus formed and still further stretching the muscular fibers. In the lungs there is atrophy of lung substance with thinning, and finally rupture of the interalveolar septa. The aerating surface of the lung is thereby diminished, the blood is improperly oxygenated and its carrying capacity of nutrition to the tissues is diminished. The lung shares in the general nutritional defect, there is increased atrophy with still further diminished aerating surface. After the limit of compensatory hypertrophy of the heart has been reached a vicious circle is instituted which rapidly involves the liver, kidneys, brain, and other organs.

Primary Senile Diseases.—*Arteriosclerosis.*—The most important and widespread of the primay senile diseases is arteriosclerosis. The senile arterial degenerations include atheroma, fibrosis, and calcification. Faulty nomenclature and a failure to differentiate between various forms of arterial degeneration lead to errors in dealing with this condition. There are three general types of this disease; the irritative beginning in the intima as an endarteritis or atheroma, the mechanical beginning in the media with loss of tonicity and waste of muscle fiber replaced by fibrous tissue; the nutritional beginning in the vasa vasorum with thickening of the endothelial cells, diminishing the caliber of the fine vessels and diminishing the blood supply to the main vessel, impairing its nutrition. The pathological arteriosclerosis which accompanies syphilis, diabetes, nephritis, infectious diseases and other diseases in which deleterious matter is carried in the blood, is of the irritative type. A minute particle of fibrin, a clump of bacteria or other substance may fasten itself to the endothelium causing local inflammation or degeneration, or the irritating quality of the blood which contains an excess of urea, uric acid, sugar, etc., may cause local or more extensive inflammation or degeneration. This form of arterial degeneration is sometimes curable if the underlying disease is curable. The arteriosclerosis arising from autointoxication belongs to this type but as the cause is rarely removable the disease is rarely cured. In some cases the irritation to the endothelial cells causes a swelling of the cells which then undergo granular and fatty degeneration. This is atheroma. In this stage there is softening, not hardening of the arterial wall. Later calcium soaps are formed by the combination of calcium from the blood with the fat, these break down, the calcium combining with the carbonic acid and phosphoric acid radicals in the blood, and thus the calcareous plaques are formed. Plaques in the intima occur only in this type of the disease. In the mechanical type the loss of tonicity permits at first a dilatation of the vessel. The muscle fibers waste and are replaced by fibrous connective tissue which causes a stiffening of the vessel and continued increase of this tissue produces a thickening of the vessel with diminution of its caliber. Calcification comes on late if at all. This is the true physiological arteriosclerosis.

In the nutritional type the amount of blood supplied to the vessel is diminished either through swelling of the endothelial cells of the vasa vasorum whereby the caliber of these fine vessels is diminished or the increased viscosity of the blood makes it more difficult to pass through the nutrient vessels. In this type there is a waste of muscular fibers and proliferation of connective-tissue fibers, minute cavities form where

the muscle fibers have disappeared and these cavities become filled with granular and fatty matter and later with calcium deposits.

Whatever the basic cause of ageing is, is the basic cause of senile arteriosclerosis. There are, however, many factors not connected with ageing which initiate or hasten the degenerative process. The right arm being more actively employed than the left, it requires a greater blood supply to repair the waste and the vessels of that arm being consequently subjected to greater strain they degenerate earlier and faster than the vessels of the left arm. This is evidenced by the higher blood pressure in the right arm of those who do active work with that arm. The reverse is found in left-handed persons. Excessive muscular activity whereby toxins are formed which are not promptly eliminated, and the heart is stimulated increasing the activity of the vessels, is an important factor in the more rapid degeneration of the blood-vessels. Smoking whereby the activity of the adrenals is stimulated by the inhaled nicotine, meat, eggs, and other purin-forming foods which in their metabolism leave behind toxic decomposition products, excessive mental activity, a moist atmosphere diminishing elimination by the skin, are all incidental factors. The earliest symptoms of arteriosclerosis are referable to the organs and tissues affected by the impaired functions of the vessels; occasionally the physical signs precede the symptoms. High blood pressure is usually looked upon as the earliest sign of arteriosclerosis but many things beside arterial degeneration will produce high blood pressure and senile neurasthenics usually have a low pressure while cardiac decomposition will produce a rapid or sudden lowering of the systolic pressure. In addition to the usually accepted determinants of blood pressure, the force of the heart, condition of the vessels and peripheral resistance, the viscosity and density of the blood have some influence.

In arteriosclerosis the excess of calcium increases the viscosity and density of the blood and thus aids in raising the blood pressure. An intermittently high systolic pressure, or if the pressure rises much higher than normal under the usual causes for increased blood pressure, points to arteriosclerosis. If the pulse rate when standing is less than six more than the recumbent rate it is suggestive of arteriosclerosis and if the recumbent rate is equal to or exceeds the standing rate the disease is far advanced. These two signs together are fairly diagnostic of diffuse arteriosclerosis. In some cases the earliest sign is tortuous retinal vessels, although tortuosity and a hard or beady feel of the vessels usually appear only when the disease is well advanced. The temporal artery usually shows the most marked tortuosity and the radial artery has the most pronounced hardness or beady feel. Aortic atheroma and arteriosclerosis are the most frequent of the arterial degenerations but they do not give any clearly defined symptoms. There may be a systolic murmur over the vessel, jugular pulsation, pulsation in the suprasternal notch if the arch is involved, an increased area of dulness over the vessel or a difference in the character of the carotid pulse on the two sides. If the abdominal aorta is involved it is sometimes possible to feel nodular areas if the abdominal walls are thin.

An acute degenerative aortitis is occasionally found in plethoric persons with cardiac hypertrophy. There are spasmodic attacks resembling angina pectoris but the intense pain is above the heart and over the aorta, and there is sudden intense dyspnea which gradually lessens but does not disappear entirely. The pain disappears suddenly and completely but in the interval between the attacks there is a dull ache over the vessel, dyspnea and palpitation, and there is a constant sense of anxiety or dread. Death sometimes occurs during the first attack, more frequently during a subsequent attack. Coronary arteriosclerosis is usually associated with angina pectoris although cases have been reported in which extensive coronary degeneration has been found which gave no evidence during life and persons have died during an attack of angina pectoris yet no coronary lesion was discovered. As cardiac malnutrition through sclerosed coronaries leads to cardiac degeneration, either fibrosis or fatty degeneration, when such degeneration coexists with angina pectoris it is fairly certain that there is coronary arteriosclerosis. In degeneration of the abdominal aorta there are occasionally abdominal crises, intense neuralgic pains centered about the umbilicus, which at first last but a moment, later disappear slowly or leave a dull ache not referable to any organ. Cerebral atheroma and sclerosis occur frequently in the aged. An early symptom of this is a dull headache upon arising, disappearing during the course of the day and followed toward evening by the disagreeable lightheadedness of cerebral anemia. The morning headache is due to a passive hyperemia. Vertigo is an early symptom. There is a momentary feeling of fullness in the head as though a gush of blood came up from below, went whirling through the brain and then suddenly dropped down again. Later these attacks become more frequent and more prolonged, the patient becomes unsteady or if momentary complete unconsciousness occurs he may fall. Insomnia is frequent, there is sometimes temporary mental confusion or graver psychoses, illusions which the patient occasionally recognizes as illusions, more often they are the precursors to melancholia and dementia. Paralysis, hemianopsia, aphasia, and various neuroses occasionally appear. There is always danger of rupture of a minute vessel producing apoplexy, or thrombosis or embolism with slow cerebral degeneration.

Ear symptoms begin as a unilateral, later bilateral, tinnitus, slight and progressive deafness, diminished air and bone conduction and auditory illusions. In the eye the retinal vessels show early tortuosity, occasionally minute retinal hemorrhages. If the vessels appear anemic the central artery is degenerated or it is blocked by an embolus or thrombus. Arteriosclerosis of the spinal arteries causes symptoms resembling chronic myelitis, occasionally there are symptoms resembling multiple sclerosis, syringomyelia, tabes, or paresis. In rare cases there is a compression myelitis when the beaded zone of sclerosed tissue presses upon the cord. Paralysis agitans, senile tremor and Charcot's claudication are supposed to be due to spinal arteriosclerosis. In peripheral arteriosclerosis the muscles and skin are affected. There are cramps, myalgia, abasia, perhaps claudication, a feeling of coldness, tingling, numbness, occasionally purpura and other skin and muscle affections. Raynaud's disease is believed to be a peripheral arteriosclerosis and neuritis. Senile gangrene is generally due to a localized peripheral arteriosclerosis and many cases are preceded by mild symptoms of Raynaud's disease. Arteriosclerosis of the vessels supplying the abdominal organs does not give distinctive symptoms but the disease may be suspected when there is impairment of function and symptoms of general or local arteriosclerosis elsewhere. There is, however, one symptom common to all forms of arteriosclerosis which, while not pathognomonic, rarely occurs in any other condition in old age. This is a sudden paroxysm of pain generally accompanied by temporary loss of function of the organ or tissue supplied by the diseased vessel. The pain of angina pectoris, the gastric and abdominal crises, the intense cramp accompanying the sudden lameness of Charcot's claudication, are typical examples. The vertigo with momentary loss of consciousness that occurs in cerebral atheroma is of the same character. These paroxysms are probably due to a spasm of the mus-

cular fibers of the vessels when subjected to a strain to which they cannot respond.

When dealing with arteriosclerosis in the aged it is necessary to determine if it is the normal senile degeneration or a pathological condition, or if both physiological and pathological causes are at work. The physiological degeneration is incurable in the sense that it can neither be prevented nor removed, although distressing symptoms can often be relieved. The pathological condition is sometimes curable. As the disease may have been secondary to a syphilis, gout, diabetes, or nephritis or other disease it is well to begin treatment with the iodides in every case in which a history of such preceding disease can be obtained although the symptoms may have disappeared years before. If the degeneration is purely physiological the drug will soon give its physiological effects, rashes, catarrhs, gastric irritation, etc. In some cases there will be a reduction of blood pressure, relief from vertigo, and improvement of functions to a certain point and beyond that the therapeutic action is replaced by the physiological action of the drug. In these cases so much of the disease as is pathological is cured while the physiological degeneration remains. The iodides act by stimulating thyroid and diminishing suprarenal activity while the alkaline bases diminish the viscosity of the blood thereby permitting a freer circulation of blood through the capillaries and organs.

High blood pressure is a symptom, not a disease, and drugs which lower blood pressure should be selected for their action upon the determinants of the high pressure and not for the sole purpose of lowering the blood pressure. The cardiac depressants like aconite, veratrum, gelsemium, lower the blood pressure by weakening the heart and are therefore contraindicated in arteriosclerosis. The nitrites reduce the peripheral resistance by dilating the arterioles thereby lessening the necessity for cardiac hyperactivity, and relieving an overfilled heart without weakening it. The nitrite of amyl given by inhalation, or the nitroglycerin given hypodermically will give almost instant relief in the paroxysmal attacks of angina pectoris and gastric and abdominal crises and similar conditions requiring rapid relief of an overstrained heart or blood-vessels. As prolonged hyperactivity of the heart hastens decompensation it is sometimes necessary to cause a prolonged lessening of the peripheral resistance. In these cases the nitrite of soda should be used in grain doses three or four times a day. If there is cerebral hyperemia the rapidly acting nitrites are liable to cause rupture of a cerebral vessel while the prolonged use of the nitrites may cause peripheral stasis.

Thyroid extract causes dilatation of the vessels by inhibiting the vasoconstrictor centers and thereby reduces blood pressure but in the aged it soon produces palpitation and arrhythmia even in small doses. It may be tried in grain doses but the moment the cardiac symptoms appear it must be discontinued. Theobromin, recommended by Huchard, causes dilatation of the peripheral vessels while stimulating the heart. It also stimulates the kidneys causing an increased flow of urine but this abstraction of fluid causes an increased viscosity of the blood and produces excessive thirst which must be appeased by supplying more fluid to the system. Trunecek's serum, a solution of the salts found in the plasma, is supposed to reëstablish the normal proportion of salts in the blood. Good results have been reported from their use. The writer has given amorphous phosphorus in grain doses several times a day, on the assumption that in its elimination as amorphous phosphate of lime the calcium is withdrawn from the calcium excess in the blood. Good results have been obtained, especially in cerebral atheroma. Both favorable and unfavorable results have been reported from the use of the high-frequency current. Bishop has laid much stress upon the benefit derived from a low protein diet.

To obtain the best results in arteriosclerosis we must deal with each case individually, discover what underlying pathological condition or what other factors initiated or hastened the degenerative process, and try to eliminate or minimize these factors. Organs and tissues which are excessively employed must be relieved and where there are deficient secretions as bile, pancreatin, hormones, etc., these should be supplied artificially rather than by stimulating the secretory organs. The waste of normally degenerating organs cannot be replaced artificially nor can a normal degeneration, *i.e.* the repair of the normal waste by a lower order of tissue, as muscle by fibrous connective tissue, cartilage by osseous tissue, bone by calcification, be converted into a regenerative process. Our treatment of senile arteriosclerosis is restricted to the relief of symptoms, improvement of pathologically degenerated tissues where the etiologically factors can be controlled, and the general improvement of the organism through rational hygienic rules. These include sufficient sleep, favoring short naps during the day, the restriction of purin-forming foods, feeding at intervals of not less than five hours, mental and physical exercise, resting the moment fatigue sets in, a dust-free atmosphere and the avoidance of depressing influences.

Phlebosclerosis is analogous to arteriosclerosis. The physiological degeneration of the veins is due to the same causes as the physiological degeneration of the arteries but most cases in which the degeneration is marked and causes distress, follow phlebitis. In the senile form the symptoms are those of varix coming on slowly, occasionally areas of hardness can be felt along the course of superficial veins and there is sometimes a hypostatic edema. Lumps due to thrombi can sometimes be felt in varicose veins. Treatment aside from a rubber stocking, is rarely required. A tight-fitting stocking is liable to compress arteries as well as veins and deprive the part of nutrition. Pruritus which is sometimes exceedingly annoying can generally be relieved by a two per cent. cocaine ointment using an animal fat base.

Senile arthrosclerosis is a hardening and stiffening of joints due to the contraction and hardening of ligaments, drying of the synovial sac, and fibrillation and waste of the articular cartilages. In extreme cases the hardening and contraction of the capsular ligament may cause complete immobilization of the joint. This condition is frequently mistaken for chronic rheumatism or other pathological arthritic condition. In senile arthrosclerosis there is no inflammation, no painful spot, and no pain when the joint is at rest. There is some stiffness upon motion and if prolonged the stiffness increases and there is a pain in the whole joint and along the ligaments involved. This affection is progressive and incurable but bathing in hot salt water followed by inunction with an animal fat will temporarily relieve the stiffness and relieve the part after exercise of the joint.

Myofibrosis is the usual form of senile degeneration of the heart. It is marked by an increase of the interstitial connective-tissue fibers and a waste of muscle fibers, but the tissue is not infiltrated with granular matter as occurs in chronic myocarditis following an acute myocarditis. The senile degeneration gives the same symptoms as the pathological myocarditis, progressive weakening of the heart with weakened contractions, vague precordial distress, palpitation, and dyspnea upon slight exertion, while upon intense excitement or strain there may be delirium cordis, heart block or spasm or paralysis. Later, symptoms of impaired circulation including constant dyspnea, cyanosis, cerebral and surface anemia, appear. The antecedents of the senile degeneration are cardiac hypertrophy and coronary arterio-

sclerosis; of the pathological degeneration, an acute myocarditis following infection, the action of toxin, or other causative disease.

In both conditions the heart becomes stronger upon complete rest but in the senile degeneration slight exertion causes it to weaken even after prolonged rest while in the pathological condition it remains strong or weakens slowly. In fatty degeneration of the heart, which gives similar symptoms, the heart does not become stronger under prolonged rest. When the limit of functional capacity has been reached further exertion in senile myofibrosis causes atony and dilatation with decompensation. In the treatment of senile degeneration of the heart the most important measure is rest. Every form of strain and excitement is injurious and the strain and excitement of sexual intercourse has caused death. Food should be light and not constipating and the patient should lie down after meals. The rarified air of the highlands is injurious and the much vaunted Nauheim, Schott, and Oertel treatments for heart diseases, are dangerous in this class of senile cases. Digitalis should not be given in this condition until dilatation sets in. When decompensation occurs absolute rest in bed is imperative and the heart tonics and stimulants are required, the former for constant use the latter for emergencies. Strophanthus is preferable to digitalis and where strychnine has been given in small doses for a long time it is useless except in almost toxic doses in an emergency.

Brown atrophy is the normal senile degeneration of a heart which was not hypertrophied before the senile degeneration began. The symptoms and treatment are like the more common form of senile degeneration, but dilatation does not occur in brown atrophy. In most cases the atrophic condition is discovered accidentally.

The normal senile *degenerations of the lung* are atrophy, emphysema, and pneumonoconiosis, but the symptoms are seldom sufficiently pronounced to attract attention or require treatment. Dyspnea is present in all these conditions but its onset is so mild and its progress so gradual that the patient becomes accustomed to it and does not notice it except after exertion. In senile emphysema the dyspnea is both inspiratory and expiratory, the latter more marked. If a patient with senile emphysema has been lying on his back for some time, fine, dry crepitant râles can be heard at the lower part of the back with the first few inspirations he takes upon arising. They are produced by the opening of the vesicles which were compressed while in the recumbent position and are pathognomonic of this condition.

Senile emphysema can be delayed by measures which will retard compression and atrophy of the lung. Such measures are, a dust-free atmosphere, deep breathing exercises, braces, a cane, arm rests on the chair, etc. When the wheezing and dyspnea become distressing small doses of belladonna will give temporary relief. This drug has, however, undesirable secondary effects which must be counteracted.

Senile pneumonoconiosis gives no direct symptoms but it is frequently accompanied by a hypertrophic bronchial catarrh and in those cases the sputum contains alveolar cells with enclosed dust particles. This condition is sometimes called primary chronic interstitial pneumonia. The latter disease is localized, unilateral and there is little or no discoloration of the lung aside from the general discoloration due to the pneumonoconiosis. The senile condition is general and the entire lung is discolored, the discoloration depending upon the amount and character of the dust inhaled.

Gastric and intestinal degenerations rarely require medical care, but dietetic indiscretions, neglect, and persistence in a routine mode of living suitable to earlier life, frequently cause more rapid and more extensive degenerations and other pathological conditions. The falling out of the teeth is nature's signal that articles of diet that must be masticated are no longer suitable and the dentist's art cannot make them suitable. This applies especially to meat as almost all other solid foods can be crushed between the tongue and hard palate. There is usually diminished appetite and often a senile dysphagia, the patient making a sensible effort to swallow, nature's signals to diminish the amount of food. Yet aged persons accustomed to hearty meals will continue to eat heavy meals, will take nibbles and snacks between meals, gorge themselves at banquets within an hour or two after their usual dinner, and in other ways treat their myasthenic and dilated stomachs as they did when the stomach could quickly recover from abuse in earlier life. The gastric crises of arteriosclerosis usually occur during a meal and the attacks of acute gastritis, the acute indigestion of the layman, which frequently have a fatal termination, occur almost always while taking a heavy meal when the stomach is still partly filled with food and gas. In these cases the stomach is extremely dilated and presses upward upon the diaphragm, and the heart is so greatly disturbed as to cause spasm and paralysis. Senile atony and dilatation of the stomach can readily be demonstrated by physical signs but they do not normally give marked symptoms. Portions of a test meal can generally be found six or seven hours after eating and other conditions in which this occurs, hour-glass contraction, pylorospasm, and pyloric obstruction, are readily differentiated.

Gastric dilatation can sometimes be demonstrated by inspection alone while radiography is a certain means of determining its existence. Acid eructations which are common in young persons suffering from atonic dyspepsia, are rare in the aged and other symptoms such as a feeling of bloating, nausea, belching, and cramps occur only when there has been improper feeding. In dilatation the vomiting which is a prominent symptom in the young, is rare in the aged. Eructation of gas may occur an hour or two after meals and clapotage can generally be elicited. There is generally a gastroptosis and in some cases a pyloric insufficiency, the only symptom of which is the presence of undigested proteid matter in the feces but this may be due to other causes than pyloric insufficiency.

The one prominent symptom of senile intestinal degeneration is constipation. The following factors contribute to the production of this condition: diminished intestinal secretions, diminished peristalsis, diminished reflex irritability, diminished bile supply, and factors connected with gastric and duodenal digestion. Beside these, unsuitable food frequently aggravates this condition. Kinks and adventitious bands are frequently found on autopsy of aged persons who did not complain of constipation and it is doubtful if these play any important part in the production of senile constipation. The character of the feces will generally indicate what factors are principally responsible for the production of senile constipation, and will give the clue for the proper treatment of this condition. If the stools are light, clay colored, there is probably a deficiency of bile and the bile salts are indicated. Dry stools are due to diminished intestinal secretions and in this condition the stools come in small lumps with but a slight fecal odor. As these secretions cannot be supplied artificially we must either stimulate the glands or supply an artificial lubricant to the bowels. Rhubarb has a slight stimulating effect upon the intestinal glands and being also a peristaltic stimulant it is the most valuable single drug in senile constipation. Paraffin oil is the ideal intestinal lubricant and the American oil is as effective as the Russian product. Diminished peristalsis and diminished reflex irritability cause delayed stools

which are then dark, dry, normally formed and have a strong odor. If a meal containing a large amount of cellulose be given in diminished reflex irritability, the constipation will be temporarily relieved. If the fault lies in diminished peristalsis large amounts of cellulose will aggravate the constipation. In that case peristaltic stimulants like aloin, cascara, senna, are required. As there are generally several factors engaged, a combination of drugs must be used, and strychnine should be given to stimulate reflex irritability. Belladonna should not be used in senile constipation. The most important measure in the treatment of this condition is the regulation of the diet.

Atony of the anal sphincter, permitting the dribbling of small quantities of feces, soiling the clothes, is a frequent annoying ailment of the aged. The local application of ergotin and nutgall ointment will generally relieve this condition.

Contracted Kidney.—It is important to differentiate between the senile contracted kidney and chronic interstitial nephritis, the former a physiological condition, the latter pathological. In the former the degenerative process is uniform throughout the organ, in the latter it is localized.

The early symptoms of the two conditions are similar but if we trace each symptom to its source we find that the nervous and visceral symptoms in the physiological condition are due to local degenerations unconnected with the kidney. The urine is diminished in both conditions and there is generally a trace of albumin but the urine of the normal contracted kidney does not contain casts, and its specific gravity does not fall below 1,010 while in interstitial nephritis it is usually below 1,010. In the senile condition the urates and the calcium phosphate are diminished. Senile contracted kidney does not require treatment.

Vesical and prostatic troubles are among the most frequent and the most annoying of the ailments due to the process of ageing. Hypertrophy of the prostate occurs in about one-third of all men and nearly one-half of these have distressing symptoms. The earliest symptoms are frequent urination, the patient must make a sensible effort to start the flow, and a feeling of discomfort in the perineum when sitting on a hard seat. These symptoms become later aggravated and as prostatic hypertrophy and dilatation and atony of the bladder are generally found together symptoms of the three conditions are found. The earliest symptom of atony is a diminution in the expulsive power, the patient being unable to send the stream as far as formerly. In dilatation of the bladder there is retention of urine with a feeling of weight in the pelvis which is relieved by urination. In retention due to other causes as stone, tumor, stricture, etc., without atony and dilatation, there is difficulty in starting the flow but when started it comes with force. Retained urine becomes ammoniacal and often contains bacteria especially in those who must be catheterized. In the senile degeneration of the bladder small quantities of urine may be retained in the vesical pouches for days, decomposing and irritating the organ. The presence of this retained urine can be demonstrated and the condition relieved if after catheterization the patient is made to lie on his back, then turned upon his abdomen, and then arising is immediately again catheterized, when the urine that has been dislodged from the pockets is withdrawn.

Medical treatment of senile hypertrophy of the prostate is useless and there is great diversity of opinion as to the time and method of surgical procedure. Wolbarst says from fifteen to twenty per cent. of all prostatic hypertrophies are malignant. The early symptoms of this condition are the usual symptoms of hypertrophy and a dull pain in the perineum which is constant, made worse by pressure, gradually increasing and occasionally accompanied by hematuria without other calculus symptoms. Where malignancy is suspected there is no question about early operation. In other cases the conservative surgeon will defer operation until daily catheterization becomes necessary and then the condition of the patient will determine if, and what form of, operation is best.

The most important measure for the relief of dilatation of the bladder is frequent emptying of the organ. If the patient feels that he has not passed all he should get on his knees and press the vessel against the perineum. When catheterization becomes necessary the utmost care should be taken to secure perfect sterilization as nearly every case of bacterial cystitis in the aged can be traced to a catheter which had not been thoroughly cleaned. The injection of mild silver solution is frequently beneficial. Internal medication is of little avail although benefit has been claimed from strychnine, ergot, aloes, and belladonna. The last is clearly contraindicated as it relaxes unstriped muscular fiber, it is doubtful if the peristaltic activity of aloes extends beyond the bowels, and ergot is dangerous if there is arteriosclerosis. Urinary antiseptics are, however, beneficial in all cases.

Senile impotence is an important ailment on account of its depressing psychic influence upon those in whom the libido remains while the potentia is lost. In these cases the patient wants the power restored and he will not willingly submit to any treatment which might lessen the desire. While it is possible to increase the power of erection for a short time through the use of local measures as electricity, massage, cold sounds, etc., the best results in such cases are obtained by anaphrodisiacs, bromides, monobromated camphor, lupulin, valerian, using local stimulants until the lessened desire makes them unnecessary. Every source of erotic stimulation must be avoided.

In some cases there is a recrudescence of desire about the time of the senile climacteric and the inordinate erotic desires may then lead to sexual attacks, the victims in such cases being usually little girls. In this state of sexual fury the desire is uncontrollable, the individual has no conception of the criminal nature of his act and what is generally looked upon as a heinous offense is really an insane act.

The Skin.—The senile changes in the skin are important mainly on cosmetic grounds. Pruritus, which is frequent in the aged, is believed to be due to degeneration of the nerve terminals. It occurs most frequently about the genitals and anus, sometimes on the legs, rarely in other locations. There is no routine treatment for senile pruritus the same measures beneficial in one case being detrimental in another case or at another time. A two per cent. cocaine ointment, in an animal base, generally gives temporary and occasionally permanent relief. Pigment deposits, wrinkles, and hypertrichosis are unsightly, but do no harm. Massage and inunction with an animal fat is sometimes of service in wrinkles and epilation with tweezers is the best method of getting rid of superfluous hairs. There is no effective method of removing pigment deposits in the aged and the irritants which are sometimes employed for that purpose may cause ulceration and gangrene. Senile alopecia and canites are still classed among the incurable conditions although there are cases in which a new growth of hair was stimulated. Alopecia was far less prevalent when hair oils, which consisted of animal fats, were used, and in some senile cases the use of animal fats has undoubtedly contributed to a renewed growth of hair.

Bromidrosis occurs frequently among the aged and owing to the impairment of the sense of smell the individual is not cognizant of it. This condition can generally be cured by the application of belladonna ointment or a mixture of equal parts of salicylic acid and stearate of zinc.

Muscular Weakness.—There is in old age a progressive muscular enfeeblement due to waste, but in some cases the weakness is greater than the muscular waste would account for. In these cases there is a fatty

infiltration of the muscles and probably some neural degeneration. Fatigue sets in upon slight exertion, recuperation is slow, and as the disease progresses any exertion becomes irksome. This condition may be mistaken for neurasthenia but here there is the will but not the power to move while in neurasthenia the will is impaired but under some powerful stimulus the patient will act as vigorously as in health. This fatty degeneration of the muscles occurs most frequently in obese individuals who do little work involving muscular exercise, and there is generally some mental or physical cause such as shock, fear, prolonged pain, a grave disease, which will initiate or hasten this form of degeneration. The treatment in this class of cases consists of the stimulation of muscular irritability and the destructive metabolism of fat. Massage, coarse vibration and the galvanic current can be used for the former, and passive exercise and iodide of potassium for the latter indication. Strychnine, phosphorus, and other nerve stimulants should be given.

Mental deterioration, as a result of the degeneration of the brain, occurs in every senile case. This is evidenced in forgetfulness, mental abstraction, more rapid brain fag, diminished cautiousness, weakened control over the emotions, lessened capacity for work, impaired quality of work, etc. In determining the extent of the mental impairment the mental condition of the individual when at its best must be known. It is folly to judge of the mental condition of an aged individual who shows remarkable mental capacity in one direction, without comparing his mental condition in other directions, since all his mental efforts may be concentrated upon one object while in every other direction there may be pronounced mental impairment. Attention is defective and prolonged attention causes brain fag. For this reason the aged person falls asleep at the sermon or play, not through inattention but through excessive attention which caused brain fag. There is generally a change in temperament, excessive self-interest, a loss of interest in the affairs of others and lessened interest in the affairs of the day. What are usually looked upon as the whims, hobbies, and peculiarities of the aged are really manifestations of mental impairment. During the senile climacteric there is usually a deeper grade of mental impairment evidenced by mental confusion, disorientation, and mental abstraction. This condition may be so mild as to be noticed only by close associates or it may be so severe that the individual may lose track of time, distance, direction, may become garrulous, talking incoherently to self or strangers. After the senile climacteric there is a progressive impairment in all directions but the state of complete dementia is seldom reached. There is no unanimity in either the legal or the medical conception of what constitutes senile dementia, and it is difficult to formulate any rule which will cover every case of mental impairment.

The keynote of treatment of senile dementia is mental stimulation. This is contrary to the usual treatment by rest and quiet, in a sanatorium. Unless the mental condition is so defective that an attendant is necessary he should not be placed among insane patients nor where he is liable to acquire by mimicry the gait, talk, or actions of nervous cases. At the same time, while stimulating mental activity, mental confusion must be avoided. He may watch a one-ring circus until brain fag sets in and he will fall asleep, but if he tries to watch a three-ring circus mental confusion will ensue and insomnia will follow. Harmony of sound, color, and motion is beneficial. Change of environment will cause mental stimulation but the sights and scenes must be pleasing. Flattery and association with the young will keep up the spirit of youth and prevent the mental depression which leads to melancholia and dementia. Among drugs phosphorus is the best mental and nervous stimulant. Morphine in small doses produces mental stimulation which passes off in a few hours. Cannabis indica stimulates the imagination generally in the direction of illusions and delusions. Alcohol is worse than useless in mental impairment.

Senile degeneration of the cord is evidenced first by slowed and weakened impulses and response to impulses, later weakened irritability, lessened coordination, impairment of the muscle sense and muscular power and finally senile tremor. In most cases there is a senile paraplegia, a weakening of the lower limbs, but there is never complete paralysis. Senile abasia, the slow unsteady gait of the aged, is due to lessened coordination and the consequent fear of falling, muscular weakness, and the bent knees necessary to maintain equilibrium. Senile tremor is an infrequent and late manifestation of spinal degeneration. It is distinguished from paralysis agitans by the absence of the characteristic attitude, gait, forward pitch, muscle stiffness, posture of the hands and immobile expression of paralysis agitans. The senile tremor ceases during sleep and may be temporarily controlled by the will. The drugs useful in other tremors, as the bromides, iodides, hyoscine, duboisine, are useless in senile tremor. Arsenic given to the limit of tolerance and strychnine until palpitation of the heart sets in, will control the tremor but both drugs must be given in increasing doses and sooner or later both must be discontinued when the tremor will reappear. Spinal activity can be stimulated by the faradic current and the administration of strychnine and phosphorus. Cold applications to the spine are contraindicated.

The sense of *smell* is usually the first of the special senses to suffer diminution, owing to senile changes, and this may proceed to complete anosmia without the knowledge of the patient. Nothing can be done for this condition.

Presbyopia, the usual senile degeneration of the lens, can be overcome by appropriate glasses and presbyacusia can sometimes be benefited by using a speaking tube, artificial drum, or other appliance. Drugs and operations are useless in these conditions.

Gustatory anesthesia usually accompanies anosmia but the sense of taste is rarely completely lost. Nothing can be done to improve this condition.

Secondary Senile Diseases.—Few of these require special description. There is a form of *trifacial neuralgia* of the lower jaw probably due to compression of the terminal fibers in the bony structure. It is really a compression neuritis but the symptoms are those of neuralgia. There are paroxysms of pain when the jaws are closed forcibly, or when an attempt is made to crush a hard substance between the jaws, or when pressure is made upon the alveolar process. There are usually several pressure points along the alveolar ridge upon which when a certain degree of pressure is applied the agonizing pain is produced. The attack may, however, come on without any discernible cause. When it is found that it is a compression neuritis, the treatment is to avoid any cause for pressure upon the gums. If pains arise at other times than when the gums are pressed upon the treatment is as for other forms of trifacial neuralgia.

Senile gangrene is a dry gangrene due to tissue starvation through an obliterating arteriosclerosis. There is a feeling of numbness and tingling in the part which becomes cold and afterward livid. Later a brownish or purplish spot appears which increases in size and becomes darker in color. The part involved becomes insensible and motionless and the tissues become mummified, the destruction proceeding until all the tissues which have been deprived of their blood supply are destroyed. A dry gangrene due to an embolus begins with a sharp pain and rapid destruction of tissue. In the senile form it is sometimes possible at the onset of the disease to localize it or even prevent destruction of tissue by bringing about rapid collateral circulation

through the application of hot water, giving at the same time iodide of potassium to the point of iodism. Tissue that has become gangrenous must be removed.

Senile bronchitis is an atrophic catarrh of the degenerated mucous membrane of the bronchial tubes. In this form of catarrh there is a morning cough when a small amount of thick, dark, tenaceous mucus is brought up after considerable effort. The patient does not cough during the day unless the bronchial tubes are irritated. Some moist râles are heard at the lower part of the back before the morning cough but not afterward. This disease can be cured in a dense, humid atmosphere free from dust, and not subjected to great temperature changes. The drug treatment consists of syrup of the hypophosphite of ammonium as a stimulant to the mucous glands, and senega to aid in the expectoration. Codeine and other drugs which diminish secretions are contraindicated.

Cerebral softening is a degeneration of the brain due to sudden or rapid deprivation of nutrition. It occurs most frequently as the result of a thrombus, occasionally there is an obliterating arteriosclerosis or embolus. The symptoms of arteriosclerosis and thrombus come on slowly until complete closure of the vessel; of cerebral embolus the symptoms come on suddenly and resemble the symptoms of apoplexy. In apoplexy the face is congested, there is stertor, and the pulse is full and slow, differing in these respects from embolus. In the gradual form of softening there are at first the usual symptoms of cerebral atheroma, later a gradual loss of motion and sensation on one side and when complete closure occurs, there is paralysis and unconsciousness. There are occasionally mild apoplectiform attacks, each attack leaving the patient worse than before. Aphasia is frequently present and mental impairment is marked, in some cases proceeding to complete dementia. The treatment of cerebral softening is unsatisfactory as the same treatment which is of service in one case may be detrimental in another. The first indication when the paralysis and unconsciousness occur is to maintain the strength of the heart. This can be done by the hypodermic injection of strychnine, camphor, or ether. After the first shock is over the further treatment depends upon the condition of the patient. Recovery is possible only if collateral circulation can be established and for this purpose cardiac stimulants and hot applications to the head are required. We must be certain, however, of our diagnosis for this treatment in apoplexy will destroy the patient. The later treatment is symptomatic. Electricity, massage, and passive exercise can be tried for the paralysis and phosphorus for the mental impairment.

Preferential Senile Diseases.—Most of the diseases in the preferential group occur also in earlier life and need not be discussed here. *Grawitz' cachexia*, the disease described by him under the title, fatal cachexia without discernible cause, resembles in its symptoms pernicious anemia, but the red blood cells show no degenerative change although the number is diminished. There is a rapidly increasing pallor, loss of strength, mental and physical depression leading to fatal exhaustion. There is no known cure.

Hypertrophic bronchial catarrh, the old man's winter cough is the most frequent of the senile bronchial affections. In this condition there is an abundant, yellowish, mucopurulent expectoration brought up without difficulty. Many cases are associated with bronchiectasis. This disease can be cured only in a warm, dry, equable climate, free from dust and other sources of bronchial irritation. If the patient continues to be exposed to the extremes of temperature, especially to the cold of our northern winters no medical treatment is of the slightest avail. If the expectoration becomes putrid the inhalation of creosote is beneficial but so long as the cause persists the disease will remain.

Arthritis deformans is a progressive disease of the joints occurring after middle age. The anatomical changes seem to be identical with the senile changes found in arthrosclerosis proceeding, however, faster and further than in the normal senile joint changes. The disease generally begins in the joints that have been most actively employed, the hands, then the ankles, feet, wrists, knees, elbows, shoulders, cervical spine, hips, and lastly dorsal spine. The flexor muscles which are the ones most actively employed become permanently contracted and the articular cartilages and ligaments undergo the same changes as in arthrosclerosis. It seems that this disease is but an early and exaggerated senile process. Every conceivable departure from the normal mode of life has been given as a cause of this disease some of these causes being the same as are sometimes given as the causes of ageing. Still its etiology is unknown and its treatment unsatisfactory. Temporary relief during painful attacks can be afforded by hot applications to the swollen joints but no cure for this disease is known. Prolonged periods of remission with temporary lessened rigidity can sometimes be effected but there is no uniformity in results from the same measures. Drugs are useless except to relieve pain when the opiates and salicylates may be used. The high-frequency current, *x*-ray, hot air, Bier's hyperemia treatment, hot baths and packs, various medicinal springs, forcible extension and other surgical measures have been found of service in some cases and not in others.

Paralysis agitans is a progressive motor neurosis occurring in middle and old age, of which neither the cause nor the pathology is known and there is no known remedy. At the present time we are wont to ascribe the cause of all pathological conditions where the etiological factor is unknown, to a microorganism, perverted internal secretion or autointoxication. It is probable that most of the preferential diseases of old age that appear as primary diseases are due to some perversion in the degenerative process of senescence, this disease being due to some lesion of the cord, and the nutrition of the muscles is probably impaired. In this as in other diseases of which neither the cause nor the pathology is known treatment is necessarily empirical. Arsenic has been found of service in some cases, hyoscine and hyoscyamine sometimes relieve the stiffness and muscle cramps, hydrotherapy, electrotherapy, hot air and other non-medicinal measures have been tried with occasional benefit but there is no record of a permanent cure. Nux vomica which has been recommended as a tonic in paralysis agitans seems to intensify the cramps.

Some valvular lesions, chronic rheumatism, gout, diabetes, carcinoma, Paget's and Pseudo-Paget's disease, belong to this group but with the exception of the last they are well known and need not be described here. Pseudo-Paget's disease really belongs to the first group being a rare form of osteoporosis, an extreme type of senile degeneration of bone occurring late in life. The general appearance is that of Paget's disease, but it occurs much later in life and proceeds more rapidly, the spinal column shows one curve only and in the bent forward position the thorax seems to be pushed down into the abdomen. Nothing can be done for this condition.

Modified Diseases.—These may be made to include almost all diseases occurring in old age and in earlier life as the senile degenerative processes modify pathological processes, complicate symptoms and necessitate different treatment.

In many diseases these differences in pathology, symptoms, and treatment are slight but in some they are sufficiently marked to require special description. In hay fever in the aged, owing to the increasing atrophy of the mucous membrane the coryza becomes milder, conjunctivitis is usually absent and there is a dry, irritating bronchial catarrh with asthmatic attacks

with expiratory dyspnea, coming on at night. Bronchial asthma is rare but gastric asthma occurs frequently. In the latter there are no Charcot-Leyden's crystals, the attack comes on after a heavy meal and there is inspiratory and expiratory dyspnea. It is usually accompanied by gastric disturbance.

Senile pneumonia is the most important disease of this group. The term is here applied to a non-infectious inflammatory process in the lung of the aged. It may be primary or secondary, localized or diffused, acute or chronic, mild or virulent, masked or latent. Primary senile pneumonia is generally acute, virulent, and diffused. The secondary form is generally mild and may be latent or masked by the symptoms of the primary disease. Its existence is frequently not suspected until the terminal pulmonary edema sets in, and in some cases it is first recognized upon autopsy. The primary disease is generally due to sudden temperature changes when the surface becomes chilled, the blood is dammed back and engorges the viscera and where there has been a passive hyperemia, due to valvular disease or other cause, the sudden influx of an excess of blood converts the passive congestion into an active inflammation. The pathological changes are such as are found in pulmonary hyperemia, followed by red hepatization. There is sometimes an interstitial edema and it is difficult to determine whether the disease was a simple passive hyperemia with edema or a pneumonia. The presence of fibrin in the alveoli indicates an inflammatory process. Senile pneumonia begins with symptoms so mild that they are usually unnoticed until the disease is far advanced. The patient generally feels indisposed, preferring to remain in bed and be covered with a warm blanket, yet having no distinct symptoms of disease. After a day or two there may be vague symptoms as headache, slight fever, dyspnea, an oppressive feeling in the chest, the patient striking the chest as if to dislodge some mucus. The breathing becomes rapid and shallow but there is not the panting breathing seen in the pneumonia of earlier life, there is some cough and a mucous expectoration, or an existing bronchitis may be aggravated. In some cases the patients become rapidly weaker and die of exhaustion, in others pulmonary edema sets in or cerebral symptoms appear. Some cases begin with rapid prostration and the pulmonary symptoms, rapid, shallow breathing, dyspnea, cough, and expectoration, appear a day or two later. If there is great exhaustion the patient will not make powerful efforts to get more air and instead of dyspnea there will be a rapidly deepening cyanosis. Primary senile pneumonia in a person who was previously healthy gives early symptoms pointing to the lungs but the secondary pneumonia may exist, unnoticed on account of the more severe symptoms of the primary disease. In all cases there are prostration, rapid, shallow breathing, some cough, occasionally an increase in temperature, and sometimes a dull muttering delirium which the family may mistake for talking in sleep. The physical signs are as in the early stage of infectious pneumonia, but the respiratory sounds and percussion note may be altered if there is a portion of emphysematous lung over the affected area, and there are frequently râles of an accompanying bronchitis. The neglect to count the respirations is responsible for the frequent failure to recognize this disease until the disease is far advanced. There is no initial chill and when a severe chill occurs in the course of the disease it is a certain indication that infection has occurred and we have an infectious pneumonia, which is almost always fatal. A sudden rise in temperature above 101° is also due to infection. In all diseases occurring in the aged a rapid increase in the gravity of the disease with increased temperature, prostration and rapid, shallow breathing, indicates a pneumonic complication.

The treatment of senile pneumonia must be directed to the prevention of the fatal complications, general exhaustion, cardiac exhaustion, hypostatic congestion, edema, and cerebral complications. Mild cardiac stimulants should be given from the start but the powerful stimulants like strychnine, digitalin, camphor, ether, ammonia carbonate, and alcohol should be reserved for emergencies. If the pulse is slow and weak spartein and strychnine are required. If there is great exhaustion and there is danger of death from this cause, alcohol and strychnine must be given.

Phosphorus and arsenic are the best general tonics in this disease. Frequent change of position is necessary to prevent hypostatic congestion. Cerebral complications in this disease are usually due to deficient oxygenation of blood and to overcome this atropia should be given as a respiratory stimulant. As a last resort the inhalation of oxygen may be tried. The nitrites are of service if there is a sallow cyanosis but not if there is a purplish cyanosis. Cerebral symptoms may also be due to toxemia, either retained decomposition products, urea, or bacterial toxins. Urea intoxication is rare and the bacterial toxins occur in bacterial diseases. For the elimination of decomposition toxins active cathartics and intestinal antiseptics are required. Hygienic measures are of the greatest importance. Fresh air is imperative but the patients must not be kept outdoors in cold weather as they do not react to cold. Predigested food but no meat, coffee, and skimmed milk should form the bulk of the diet during the height of the disease.

Acute gastritis and simple *chronic gastritis* in the aged differ somewhat from the same diseases in earlier life. The senile stomach is less sensitive to gastric irritants and consequently more damage is done by them before they give pronounced symptoms. For this reason these diseases are graver, acute indigestion being sometimes rapidly fatal. The symptoms of acute gastritis are generally well marked and the indications for treatment are clear. Patients will sometimes in a mistaken sense of propriety endeavor to repress eructations when the rapid expulsion of gas should be encouraged. As emetics given when the stomach is filled with food are slow in action, emesis should be produced by the hypodermic injection of one-tenth of a grain of apomorphine. Chronic gastritis in the aged is generally associated with dilatation of the organ and the symptoms point to both conditions.

In the senile form of *chronic cystitis*, which is due to retention of urine, there is absent the glairy mucus which is a prominent symptom in the ordinary form of the disease. The ordinary form of chronic cystitis may occur in the aged as a result of the presence of a stone, growth, or some irritating constituent of the urine or as a sequel to an acute cystitis. Irrigation is of little use in this form of cystitis except as a momentary cleansing wash. Treatment should be directed toward the relief of the causes of the retention if possible, or else the frequent emptying of the bladder.

Dermal affections generally present some peculiarities in the aged owing to the senile changes in the skin. Senile purpura, a transitory and a permanent form, senile angioma, senile sebaceous nevi, senile keratoma, senile warts, and acne rosacea occur exclusively in middle or advanced life. The transitory form of purpura occurs as hemorrhagic macules upon the lower limbs after prolonged standing and disappears when the legs are at rest in a horizontal position. The spots are probably due to capillary engorgement. The permanent form occurs most frequently upon the back of the forearms and hands, beginning in bright red spots which increase in size, later becoming darker for a few weeks or months, then gradually becoming lighter in color until they have disappeared. They may, however, reappear at irregular intervals. These two diseases produce no distress, do not affect the health and nothing need be

done for them. Senile angioma or capillary varix consists of a minute mass of dilated capillaries lying under the epidermis, appearing as dark red macules about the size of a pin head on the back and chest. They are harmless and need no treatment.

Senile sebaceous nevi are hypertrophied sebaceous glands sometimes covered by fine telangiectases and topped by comedones from which upon pressure a small amount of sebum can be expressed. They appear generally on the forehead, sometimes upon the cheek and nose. No treatment is necessary although they can be squeezed out.

Senile keratoma is a warty growth generally upon the face or back of the hands sometimes upon the neck or scalp. The growth begins as a small reddish or brownish plaque, gradually increases in height and size until it is about as large as a coffee bean, it is granular or rough to the touch and is covered by fine dry or fatty scales. Removal of the lower layer of these scales leaves a granular bleeding surface. Senile keratoma sometimes becomes malignant and it should therefore be removed as soon as its character is determined. It is distinguished from the senile wart which is a soft growth occurring generally on the back, occasionally on the chest and rarely on the face, by the location, origin, and the presence of scales. The senile warts are the most frequent dermal affections of old age and aside from their unsightly appearance they are innocuous. Acne rosacea occurs most frequently in those who use alcohol to excess, occasionally in those suffering from digestive disorders. According to Kaposi the rosacea nose of the wine drinker is bright red, of the beer drinker it is cyanotic or violet, of the liquor drinker it is dark blue. Owing to the unsightly appearance of the face especially in the second stage when papules and nodules occur these cases often come for treatment. The telangiectasis surrounding the hyperplastic sebaceous glands can generally be relieved by an injection of a one-tenth per cent. solution of adrenalin. Sometimes the negative current, the thermocautery, or the knife is more effective. For the glandular enlargement sulphur, ichthyol, tincture of iron, tannic acid, and other astringents have been recommended. Radiotherapy has given good results in a few cases. Eczema in the aged presents some peculiarities. The acute form occurs almost exclusively about the genitals and lower limbs after scratching. The chronic forms are more tenaceous, the itching is more severe, scale and crust formation more profuse, and there is frequently a sero-sanguineous or purulent sanguineous exudation. The most frequent type, eczema rubrum, exhibits the typical symptoms, exudation and crusting following redness, swelling, and infiltration. Intertrigo occurs frequently in the aged and many cases of eczema follow scratches. Pityriasis tabescentium, in which fine scales can be rubbed off the skin, is a normal senile condition.

Dermatoses.—While bacterial diseases are rather infrequent in the aged some of the bacterial dermatoses are often met with. Erysipelas occurs frequently and is confined almost solely to the lower limbs, when there are scratch lesions or ulcers. Furuncles occur frequently during diabetes, sometimes during the progress of a nephritis or intestinal disorder. These do not differ from the diseases as they occur in earlier life. Zoster senilis is a form of zoster occurring in the aged in which the symptoms are much more severe and persistent than in earlier life. Hidrocystoma occurs frequently on the face of elderly women who work in hot rooms. These are retention cysts in the opening of the sweat glands and when the patient perspires the perspiration fills these cysts which become elevated above the surface of the skin. We find some difficulties in treating senile dermal affections on account of the changes in the skin. Being dryer and the surface circulation poorer, drugs are not readily absorbed, the healing process is slower, irritants are liable to produce ulcer and gangrene, and rubbing leaves an excoriated surface which is a good field for bacterial invasion. If absorption of a drug is sought an animal base must be used and for this purpose sweet butter is an ideal base. It is, however, liable to become rancid in hot weather and to prevent this a small amount of salicylic or boracic acid must be added. Drugs in a petrolatum base are slowly, if at all, absorbed. Few dermatoses are purely local. Most have a constitutional or bacterial origin and any successful treatment must include the treatment of the cause.

Chronic ulcer, especially upon the leg, is frequently met with in the aged and is usually due to a scratch, blow, bruise, or other injury which on account of the poor surface circulation does not heal. Syphilitic and tubercular ulcers can generally be determined by their history and malignant ulcer has usually a history of a preceding growth or a scar. The simple ulcer gives no local distress, does not produce constitutional symptoms unless infected, and is generally neglected until symptoms of infection or the pain due to nerve involvement appears. In dealing with simple chronic ulcer in the aged we must bear in mind that granulations will not start in disorganized tissue and that an active hyperemia is necessary to initiate healthy granulation and a mild hyperemia is required to keep it up. The following treatment has been successful in many cases. The ulcer is first cleaned with warm water then with a solution of peroxide of hydrogen. When the bubbling ceases the peroxide must be washed away with warm water. A five per cent. solution of cocaine is then applied followed by a caustic, either nitrate of silver, chromic acid or carbolic acid. This is then washed away and the ulcer filled with lanoline or other animal fat. The next day the washing is renewed and after the cocaine application the slough should be removed with a pair of forceps or the knife. An antiseptic wash can be used during or after the removal but this must be washed away again with clean water. To bring about the active hyperemia necessary to start the granulations, small cups should be used or hot cloths, dry or moist, should be applied. After a few minutes and while the ulcer and surrounding skin is still red, the ulcer should again be filled with an animal fat and covered with gauze. Warmth should be maintained for a day or until the base of the ulcer shows that the healing process has begun.

Various *psychoses* and *neuroses* occur in the aged, some being distinctively senile, some modified in their clinical picture. Senile dementia, the most frequent psychosis, has been described. An acute senile dementia has been reported in which there was rapid dementia, with incoherence and confusion, restlessness, insomnia and rise in temperature. Hypochondria followed by melancholia occurs frequently in the aged and these generally terminate in dementia. Hypochondria is sometimes primary, in other cases it follows psychasthenia or neurasthenia. In hypochondria there is always an unnatural fear or a haunting anxiety without a definite object. The hypochondriac is given to introspection and self-examination and the discovery of any thing or circumstance that appears to him abnormal gives rise to an agonizing fear of disease. It is often possible to explain away the cause of the fear of the hypochondriac, but when melancholia has set in this is impossible. It is sometimes possible to rouse the melancholic patient in the early stage of his disease through some powerful impression upon his senses or through memory as when an old familiar air is repeated.

Incarceration in an asylum is probably the worst possible treatment for senile psychoses. Constant diversion is necessary, the senses must be kept engaged but not confused, hobbies which are not foolish should be encouraged, and every means should be taken to instil interest in something else than self and disease. Senile paranoia and oikeomania, the unnatural fear of members of the family, occur frequently but

are seldom recognized as the fear of persecution is generally suppressed and the patient becomes melancholic. Senile psychasthenia and senile neurasthenia are sometimes met with differing but slightly from these conditions in earlier life. In the aged even slight mental tension after a period of rest will suffice to bring on brain fag and if continued there will be mental confusion ending in mental exhaustion. A similar process leads to nervous exhaustion, a period of excessive nervous irritability and generally muscle activity, nerve fatigue similar to brain and muscle fatigue, and finally complete nervous exhaustion. In the aged neurasthenia is always accompanied by mental depression and the patient exaggerates his loss of power and energy. The senile neurasthenic generally becomes hypochondriacal and unless improvement is soon brought about this proceeds to melancholia. The treatment is the same as for senile psychoses.

The aged frequently complain of insomnia but close questioning will generally show that the individual has sufficient sleep in short naps during the day and the longer periods at night. The aged person may take a nap after each meal, after reading the paper or doing other mental work, after physical exercise, etc., and in this way he may get two or three hours sleep during the day, and going to bed early, sleeping five or six hours, he awakes in the early morning unable to sleep longer. This is the usual basis for his complaint. Nothing need be done for this condition, but efforts should be made to keep him awake longer in the evening. Real insomnia is rare in the aged and always due to some pathological condition.

Of the infectious diseases *erysipelas* is the only one common in the aged. This is due to the frequency of ulcers and scratch lesions these being fruitful fields for infection. Influenza occurs often in the aged, the victims being usually sufferers from chronic bronchitis. Here the impaired mucous membrane offers a good field for the propagation of the bacillus of the disease. The resisting power to infection is apparently greater in old age than in earlier life, some of the infectious diseases of early life rarely or never occurring in the aged. Diphtheria is sometimes found in the aged and is then so mild as to pass unnoticed, unless it involves the larynx. Malaria, if it occurs, is a recrudescence from earlier life, rarely a primary attack. Dysentery occurs occasionally and cholera and variola, during epidemics, attack the aged who generally succumb in a day or two after the initial symptoms appear. Typhoid is infrequent and when it occurs it follows an irregular course. Infectious pneumonia is generally a secondary infection of a senile non-infectious pneumonia and is then rapidly fatal. Fibroid phthisis is the only form of tuberculosis that is at all prevalent in the aged although the acute form of pulmonary tuberculosis has been reported in the aged. Acute articular rheumatism is almost always carried over from earlier life. Sepsis is rare in the aged and is almost always fatal. The temperature range in the aged is usually low but cerebral symptoms are almost always present, sometimes so marked that in the absence of chills and high temperature, a cerebral disease is suspected. Gonorrheal infection is rare in the aged and syphilis when it is found in advanced life is almost always in the third stage. Tertiary symptoms are known to have appeared more than fifty years after the initial lesion. Serum therapy is not as effective in the aged as in earlier life and the danger from anaphylaxis is greater. The aged possess greater immunity from infection, but when this immunity is overcome, either through the virulence of the microorganism or through diminished vital resistance, the infection is more profound and though the symptoms may be milder or atypical the disease is generally grave. The only exceptions to this are erysipelas when affecting the lower limbs in which case the constitutional symptoms are mild, and diphtheria in which the local symptoms are usually mild though prolonged.

Care of the Aged.—The aged want constant attention and need constant care. But sympathy without a knowledge of the senile organism, of the mental and physical capacity, of the needs and wants, of the peculiarities and infirmities of the aged, is worse than useless. The sudden withdrawal of the old man from his accustomed routine of life and work, to give him a well-earned rest, will cause a more rapid mental and physical breakdown than if he were left to continue in his accustomed mode of life. Advancing age requires certain changes but these must be introduced gradually. Old persons cannot readily accommodate themselves to radical innovations, they cannot break themselves of life-long habits at once, they cannot dismiss old ideas and replace them with modern ideas and measures. They are looked upon as old fashioned and the younger generation soon loses patience with them.

The mental attitude of the aged is usually apathy, depression, or resignation, rarely elation. Unless the mind is occupied in some pleasurable pursuit it is engaged in introspection and retrospection or else in looking forward to the inevitable end. Pleasurable mental occupation is the best prophylaxis against melancholia and dementia. Harmless hobbies should be encouraged. The association with the young, not with children but with mature men and women, the discussion of topics with which the old person is familiar, new sights and scenes, all have a beneficial effect upon the mind of the aged. Flattery, especially by the young, has a powerful psychic influence. It stimulates the old person's pride in his appearance and he will make an effort to look young and feel young, it will rouse ambition and he will take a brighter view of life. Mental stimulation in a pleasurable direction should be the first and foremost consideration in dealing with the aged. Mental confusion should be avoided and those who have the care of the aged should remember that the old man's mind does not operate as fast as their own. They must not lose patience if their charge does not respond instantly to their suggestions. The old person should be encouraged to read and if there is presbyopia proper glasses should be secured. The neglect to furnish glasses in institutions, thereby depriving the inmates of the mental stimulation which the reading of books and newspapers arouses, is one of the principal causes for the apathetic attitude of these old persons. Another fault in institutions generally is the segregation of the sexes. The association of the sexes in institution as in home life conduces to the happiness and well-being of the aged. Old people like old familiar airs, old books, old friends. Whatever will tend to stimulate pleasant memories of the past and interest in the present should be supplied without imposing upon the mind the idea that it is done on account of the individual's age or in a spirit of charity.

The most important hygienic measures applicable to the aged relate to food and exercise and the retardation of degenerative processes. Some of these have been mentioned in the treatment of various senile degenerations. A cane should be used as soon as the tendency to stoop is noticed, and the cane should be so long that the person will not be obliged to stoop forward when the point on the ground is at a distance of an ordinary step from the body. Shoulder braces aid in preventing the compression of the chest walls, and an arm chair will enable the individual to expand the upper part of the chest better when the arms are on the rests. The aged person should not be permitted to neglect the bowels or bladder. The aged will defer the evacuations if there is any difficulty in defecation or urination and will assure the family that it is all right even when bowels and bladder are both overdistended. The sterilization of the catheter should never be left to the patient although he may become quite expert in its introduction. Some old persons become accustomed to cathartics and insist

upon taking them when there is no necessity. A placebo will sometimes help as well as the accustomed drug but it will be virtually impossible to convince the old person that he can get along without a drug. For this reason it is better to continue the placebo than to disillusion the patient. As the surface circulation is poor the aged generally feel cold and need warm clothing even in summer. Close-fitting woolens are better than heavy overcoats and wraps. Special care should be taken to keep the feet and legs warm as the lessened sensibility makes them less sensitive to cold while the poor surface circulation makes them liable to chilblains, frost-bites, etc.

Obese aged persons dread the tub bath as they find it difficult to get in and out. A shower bath, the individual seated on a chair, will overcome this difficulty. Alcohol, glycerin, and strong alkaline soaps are injurious on the dry, senile skin. Unless the person is accustomed to the cold bath this should be forbidden and even when accustomed to the cold bath the lessened reaction to cold makes it dangerous.

It is impossible to give definite rules for feeding the aged. The "little and often" rule is irrational, and the custom to give the aged what they want, is worse. Food should not be given in shorter intervals than five or six hours, and with the falling out of the teeth the amount of meat should be diminished and only soft boiled meat should be given. The amount of food altogether should be diminished, especially carbohydrates, as with increasing inactivity there is less necessity for energy-producing substances. Feeding by rule, by percentages and calories is rarely applicable or advisable in the aged. When persons have lived so rationally that they have reached old age the amount and character of their food can safely be left to their judgment until their judgment is impaired. This also applies to drinking and smoking. As the appetite diminishes the old person eats less, there is a distaste for fats, sweets, and insipid foods, and when he does make an occasional dietetic error, he will learn more from such a lesson, applicable to himself, than any work on dietetics can teach him. It is equally impossible to give any definite rules for exercise. Physical exercise is necessary, but the amount and kind must depend upon the strength, the condition of the heart and lungs, the mental attitude, the character of exercise to which the individual is accustomed, and the needs of the organism. Exercise is necessary to produce heat, to increase metabolic activity, to prevent anchylosis, and to serve as a recreation from mental work or other physical exercise. The kind of exercise depends upon the preferences of the individual and here there is one rule: no exercise which involves sudden strain, as jumping, or prolonged strain, as tug of war, rowing, wrestling, etc. An imperative rule in all forms of exercise in the aged is to stop the moment fatigue, dyspnea, or palpitation sets in. The best form of exercise for the aged is a walk over an unfamiliar road having a slight incline and having opportunities for taking frequent rests. As the mental powers wane it may be necessary to enforce exercise and this should be done by a tactful attendant who will use common sense as well as strength. As most of the diseases of the aged begin insidiously and proceed gradually, the family and attendants of the aged should be instructed to observe slight changes in the physical and mental condition of their charges. When an aged person, accustomed to be up shows a disinclination to leave his bed, or there is anorexia without other symptoms of gastric disorder, or if he talks in his sleep and has never done so before, or he remains an unusually long time in the closet, or strikes his chest in an effort to dislodge some mucus, the persons around him should understand that there is probably some serious illness present. Snoring during sleep does no harm, but groaning during sleep or a complaint of pain at any time should receive immediate attention.

"Senility is a state of physiological valetudinarianism. It requires special study, not as a pathological condition of maturity, but as an entity entirely apart from maturity; and the person having charge of the aged should have the knowledge that comes from such study. This applies as well to the physician who treats the ailments of the aged." I. L. NASCHER.

BIBLIOGRAPHY.

Nascher: Geriatrics; The Diseases of Old Age and Their Treatment; Philadelphia, 1914. P. Blakiston's Son & Co.
Saundby: Old Age; Its Care and Treatment. London, 1913.
Pic and Bonnamour: Maladies des Vieillards. Paris, 1912.
Schwalbe: Lehrbuch der Greisenkrankheiten. Stüttgart, 1909.
Seidel: Diseases of Old Age. Wood's Monographs. June, 1890.
Fothergill: Diseases of Sedentary and Advanced Life. London, 1885.
Charcot and Loomis: Diseases of Old Age. New York, 1881.
Floyer: Medicina Gerocomica. London, 1724.

Old Point Comfort, Newport News, and Virginia Beach.—Old Point Comfort, Va., is situated at the southeastern extremity of Yorktown Peninsula, at the entrance to Hampton Roads, through which the James River empties into Chesapeake Bay. Situated thus it commands a view directly out to sea between Cape Charles and Cape Henry. Directly south of Old Point Comfort, at a distance of about eleven miles, is the city of Norfolk, Va. In a westerly direction from Old Point, seven miles distant, as one passes up through Hampton Roads to enter the James River, is situated Newport News. "All vessels coming down the James River from Richmond and Petersburg, and those entering and leaving the harbor of Norfolk (and the Portsmouth Navy Yard there situated) must pass close to Old Point Comfort, while the entire seagoing commerce of Chesapeake Bay passes it at no great distance on its way to and from the ports of Baltimore, Annapolis, and Alexandria."

Old Point Comfort is a government reservation, and here is situated the famous fortification of Fort Monroe, the largest of its kind in America, commanding the entrance to Hampton Roads and the approach to the navy yard at Norfolk. The very extensive marine view, the attractions of a large military garrison, combined with a mild climate a considerable portion of the year, render this resort one of the most popular ones in the country. Moreover, it is very easily and comfortably reached from the North, and affords excellent accommodations, though expensive.

The accompanying climatic table based upon observations taken at Norfolk, will serve also to illustrate the climate of Old Point and Newport News, for the three places are so near one another that there can be but little difference in their climatic elements.

A comparison is also given of the temperatures of Norfolk, New York, and Boston for the months of February, March, and April, the season at which "Old Point" is especially resorted to by visitors from the North.

Like Atlantic City, Old Point Comfort is an all-year-round resort, frequented during the colder seasons of the year more especially by visitors from the North, and during the summer by those from the South. As has been said, and as is the case with Atlantic City, the season of February, March, and April is the popular one for Northern visitors and invalids who desire to escape the unstable climatic conditions of a Northern spring during these months. One will find at this resort a large amount of sunshine, a comparatively mild temperature, no great amount of rain, and less wind than at Atlantic City. When one considers the ready accessibility of "Old Point" from the North, and its favorable climatic features, its value as a health resort must be regarded as very considerable. The sources of amusement and

CLIMATE OF NORFOLK, VA., LATITUDE, 36° 51′; LONGITUDE, 76° 17′. PERIOD OF OBSERVATION, THIRTEEN YEARS.

	Jan.	Feb.	March.	April.	May.	July.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature (degrees Fahrenheit):														
Average or normal, degrees	40.8	42.9	48.0	56.3	67.1	79.6	61.0	49.6	42.2	57.1	77.4	60.4	41.8	59.2
Average daily range	14.8	16.1	16.9	17.5	17.8	18.1	14.5	14.9	14.2	17.4	17.2	14.4	15.0	16.0
Mean of warmest	47.5	53.2	57.7	64.0	75.9	89.0	70.9	58.7	50.9					
Mean of coldest	32.7	37.1	40.8	47.5	58.1	70.9	56.4	43.8	36.7					
Highest or maximum	80.0	81.0	81.0	92.0	98.0	102.5	89.0	80.0	73.0					
Lowest or minimum	8.0	9.0	16.0	27.0	38.0	60.0	31.0	20.0	6.0					
Humidity:														
Average mean relative (per cent.)	75.5	70.6	66.4	68.2	68.8	70.3	74.7	72.7	71.8	67.8	71.8	74.8	72.6	71.8
Precipitation:														
Average in inches	3.89	3.85	4.35	4.29	3.54	5.39	3.96	3.58	3.80	12.18	15.65	12.77	11.54	52.1
Wind:														
Prevailing direction	N.	N.E.	N.	S.W.	S.W.	S.W.	N.E.	N	S.W.	S.W.	S.W.	N.E.	N.	S.W.
Average hourly velocity in miles	7.5	8.7	9.5	8.9	8.0	6.7	7.2	7.7	7.5	8.8	6.8	7.2	7.9	7.7
Weather:														
Average number clear days	8.8	8.6	10.0	9.5	11.0	8.5	13.7	11.2	10.1	30.5	27.1	35.5	27.5	120.6
Average number fair days	11.2	10.9	10.8	10.5	12.3	14.5	9.6	9.8	11.8	33.6	40.9	29.8	33.9	138.2
Average number clear and fair days	20.0	19.5	20.8	20.0	23.3	23.0	23.3	21.0	21.9	64.1	68.0	65.3	61.4	258.8

TEMPERATURE AND RAINFALL AT FORT MONROE, VA. LATITUDE, 37° N.; LONG., 76° 19′ W.

	Feb.	March.	April.	July.	Oct.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
Mean temperature (degrees Fahrenheit)	41.81	49.90	55.99	78.73	61.90	41.10	57.34	77.07	61.92	41.77	59.52
Maximum temperature	72.00	78.00	91.00	102.00	89.00	69.00					
Minimum temperature	4.00	13.00	31.00	61.00	30.00	17.00					
Mean precipitation in inches	2.72	3.30	2.98	5.34	2.92	4.58	10.17	15.32	10.18	10.67	47.04

Temperature (degrees Fahrenheit).	February.			March.			April.			Season.		
	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.
Average daily maximum, degrees	53.2	40.1	38.6	57.7	45.9	43.2	64.0	56.3	53.2	58.3	47.4	45.0
Average daily minimum	37.1	25.9	20.1	40.8	31.3	26.7	47.5	40.5	36.1	41.8	32.5	27.6
Average daily temperature	42.9	31.3	28.1	48.0	36.8	34.2	56.3	46.9	43.9	49.1	38.3	35.4

diversion are also many, and greatly enhance the value of the resort. They are the ever-shifting panorama of the ocean with the constant passing of various craft; the fascination of the military life, such a predominant feature here; the frequent visits of warships; the Normal and Agricultural Institute for colored people and Indians at Hampton, two and a quarter miles distant; and the National Soldiers' Home at the same place; the various shorter or longer excursions by water to Norfolk, Richmond, Virginia Beach, the York River, etc. The Hampton Golf Club and the Country Club are accessible to the guests of the hotels, and are said to be kept in excellent shape. The links overlook the sea, and at the attractive club house there are a tea room and café, and music on Saturday afternoons. There are also sailing, driving, and bathing in the season. Attention should also be called to the great advantage of the beach as a playground for children. Such a climate and such a resort are especially to be recommended for those who with difficulty endure the rigors of a Northern winter, and at the approach of spring find themselves in a depressed condition, physically and mentally, without being seriously ill. It is also to be recommended for convalescents from various acute diseases, for those who are recovering from the effects of an operation, and for scrofulous children. For the aged, the feeble, the neurasthenic, those suffering from insomnia, and for weakly children it offers, for a portion of the year at least, a mild and pleasant asylum. It is said to be immune from malaria. It can hardly be recommended for those suffering from any serious disease of the respiratory organs or from renal disease.

As a halfway station between the North and the more Southern resorts in Florida, Georgia, and South Carolina, "Old Point" proves serviceable in the late autumn and in the spring.

The "Chamberlin," a vast caravansary, affords excellent accommodations. It is directly upon the water and has a pavilion over the water, sun parlor, palm garden, etc. Inside of the hotel is a large swimming pool of filtered sea water, maintained at an equable temperature at all seasons. An important feature at this hotel is the elaborate hydrotherapeutic department under the direction of a competent physician. All varieties of baths are given, such as the Schott treatment, the Aix-les-Bains and the Vichy systems, and all within the hotel. Electricity is also employed in all its forms. Not only sea water at various temperatures is used, but many kinds of medicated baths including those with radioactivated waters. Many and varied diseased conditions are treated here by means of the baths and electricity,

such as rheumatism, gout, chronic disorders of the kidney, bladder, liver, gastric, and intestinal derangement, neurasthenia, hypochondria, insomnia, diseases of the heart and blood-vessels, and, in brief, such diseases and abnormal conditions as are benefited by hydrotherapeutic and electro-therapeutic applications. From an artesian well is obtained an "alkaline-saline-purgative" water which is employed both for bathing and drinking. While taking the "cure" the exercise and diet are supervised by the physician. For those desiring less expensive accommodations, there are private boarding houses and cottages. Old Point is easily reached either by water or rail.

Newport News, while possessing a similar climate, has less in the way of attractions to offer than Old Point, and is not so popular a resort, though it possesses much of historic interest. Here is located an extensive ship-building plant, with an immense dry-dock. It is also a port of importance. The Hotel Warwick offers good accommodations, and for one who desires a quieter existence than that at Old Point, Newport News would appear to be the more attractive of the two. It is reached by boat from Norfolk.

Virginia Beach is situated eighteen miles east of Norfolk, with which it is connected by rail, and six miles south of Cape Henry. It has a fine and extensive beach, affording good surf bathing, and is protected landward by extensive pine forests. The average winter temperature is 54° F., and the extremes for the year 34° F.

The climate is equable and mild and the soil dry. The Princess Anne Hotel is well appointed and offers excellent accommodations and food. The attractions are boating, bathing, fishing, shooting, and horseback riding. This climate and resort "are adapted for cases of chronic nephritis, bronchitis, overwork, and neurasthenia." (Hinsdale.)

EDWARD O. OTIS.

Old Sweet Springs.—Monroe County, West Virginia.

POST-OFFICE—Old Sweet Springs. Hotels, Cottages.

ACCESS—Viâ Chesapeake and Ohio Railroad to Alleghany Station, where automobiles meet all passengers for the springs. The location of Sweet Springs is more open than is generally the rule in mountain districts. They issue up in a valley of great loveliness, but are surrounded by mountain scenery of surpassing grandeur. The elevation is 2,200 feet above the sea level, and the climate during the summer months is of the usual delightful character found in this region. The buildings at the springs are of brick and of a very substantial character, and at the height of the season the place resembles a miniature city. Six hundred guests are easily entertained at one time. The main building is about 300 feet in length, and no expense has been spared to make it one of the best summer hotels in the country. The hotel property embraces a grass farm of 2,000 acres, which guarantees an abundant supply of dairy products, the best of poultry, mutton and beef. The golf links are unsurpassed. The water of the Sweet Springs is not unpleasant to the taste, but its temperature (79° F.) renders it rather warm for general use in drinking. For bathing, however, it is very agreeable. Two pools have been provided—one for men, the other for women—each seventy-five feet long, forty feet wide, the women's from three to five feet deep; the men's from five to six feet deep. The water is so clear that moss-covered stones on the bottom are distinctly visible. There are also warm and hot steam baths of both mineral and freestone water. The following analysis of the mineral water here was made by Prof. William B. Rogers:

100 CUBIC INCHES CONTAINS:

Solids.	Grains.
Calcium sulphate	5.703
Magnesium sulphate	4.067
Sodium sulphate	2.746
Calcium carbonate	13.013
Magnesium carbonate	0.357
Calcium chloride	0.065
Sodium chloride	0.060
Magnesium chloride	0.156
Iron peroxide	0.065
Silica	0.075
Earthy phosphates	Trace.
Iodine	Trace.
Gases.	**Cu. in.**
Carbonic acid	37.17
Nitrogen	1.08
Sulphureted hydrogen	Trace.
Oxygen	Trace.

This is a very good alkaline-calcic water possessing tonic, diuretic, alterative, and mild cathartic properties. It is valuable in functional disorders of the stomach, and is said to be employed with signal benefit in chronic diarrhea and dysentery. It has also produced good results in rheumatic troubles, and in some forms of neuralgia, as well as in renal and urinary disorders.

The water of the Chalybeate Spring has proved beneficial in various forms of anemia and other maladies. Old Sweet Springs has been famous as a health resort for more than 125 years.

EMMA E. WALKER.

Olea.—Plural of *oleum*, oil. The latter is a vague term for many kinds of substances of different chemical characters and of various composition. They are fluid at ordinary temperature or below the boiling point of water; they are composed (mainly or entirely) of carbon and hydrogen; they are insoluble in water; they are inflammable; they may be classified as (1) minerals oils, (2) fixed oils (with fats and waxes), (3) essential or volatile oils. For a consideration of these different varieties the reader is referred to the article *Oil*, and here will be given only a list of the oils official in the U. S. Pharmacopœia.

	Dose.
OLEUM ADIPIS (lard oil).	
OLEUM ÆTHEREUM (ethereal oil).	
OLEUM AMYGDALÆ AMARÆ (oil of bitter almond).	♏ss (0.03)
OLEUM AMYGDALÆ EXPRESSUM (expressed oil of almond).	fl. ʒi. (30.0)
OLEUM ANISI (oil of anise)	♏iii. (0.2)
OLEUM AURANTII CORTICIS (oil of orange peel)	♏iii. (0.2)
OLEUM BETULÆ (oil of betula)	♏xv. (1.0)
OLEUM CADINUM (oil of cade)	
OLEUM CAJUPUTI (oil of cajuput)	♏viii. (0.5)
OLEUM CARI (oil of caraway)	♏iii. (0.2)
OLEUM CARYOPHYLLI (oil of cloves)	♏iii. (0.2)
OLEUM CHENOPODII (oil of chenopodium)	♏iii. (0.2)
OLEUM CINNAMOMI (oil of cinnamon; oil of cassia).	♏i. (0.05)
OLEUM COPAIBÆ (oil of copaiba)	♏viii. (0.5)
OLEUM CORIANDRI (oil of coriander)	♏iii. (0.2)
OLEUM CUBEBÆ (oil of cubeb)	♏viii. (0.5)
OLEUM ERIGERONTIS (oil of erigeron)	♏iii. (1.0)
OLEUM EUCALYPTI (oil of eucalyptus)	♏viii. (0.5)
OLEUM FŒNICULI (oil of fennel)	♏iii. (0.2)
OLEUM GAULTHERIÆ (oil of gaultheria)	♏xv. (1.0)
OLEUM GOSSYPII SEMINIS (cotton seed oil)	fl. ʒss (16.0)
OLEUM HEDEOMÆ (oil of hedeoma)	♏iii. (0.2)
OLEUM JUNIPERI (oil of juniper)	♏iii. (0.2)
OLEUM LAVANDULÆ FLORUM (oil of lavender flowers).	♏iii. (0.2)
OLEUM LIMONIS (oil of lemon)	♏iii. (0.2)
OLEUM LINI (linseed oil)	fl. ʒi. (30.0)
OLEUM MENTHÆ PIPERITÆ (oil of peppermint)	♏iii (0.2)
OLEUM MENTHÆ VIRIDIS (oil of spearmint)	♏iii. (0.2)

	Dose.
Oleum Morrhuæ (cod liver oil)	fl. ʒss (16.0)
Oleum Myristicæ (oil of myristica)	♏iii. (0.2)
Oleum Olivæ (olive oil)	fl. ʒi. (30.0)
Oleum Picis Liquidæ (oil of tar)	♏iii. (0.2)
Oleum Pimentæ (oil of pimenta)	♏iii. (0.2)
Oleum Ricini (castor oil)	fl. ʒss (16.0)
Oleum Rosæ (oil of rose)	.....
Oleum Rosmarini (oil of rosemary)	♏iii. (0.2)
Oleum Sabinæ (oil of savin)	♏i. (0.05)
Oleum Santali (oil of santal)	♏viii. (0.5)
Oleum Sassafras (oil of sassafras)	♏iii. (0.2)
Oleum Sinapis Volatile (volatile oil of mustard.	♏ss (0.008)
Oleum Terebinthinæ (oil of turpentine)	.....
Oleum Terebinthinæ Rectificatum (rectified oil of turpentine).	♏xv. (1.0)
Oleum Theobromatis (oil of theobroma)	.....
Oleum Thymi (oil of thyme)	♏iii. (0.2)
Oleum Tiglii (croton oil)	♏i. (0.05)

R. J. E. Scott.

Oleata.—An oleate (*oleatum*) is a liquid solution of a metallic salt or alkaloid in oleic acid; it is intended for external administration only. (See *Oleic acid.*) There are five oleates official in the United States Pharmacopœia and four in the National Formulary.

Oleatum.		Composition.
Oleatum Aconitinæ (oleate of aconitine).	N. F.	Aconitine (U. S. P.), 2 gm.; oleic acid (U. S. P.), 98 gm.
Oleatum Atropinæ (oleate of atropine).	U. S. P.	Atropine, 2 gm.; alcohol, 2 c.c.; oleic acid, 50 gm.; olive oil, to make 100 gm.
Oleatum Cocainæ (oleate of cocaine).	U. S. P.	Cocaine, 5 gm.; alcohol, 5 c.c.; oleic acid, 50 gm.; olive oil, to make 100 gm.
Oleatum Hydrargyri (oleate of mercury).	U. S. P.	Yellow mercuric oxide, 25 gm.; distilled water, 25 c.c.; oleic acid, to make 100 gm.
Oleatum Quininæ (oleate of quinine).	U. S. P.	Quinine, 25 gm.; oleic acid, 75 gm.
Liquor Sodii Oleatis (solution of sodium oleate).	N. F.	White castile soap, 625 gm.; water, to make 10,000 c.c.
Oleatum Veratrinæ (oleate of veratrine).	U. S. P.	Veratrine, 2 gm.; oleic acid, 50 gm.; acid, 50 gm.; olive oil, to make 100 gm.
Oleatum Zinci (zinc oleate).	N. F.	Zinc acetate, crystallized, 115 gm.; solution of sodium oleate (N. F.), 5,000 c.c.; water, a sufficient quantity.
Oleatum Zinci (oleate of zinc; U. S. P., 1890).	N. F.	Zinc oxide, 50 gm.; oleic acid, 950 gm.

R. J. E. Scott.

Oleic Acid.—Oleic acid ($HC_{18}H_{33}O_2$) is the acid product of the decomposition of olein, the fluid constituent of natural oils and fats. Under the title, *Acidum Oleicum*, Oleic Acid, the United States Pharmacopœia recognizes the acid "prepared in a sufficiently pure condition by cooling commercial oleic acid to about 5° C. (41° F.), then separating and preserving the liquid portion." Such grade of acid is an oily liquid, yellow or brownish yellow in color, and having an odor and taste as of lard. On exposure to air it absorbs oxygen and darkens in color. Its specific gravity is about 0.900 at ordinary temperatures. It is insoluble in water, but dissolves completely in alcohol, chloroform, benzol, benzin, oil of turpentine, and the fixed oils. On cooling the acid first becomes semisolid, and at 4° C. (39.2° F.) congeals to a whitish, crystalline mass.

The medicinally valuable property of oleic acid is that while retaining the physical properties of a fixed oil, the acid is yet of high diffusive power, and, accordingly, upon inunction passes through the unbroken skin into the general circulation, and leaves behind a smooth, soft, and supple, but not greasy condition of the integument. Being an acid it forms salts with salifiable bases, many of which salts are soluble in excess of oleic acid. Such solutions of oleates in oleic acid are found to permeate the skin as readily as the simple acid, and for this reason such solutions form a class of medicines defined as "oleates," and devised as means of medicating the general circulation through the unbroken skin. Oleic acid is used exclusively for the manufacture of these pharmaceutical "oleates."

Edward Curtis.
R. J. E. Scott.

Oleoresinæ.—An oleoresin (*oleoresina*) is a liquid preparation made by extracting with ether certain drugs whose medicinal activities reside jointly in oily and resinous constituents. After extraction the ether is evaporated and the oleoresin obtained in concentrated condition. The pharmacopœial oleoresins (six in number) are thick fluids of concentrated medicinal strength; and are administered in capsule or emulsion. Oleoresins differ from fluid extracts in not being of any uniform strength.

Oleoresina Aspidii (oleoresin of aspidium).	Aspidium, 500 gm.; acetone, q.s. Dose gr. xxx. (2.0).
Oleoresina Capsici (oleoresin of capsicum).	Capsicum, 500 gm.; acetone, q.s. Dose gr. ss. (0.030).
Oleoresina Cubebæ (oleoresin of cubeb).	Cubeb, 500 gm.; alcohol, q.s. Dose gr. viii. (0.5).
Oleoresina Lupulini (oleoresin of lupulin).	Lupulin, 500 gm.; acetone, q.s. Dose gr. iii. (0.2).
Oleoresina Piperis (oleoresin of pepper).	Pepper, 500 gm.; acetone, q.s. Dose gr. ss. (0.03).
Oleoresina Zingiberis (oleoresin of ginger).	Ginger, 500 gm.; acetone, q.s. Dose gr. ss (0.03).

R. J. E. Scott.

Oleosacchara.—An *oleosaccharum* (or oil sugar) is a preparation made by triturating one drop of an essential oil with two grams of white sugar. This class of preparation is not found in the United States Pharmacopœia or in the British Pharmacopœia, but is referred to in the National Formulary.

R. J. E. Scott.

Oleum Amygdalæ Expressum.—U. S. P. *Expressed Almond Oil; Sweet Almond Oil; Oil of Sweet Almonds.*—The fixed oil expressed from bitter or sweet almonds. Although obtainable from both varieties, this oil is mostly the product of bitter almonds, previous to the extraction of their volatile oil. The ground or crushed seeds, enclosed in cloth bagging, are pressed between steel plates. For the finer oil, the temperature is kept below 30° C., a lower grade, for use in the arts, being afterward expressed from the cake at a higher temperature.

The U. S. P. describes sweet almond oil as a clear, pale, straw-colored or colorless, oily liquid, almost odorless, and having a bland taste; slightly soluble in alcohol, miscible with ether, chloroform, benzene, or petroleum benzin. Specific gravity: 0.910 to 0.915 at 25° C. The oil remains clear at −10° C., and does not congeal until cooled to nearly −20° C. (*distinction from olive or lard oil*).

This oil is regarded as being free from stearin. That from apricot and peach seed is frequently admixed,

or even wholly substituted, and many other seed oils have been more or less employed as adulterants.

Sweet almond oil has, strictly speaking, no medicinal properties, being used wholly for its nutritive, demulcent and mechanical properties. It is an ingredient of the official rose-water ointment.

HENRY H. RUSBY.

Olfactory Nerve.—I. ANATOMY.—The olfactory nerve exhibits many structural peculiarities, some of

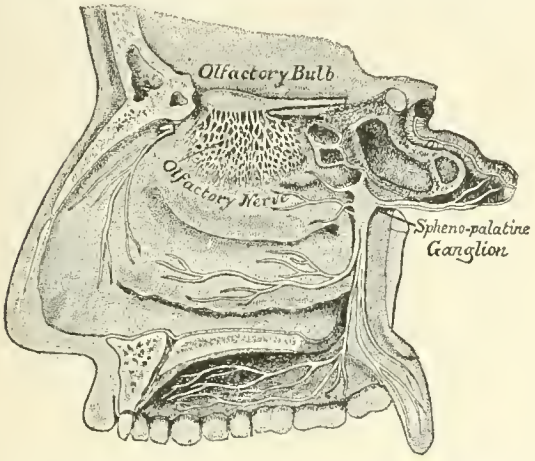


FIG. 4171.—The Right Olfactory Nerve on the Outer Wall of the Nasal Fossa. (Adapted from Hirschfeld.)

which have been interpreted as primitive, while others give evidence of a high degree of specialization. Our description will begin with a brief account of the peripheral and central relations of the human nerve, which is in a reduced condition, after which the structure of these organs in some lower vertebrates where they are better developed will be taken up and some phylogenetic and physiological considerations will be discussed.

The general relations of the olfactory nerve of man to the nose and to the primary cerebral centers are seen in Fig. 4171. The respiratory region of

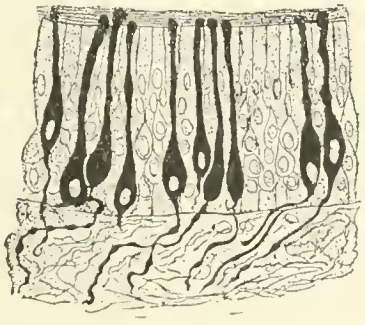


FIG. 4172.—Section of the Olfactory Mucous Membrane. (After von Brunn.) The specific olfactory cells are in black.

the nasal passages is lined with ciliated epithelium. The olfactory region is a circumscribed area in the narrow upper part of the nasal sinus, partly on the superior turbinated bone and partly on the nasal septum adjacent. This area can be distinguished in the fresh preparation by its brownish-yellow color, the surrounding respiratory membrane having a more reddish appearance.

The sustentacular cells of the specific olfactory region (Schneiderian membrane) are of the pseudo-stratified type and, in contrast with those of the respiratory region, they are non-ciliated. The specific olfactory cells are narrowly spindle shaped (Fig. 4172) and each terminates peripherally in a blunt cone bearing several olfactory hairs which project outward into the mucus with which this membrane is continually bathed. These hairs are apparently the olfactory receptors, being stimulated chemically by substances dissolved in the nasal mucus. In fishes Jagodowski has found that each of these cells is provided with a long thread-like filament which projects outward into the mucus of the nose and which may be more than twice the length of the cell body from which it springs.

The central end of each specific olfactory cell is prolonged into a nerve fiber. These fibers are non-medullated and are gathered into about twenty bundles, the fila olfactoria, which enter the cranium by separate apertures in the cribriform plate of the ethmoid bone. Upon entering the olfactory bulb which lies immediately adjacent, these fibers form tufts of terminal arborizations, termed glomeruli, where they enter into synaptic relations with dendrites of the mitral cells of the bulb; these mitral cells constitute the neurones of the second order in the central olfactory path (Fig. 4173).

Further consideration of the central relations of the olfactory nerve can best be deferred until after a summary of its comparative anatomy and embryology. In cyclostome embryos there is an ectodermal thickening near the anterior end of the head which invaginates and then divides into two pits. The posterior pit forms the glandular part of the hypophysis and the anterior pit the nasal fossa (Fig. 4174). In higher vertebrates the right and left nasal fossæ arise separately,

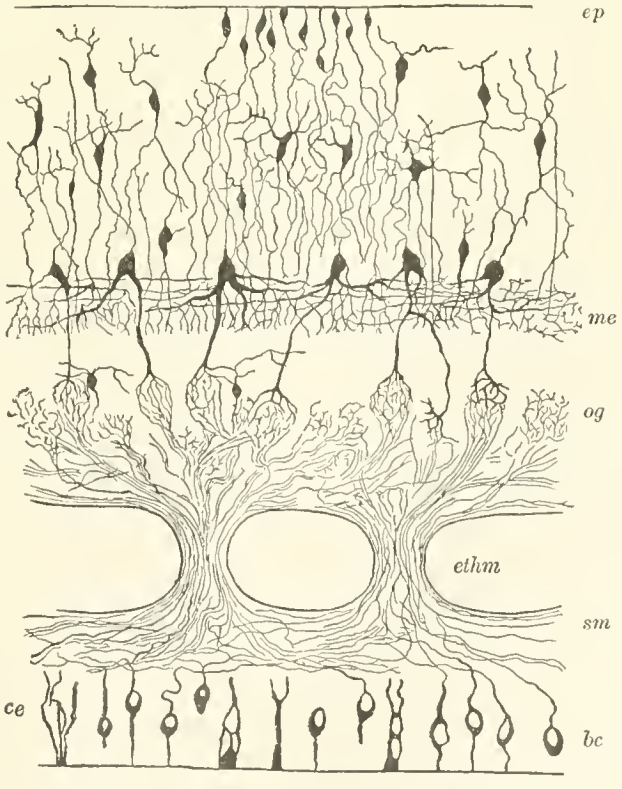


FIG. 4173.—Structure of the Olfactory Filaments and Bulb. (After Ramón y Cajal.) *bc*, Bipolar cells of the olfactory mucous membrane; *sm*, submucosa; *ethm*, cribriform plate of the ethmoid; *og*, olfactory glomeruli; *me*, mitral cells; *ep*, epithelium of the olfactory ventricle; *ce*, epithelial cells of the olfactory membrane.

each from an ectodermal placode, and the invaginated nasal pits come to lie on each side close to the anterior end of the fore-brain. The lateral evagination of the olfactory centers of the fore-brain is correlated with the invagination of the olfactory epithelium from the ectoderm, and throughout life these two parts are in close physiological and anatomical relations.

In some amphibians, reptiles, and mammals there is a peculiar diverticulum of the nasal sac, Jacobson's organ, or the vomeronasal organ, in the medioventral part of the nasal chamber. In some species this organ is large and it may communicate by a separate pore through the roof of the mouth with the buccal cavity. In man the organ is present, though rudimentary. The vomeronasal organ when well developed is lined with specific olfactory epithelium and a special slip of the olfactory nerve, the nervus vomeronasalis, supplies this part of the epithelium and may terminate in a specially differentiated part of the olfactory bulb, the formatio vomeronasalis of McCotter.

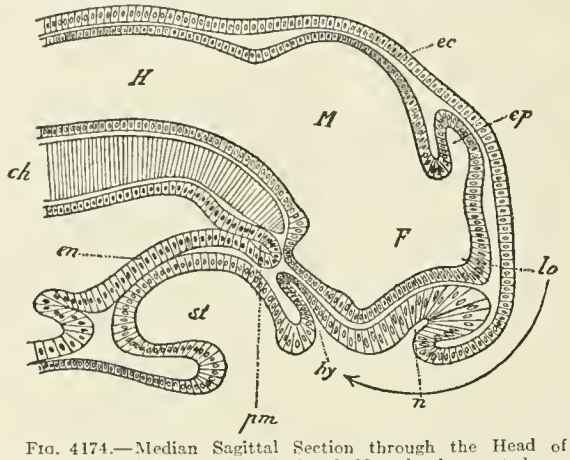


Fig. 4174.—Median Sagittal Section through the Head of Ammocœtes. (After von Kupffer.) *ch*, Notochord; *ec*, ectoderm; *en*, entoderm; *ep*, epiphysis; *F*, primary forebrain; *H*, primary hindbrain; *hy*, hypophyseal invagination; *lo*, lobus olfactorius impar; *M*, primary midbrain; *n*, nasal invagination; *pm*, pre-oral gut; *st*, stomodœum.

Associated with the vomeronasal nerve in some mammals is a very small nerve of fundamentally different type, the nervus terminalis. This is a ganglionated nerve which terminates peripherally in free arborizations under the olfactory membrane of the vomeronasal organ chiefly, and internally enters the brain quite behind the olfactory and vomeronasal bulbar formations. These fibers peripherally are mingled with those of the vomeronasal nerve and the ganglion cells from which they arise are scattered for a considerable distance along the nerve. Centrally the nervus terminalis separates from the vomeronasal nerve and enters the brain farther backward, apparently in the precommissural body in front of the anterior commissure. The nervus terminalis and its ganglion are found in the human embryo (Johnston) and in mammalian embryos generally. Fig. 4175 illustrates their relations to the olfactory organs and cerebral hemisphere in a fifteen-millimeter pig embryo. Here, as in the adult cat and dog, it clearly has nothing to do with the primary olfactory centers of the brain, but enters the precommissural body well behind the olfactory bulb. The nervus terminalis is present also in the adult human body. Its intracranial course has been described by Brookover (Fig. 4176) and its peripheral course by McCotter. It connects with the brain in the region of the olfactory trigone and peripherally it distributes in the nasal cavity to the septal mucosa anterior to the path of the vomeronasal nerves.

The first clear description of the nervus terminalis was that of Pinkus in 1894 for the lung-fish, Protopterus. About ten years later Locy in a series of important papers described this nerve in a number of selachians and gave it the name which it now bears, and it has since been described in representatives of most of the important groups of vertebrates. Its

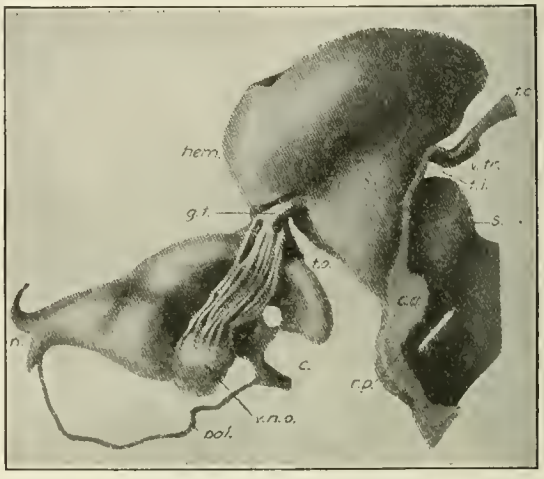


Fig. 4175.—Drawing of a Model of the Right Cerebral Hemisphere and Nasal Sac of a 15mm. Pig Embryo, Seen from the Medial Surface. The model includes the medial wall and frontal pole of the hemisphere. The groove in the hemisphere is the fissura prima of His. The root of the nervus terminalis is directed backward into the precommissural region. The olfactory nerve forms a dark background for the ganglion terminale in the drawing. It is at this point that olfactory fibers coming from the vomeronasal organ separate from the nervus terminalis fibers and enter the olfactory bulb. The two kinds of fibers run together in the bundles which go to the vomeronasal organ. (After Johnston.) *c.*, choana; *c.a.*, commissura anterior; *f.i.*, foramen interventriculare; *g.t.*, ganglion terminale; *hem.*, hemisphere; *n.*, narial opening; *pal.*, palate; *r.p.*, recessus preopticus; *s.*, corpus striatum; *t.c.*, tela chorioidea; *t.o.*, tuberculum olfactorium; *v.n.o.*, vomeronasal organ; *v.tr.*, velum transversum. (After Johnston, *Journal Comp. Neurology*, 1913.)

function is unknown, but is quite certainly different from that of the olfactory nerve, for, in the first place, peripherally it ends by free arborizations under the mucous membrane of the nose without connection with the specific olfactory cells, and in the second place, its central connections in the brain are far removed from those of the olfactory fibers in the olfactory bulb.

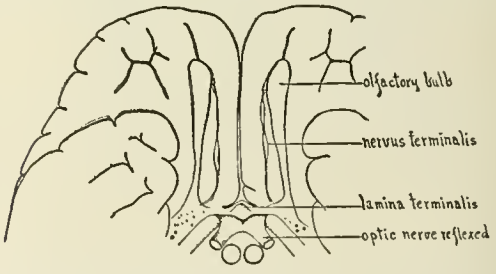


Fig. 4176.—Outline of the ventral surface of the adult human brain to show the position of the nervus terminalis. (After Brookover, *Journ. Comp. Neurology*, 1914.)

That the nervus terminalis is concerned with the general tactile sensations of the nasal cavity seems improbable from the fact that in vertebrates generally this region has an independent innervation for the tactile sense from the trigeminus nerve. This is true even in fishes, where the nervus terminalis attains its maximum development.

The details of the central connections of the nervus terminalis are not yet fully understood. Its fibers probably end by free arborizations in the precommissural body and septum and in the Amphibia also in the preoptic nucleus farther caudad. McKibben has traced fibers to this system in Necturus backward throughout the entire length of the hypothalamus and into the floor of the midbrain in the vicinity of the interpeduncular nucleus.

The exact mode of development of the olfactory nerve has been variously described, but the concurrent testimony of the best recent students supports the description of Wm. His, Jr., in 1889, that the olfactory nerve arises exclusively by inward growth from the olfactory placode.

The fibers of the olfactory and vomeronasal nerves arise as centrally directed processes of the specific olfactory cells of the Schneiderian membrane. These cells, therefore, constitute the cell bodies of the olfactory neurones of the first order, and are comparable with the spinal ganglion cells of the other sensory systems. These are the only sensory neurones found among the true vertebrates whose cell bodies are thus peripherally located (see *End-organs, Nervous*), though Dogiel has described similar sensory cells in the tentacles and adjacent parts of the skin in Amphioxus and analogous relations have long been known to occur in the skin of Lumbricus and other invertebrates.

In view of these facts, it has commonly been assumed that the olfactory apparatus represents the most primitive type of sense organ known among the vertebrates. But this conclusion by no means certainly follows, for the generalized nerves of the spinal type whose neurones develop from the neural crest, seem in some respects more primitive. And the giant ganglion cells which appear in the dorsal part of the spinal cord of lower vertebrates (chiefly as transient structures) and supply general sensibility to the skin represent perhaps a still more primitive condition. The two types of cutaneous nerves last mentioned are endowed with a very special chemical sensibility in all cases where they distribute to moist surfaces, as in the skin of fishes (Sheldon) and the mouth cavity of man. Furthermore, Landacre has shown that the specialized chemical receptors for taste, like those for smell, are differentiated from special ectodermal placodes. These placodes form an epibranchial series related to the gill clefts from which neuroblasts during early embryonic stages migrate inward to join other neuroblasts derived from the neural crest to form the mixed visceral sensory ganglia of the VII, IX, and X cerebral nerves. The general visceral sensory neurones of these ganglia are derived from the neural crest, like the generalized sensory nerves for tactile sensibility, while the more highly specialized gustatory component of these ganglia is derived from the placodes (see *Cranial Nerves*). If the olfactory placode belongs to the epibranchial series (as seems probable), it may be that the neurones of the olfactory nerve derived from it should be compared with the highly differentiated gustatory neurones of the VII, IX, and X nerves rather than with the more generalized components of these nerves derived from the neural crest. Johnston is of the opinion that the ganglion of the nervus terminalis is derived from the anterior end of the neural crest; but Brookover in fishes finds that these neurones migrate inward from the olfactory placode along with other cellular elements which go to form the sheath nuclei of the fibers of the olfactory nerve.

The problem of the functional and morphological relationships of the nervus terminalis must be solved before a complete understanding of the olfactory nerve itself is possible. It may be that the nervus terminalis is a remnant of a nerve of general chemical sensibility of the nose region, which has been largely supplanted by the more highly developed chemical receptors of the specific olfactory system. On the other hand, it may be a nerve of general visceral efferent type, the cells of the ganglion terminale being postganglionic sympathetic neurones.

The cerebral connections of the olfactory nerve are described in the article *Brain, Anatomy of*, and need not be here reviewed. In that discussion it is shown that the phylogenetic history and morphological interpretation of the vertebrate cerebral hemisphere are intimately related to the olfactory apparatus. The olfactory bulb was probably the first part of the hemisphere to be differentiated and its other parts were gradually elaborated under the physiological influence of ascending non-olfactory tracts adapted to bring the olfactory impulses into correlation with other sensory systems, particularly those of the exteroceptive type (cf. *End Organs, Nervous*). The most important of these primitive correlations are those concerned with feeding, viz., the olfactory-gustatory-tactile systems of reflexes concerned with the functions of the nose and lips, the muzzle-reflexes or "oral sense" complex of Edinger. Under the influence of these correlations a series of olfacto-gustatory and olfacto-visceral centers was elaborated on the medial side of the cerebral hemisphere and a series of olfacto-somatic centers on the lateral side. As a further differentiation from these basal reflex centers, the cerebral cortex was developed—the archipallium forming the margin of the cortex adjacent to the basal centers. The archipallium, or olfactory cortex, as the term is here employed, includes the pyriform lobe and uncus laterally and the hippocampus along the medial and posterior borders of the cortex. The non-olfactory cortex, or neopallium, is developed dorsally between the medial and lateral archipallial masses and above the corpus striatum.

II. Physiology.—The sense of smell in human beings, as compared with many of the lower animals, is very feebly developed, as will be made clear by even a cursory examination of the comparative anatomy and physiology of the organ. Animals are classified with reference to this sense as osmatic and anosmatic, and the former group is subdivided into macrosmatic and microsmatic divisions, depending upon whether the sense is highly developed or but feebly so. Man belongs to the microsmatic group, this sense playing a very subordinate rôle, either physiological or psychological, in our vital economy. Its unimportance is, however, more apparent than real and is to be explained, as Zwaardemaker points out, on psychological grounds.

As a matter of fact, olfactory sensations are always with us and our daily actions are profoundly influenced by them, though this influence is largely unrecognized as such. For these sensations are, in the case of human beings, intimately connected with the visceral and organic functions, and have a strong emotional content which obscures the process of ideation. This imperfect comprehension of olfactory impressions is reflected in our language, for our vocabulary of olfactory sensations is very limited and almost all borrowed from that of other senses. For our knowledge of the outer world we depend chiefly upon the other special senses, particularly sight. With the macrosmatic animals, on the other hand, the sense of smell is undoubtedly in some cases more potent in the elaboration of knowledge of the outer world than any other sense.

The physiology of the sense of smell is less perfectly known than that of any of the other special senses, and the same remark holds true of its psychology. While our knowledge of the anatomical arrangements of the paths of olfactory conduction to and within the brain has been greatly extended of late, we are yet ignorant of the means even by which the olfactory nerve termini are stimulated by the odorous sub-

stances. In particular, the physiological process underlying the difference between smell and taste is obscure. It is commonly stated that we taste substances in solution or in liquid form, while only gases are perceived by the sense of smell. While this is in general true, it nevertheless must be remembered that the odorous gases do not come into direct contact as such with the sensory end organs in the nose, either in fishes, where the nasal cavities are filled with water, or in air-breathing vertebrates, whose olfactory mucous membranes are always bathed with mucus in which the odorous substance must be dissolved before it can irritate the sensory endings. Again, some sapid substances, such as hydrochloric acid, are also solutions of gases, and some solids in a state of fine division seem to give rise to distinct olfactory impressions. The fact that when the nostrils are filled with water carrying an odorous substance in solution the odor cannot be perceived does not necessarily imply that the failure is due to the fact that the substance is in solution, but rather to an irritating effect of the liquid upon the olfactory organ. This is indicated by two facts: First, that all olfactory sensation may be temporarily enfeebled or even entirely abolished for some time after the close of the experiment; and second, that if normal salt solution instead of water be used as a solvent, then the dissolved substance can in some cases still be smelled.

Tyndall discovered that odorous vapors have a considerable capacity for absorbing heat, and that very minute quantities of the odorous substance in the air experimented upon would produce surprising effects. At the close of a table giving the absorptive powers of different odorous vapors, he remarks: "We find that the least energetic in the list produces thirty times the effect of air, while the most energetic produces one hundred and nine times the same effect." The significance of these facts is still obscure. We certainly are not able to affirm as yet, with Ramsay, that the sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat, though it may well be that characteristic molecular vibrations give to various substances their distinctive odors. But in any case these movements seem to be incapable of transference to the receptive sense organ by the medium of ethereal vibrations, and direct contact of the odorous particles with the nervous organ seems indispensable. The ultimate stimulus is probably electro-chemical—a matter of ions.

Olfactory sensations are aroused with difficulty or not at all by irritation of the peripheral end organ by thermal, electrical, mechanical, or other stimuli than the normal gaseous media, though tumors or other irritants of the central olfactory apparatus may call forth vivid sensations of smell. It is hardly true, as often stated, that air containing odorous particles must be in motion in order to stimulate the olfactory organ. The truth is that in ordinary respiration the air currents do not strike the sensory surface directly, and hence olfactory impressions are called forth by such particles only as diffuse themselves upward from the respiratory portion into the olfactory fossa, while in sniffing the direction of the air currents is altered so as to pass more directly over the specific sensory area.

We are not as yet able to give a natural classification of smells, nor have we any secure basis for such a classification. Even the division into agreeable and disagreeable is subject to so great variation from one individual to another that it would be of small value, even if it were admissible on other grounds. Accordingly, the names of smells are usually taken from the objects which give rise to them, with little attempt at classification or correlation of similars.

The number of smell qualities is very large. Some of those commonly recognized are compound, though authorities differ as to the extent to which such mixture is possible, or whether it is possible at all. If two distinct odors are mingled under experimental conditions, there often results, not a fusion of the two into a blended odor, as occurs with tastes, colors, and tones, but the stronger will supplant the other completely, or there will be an oscillation between the two. With some odors, again, there appears to be a true compensation. Thus, if two different olfactory stimuli of unequal strength are applied simultaneously, one will usually overpower the other completely; but if the stronger scent be diminished while the weaker is strengthened, a point may be found where the two blend into a single mixed odor. In other cases, however, a point is found where there is no sensation, *i.e.* the odors are perfectly compensated. An increase of either stimulus results in the sensation appropriate to it and there is no mixture whatever. The olfactory organ is easily fatigued, more so by some odors than by others, and it is found that when completely fatigued for one odor it may be insensible to some other odors, partially so to another group and wholly unaffected in its sensibility with reference to still another group.

Such experiments suggest points of departure for the study of olfactory qualities, and enough progress has already been made to suggest that the modalities of smell can be grouped into several graded series. The number of such groups will quite certainly be greater than those known for taste, where we have simply the four primary qualities, sweet, sour, salty, and bitter. Zwaardemaker's nine smell classes are as follows:

(1) Ethereal scents: Fruit odors.

(2) Aromatic scents: Camphor and spicy smells, anise, lavender, etc.

(3) Balsamic scents: Flower odors, vanilla, gum benzoin, etc.

(4) Ambrosiac scents: Amber, musk.

(5) Alliaceous scents: Garlic, ichthyol, vulcanized rubber, asafetida, bromine, chlorine, etc.

(6) Empyreumatic scents: Toast, tobacco smoke, naphtha, etc.

(7) Valeric, or hircine scents: Cheese, sweat, etc.

(8) Narcotic, or virulent scents: Opium, cimicine, etc.

(9) Nauseous scents, or stenches: Decaying animal matter, feces, etc.

The ability to discriminate different intensities of odors is not highly developed; in general, the least observable difference between two smell intensities of the same substance amounts to about one-third of the original stimulus. On the other hand, the olfactory organ is sensitive to exceedingly small amounts of the irritating substance, or as Ladd states it: "The sense has a great degree of 'sharpness,' or power to be excited by small quantities of stimulus, as distinguished from 'fineness,' or power to distinguish minute variations in the sensations." There are many familiar illustrations of this "sharpness." It is stated, for example, that in a liter of air 0.000005 gram of musk can be perceived, 0.000001 gram of sulphureted hydrogen and 0.000000005 gram of oil of peppermint. The sense is more delicate if the air containing the odorous substance is warmed.

Smell and taste are both chemically excited senses, but the olfactory organs can be excited by much more dilute solutions of the stimulating substances than can the gustatory organs. In the case of ethyl alcohol, which excites both of these receptors, the experiments of Parker and Stabler have shown that the organs of smell are sensitive to a dilution 24,000 times greater that that necessary to stimulate the organs of taste.

It is learned by suitable tests that the sensibility of the organ of smell is much more acute than the perception of odors. It was found in one series of tests, for example, that upon the average nine parts of camphor dissolved in 100,000 parts of water could be sensed

by the nose, but without the perception of a definite odor, it requiring a solution of more than four times this strength before the specific odor could be recognized. Experiments made to determine the relative sensitiveness of men and women in this respect have thus far yielded conflicting results. With children it has been found that the sensibility (in the sense used above) increases up to the age of six years and then progressively diminishes. The delicacy of perception, on the other hand, measured by graded solutions of camphor, increases progressively with advancing age.

One source of perplexity in the classification of odors is the fact that some substances which have powerful odors in a state of great dilution are less effective in a state of high concentration. For some perfumes there appears to be an optimum vapor density below or above which the excitation is less strong. It has also been suggested that for unknown phylogenetic reasons some odors may have greater affective values than others, or it may be that fatigue of the sense of smell is *ceteribus paribus* less for those odors which have an element of utility to the species.

It must not be forgotten that some odorous substances affect the terminals of the trigeminus nerve in the respiratory part of the nasal passages, giving rise to tactile or other general sensation which may be combined with the olfactory sensations. This can be proven by plugging the olfactory sinus, when the trigeminal stimulus alone is perceived. Classification is further impeded by the universal confusion of tastes and odors. We say a substance "smells sweet," when as a matter of fact experiment shows that the modality sweetness can be perceived only by the sense of taste; and conversely most of the tastes of common experience are greatly affected by odors simultaneously sensed.

In the majority of persons (Toulouse and Vaschide) the left side of the nose is more sensitive than the right. With most of the other senses, on the other hand, there is an asymmetry in one-fifth of the cases in favor of the right side (van Biervliet). The difference is explained by the fact that the left side of the brain is more highly developed (in right-handed persons) and that the central olfactory tract does not cross before reaching its cortical centers, while those for the other senses do cross.

The measurement of olfactory sensations cannot easily be done absolutely in terms of the strength of the stimulus, though examples of the results of some attempts at the measurement of the threshold for smell in absolute terms are given above. To arrive at a relative measurement of olfactory values there are two methods chiefly in use. According to the method of Passy a number of flasks of equal size are provided and into each is put a measured quantity of the odorous substance, the quantities being arranged in a graded series. The substance may be allowed merely to diffuse itself through the air within the flask (which must be kept stoppered when not in use), or it may be dissolved in water or some other inodorous medium. By the use of a sufficiently extensive series, threshold values of different odorous substances may be determined and various other researches carried out.

The method of Passy is very laborious and for most purposes, particularly in clinical work, the olfactometer of Zwaardemaker is more convenient. In its simplest form it consists of a glass tube, curved at one end for insertion in the nostril and bearing a scale (preferably in centimeters), which slides with easy friction into a slightly larger tube which is lined with the odorous substance to be tested. The inner tube passes through a screen near its curved end. Now, when the outer tube is slipped completely over the inner tube so that its odorous lining is wholly covered by the latter, air drawn into the nostril through the inner tube will carry no odorous particles. If, however, the outer tube is slowly slipped off from the inner tube, the air current will pass over more and more of the exposed surface of the odorous substance before entering the inner tube, until a point will be reached at which the substance is just perceivable to the sense of smell. In this way the normal threshold can be determined for various substances and numerous tests of physiological and pathological interest carried out.

This simple apparatus has been modified in various ways. A very simple instrument which has the advantage of relative permanence of adjustment can be constructed by using a section of ordinary red rubber tubing for the outer tube. This should be slipped inside of a larger glass tube to prevent the odor from escaping from the outer side of the rubber, and the odor given off from the inner surface of the rubber tubing will remain quite constant for many months. For other odors the outer cylinder may be made of porous earthenware, whose pores may be filled with a solution of the odorous substance. Commonly the olfactometer is made double with a separate cylinder and breathing tube for each nostril, and for the study of the compensation of odors Zwaardemaker has constructed a very elaborate apparatus with two separate cylinders (one for each of the odors to be employed) connected with a single breathing tube and so adjusted that the amount of odorous surface exposed in each tube may be easily varied during the experiment. With the varying adjustments one odor or the other appears in consciousness alone until the proper compensation point is reached, when both odors vanish. The apparatus is provided with self-registering apparatus for recording on the kymograph the force of respiration in each cylinder and other data of the experiment.

The unit in all of these experiments is the "olfactie," or the stimulus necessary to produce the least perceivable sensation. The position on the scale of the olfactometer having been determined for this minimal value, this value is taken as the unit, or olfactie, and other stimuli are measured in multiples of this.

C. Judson Herrick.

Literature.

Bancels, J. L.: des. L'odorat. Revue générale et critique. Arch. de Psychol., t. x., pp. 1–46, 1910.

Bawden. H. H.: A Bibliography of the Literature on the Organ and Sense of Smell. Jour. Comp. Neur., vol. xi., No. 1, 1901.

Brookover, C.: The Olfactory Nerve, the Nervus Terminalis and the Preoptic Sympathetic System in Amia calva, L. Jour. Comp. Neur., vol. xx., No. 2, 1910; The Nervus Terminalis in Adult Man. Jour. Comp. Neur., vol. xxiv., 1914, p. 131.

Dieulafé, L.: Morphology and Embryology of the Nasal Fossæ of Vertebrates (Trans. by Loeb). Annals of Otology, Rhinol. and Laryngol., 1906.

Herrick, C. Judson: On the Phylogenetic Differentiation of the Organs of Smell and Taste. Jour. Comp. Neur., vol. xviii., 1908; The Nervus Terminalis (Nerve of Pinkus) in the Frog. Jour. Comp. Neur., vol. xix., 1909.

Jagodowski, K. P.: Zur Frage nach der Endigung des Geruchsnerven bei den Knochenfischen. Anat. Anz., Bd. xix., pp. 257–261, 1901.

Johnston J. B.: Nervus Terminalis in Reptiles and Mammals. Jour. Comp. Neur., vol. xxiii., pp. 97–120, 1913.

Landacre ,F. L.: The Origin of the Cranial Ganglia in Ameiurus. Jour. Comp. Neur., vol. xx., pp. 309–412, 1910.

Locy, W. A.: On a Newly Recognized Nerve Connected with the Fore-brain of Selachians. Anat. Anz., Bd. xxvi., Nos. 2–5, 1905.

McCotter, Rollo E.: The Connection of the Vomeronasal Nerves with the Accessory Olfactory Bulb in the Opossum and Other Mammals. Anat. Rec., vol. vi., pp. 299–318, 1912; The Nervus Terminalis in the Adult Dog and Cat. Jour. Comp. Neur., vol. xxiii., pp. 145–152, 1913; The Distribution of Nervus Terminalis in Man. Anat. Rec., vol. ix., 1915, p. 107.

McKibben, Paul S.: The Nervus Terminalis in Urodele Amphibia. Jour. Comp. Neur., vol. xxi., No. 3, 1911.

Nagel, W. A.: Vergleichende physiologische und anatomische Untersuchungen über den Geruchs- und Geschmackssinn und ihre Organe, mit einleitenden Betrachtungungen aus der allgemeinen vergleichendenden Sinnesphysiologie. Bibliotheca Zoologica, Heft 18, 208 pp., 7 plates and a bibliography of 335 titles. Stuttgart, 1894.

Parker, G. H.: The Relation of Smell, Taste, and the Common Chemical Sense in Vertebrates. Jour. Acad. Nat. Sci. Philad., vol. xv., 2 Ser., pp. 221–234, 1912.

Parker, G. H. and Stabler, E. M.: On Certain Distinctions between Taste and Smell. Am. Jour. Physiol., vol. xxxii., No. 4, 1913.

Passy: Revues générales sur les sensations olfactives. L'Année Psychol., vol. ii., 1896.

Pinkus, F.: Ueber einen noch nicht beschreibenen Hirnnerven des Protopterus annectens. Anat. Anz., Bd. ix., pp. 562–566, 1894.

Read, Effie A.: A Contribution to the Knowledge of the Olfactory Apparatus in Dog, Cat, and Man. Am. Jour. Anat., vol. viii., No. 1, 1908.

Sheldon, R. E.: The Reactions of the Dogfish to Chemical Stimuli. Jour. Comp. Neur., vol. xix., pp. 273–312, 1909; The Sense of Smell in Selachians. Jour. Exp. Zool., vol. x., No. 1, 1911.

Zuckerkandl, E.: Ueber das Riechcentrum. Stuttgart, 1887; Normale und pathologische Anatomie der Nasenhöhle und ihre pneumatischen Anhänge. 2 Ed., Wien and Leipzig, 1893; Das Jacobsonsche Organ. Merkel und Bonnet's Ergebnisse, Bd. xviii., pp. 801–843, 1910.

Zwaardemaker, H. Die Physiologie des Geruchs. Leipzig, Engelmann, 1895; Les sensations olfactives, leurs combinaisons et leurs compensations, Année psychol., vol. v., 1899; Revue générale sur l'olfaction, Année psychol., vol. vi., 1900; Geruch. Ergebnisse der Physiol., Bd. 1 (II), 1902.

Olibanum.—*Frankincense. Thus. Gummi-resina olibani.*—A gum resin obtained from *Boswellia carterii* Birdw. and other species of *Boswellia* (fam. *Burseraceæ*).

Olibanum is collected in northeastern Africa, chiefly by the Somali natives, and is mostly exported viâ India. It is produced by small trees similar to those which yield myrrh, and is chiefly obtained from incisions made for the purpose. It exudes as a thick milky juice, hardening into the tears described below, which preserve their white color much longer than those of other similar substances.

Olibanum occurs in irregularly oval or subglobular tears, separate, or occasionally somewhat agglutinated in the poorer grades, usually 1.25 centimeters (0.5 inch) or less in diameter, from almost pure white to yellowish-white, occasionally reddish-brown when long kept, the surface powdery; breaking readily with a nearly flat, waxy, lustrous surface, translucent in thin fragments; odor balsamic, slightly like turpentine; softening between the teeth, aromatic and somewhat bitter. Triturated with water, it forms a white emulsion and is almost wholly soluble in alcohol. When burned, it emits a very strong and pleasant odor, on account of which it is used as incense.

Olibanum consists principally of resin, usually from 60 to 70 per cent., or occasionally 75 per cent., with from 30 to 35 per cent. of gum and from 3 to 8 per cent. of volatile oil. Its bitter principle has not been examined. The volatile oil, which is an article of commerce for perfuming purposes, combines a slight lemon-like odor with that of the drug, and is of complex composition. The resin is divisible into two portions, namely, *Boswellic* or *Boswellinic acid* and *olibano-resin*. The gum is more like acacia than like tragacanth.

From a medicinal point of view, the uses of olibanum are quite unimportant. It is no longer official in any leading pharmacopœia and is but little used in professional medicine.

Owing to its fragrant properties, it is with some a favorite ingredient of plasters and ointments, and it is elsewhere used for odorizing purposes. It has mild counterirritant and disinfectant properties, leading to its use as a vulnerary. Internally, it possesses the ordinary stimulating diuretic and expectorant properties of the oleoresins, and it also has a considerable use, especially among the laity, based chiefly on religious fancy, as an emmenagogue. The dose is from gr. xv.–xlv. (1.0–3.0). It is used chiefly, perhaps, in the form of the emulsion, although the tincture is to be preferred. HENRY H. RUSBY.

Oligemia.—A decrease in the total mass of the blood. The term is often used incorrectly as a synonym for anemia. The latter term is used to indicate a deficient supply of blood to a part, or a deficiency in the total amount of blood within the body, or, most commonly, to designate a decrease in the number of the red cells or a diminution of the hemoglobin. The expression *general anemia* may, therefore, be regarded as expressing the same idea as that conveyed in oligemia. The decrease in the total mass of blood may be due to a number of causes, and the following varieties may be distinguished:

Oligemia Vera.—True oligemia is due to a sudden loss of blood through hemorrhage. A loss of half of the total mass of the blood is invariably fatal, and hemorrhages of even less degree may cause death. The red cells may drop after a single large hemorrhage as low as 2,000,000. After such a loss of blood there is a rapid fall in blood pressure, the heart is incompletely filled, the pulse becoming very small, frequent, and irregular. Cardiac activity is at first increased, then lowered after a time. The blood-vessels become contracted at first in the effort to keep up the blood pressure; but after a time the larger vessels dilate, the smaller ones alone remaining contracted. The threatening symptoms in oligemia are small and rapid pulse, nausea, vomiting, feeling of anxiety, syncope, convulsions, and coma. The loss of one-half kilogram can produce syncope, while hemorrhages of one and one-half to two kilograms are usually fatal. Even smaller losses may cause death. Treatment consists of infusions of physiological salt solutions. In cases of hemorrhage of slight degree, but continued through a long period of time, the deficiency is partly made up by an increase in the fluids of the blood, the true oligemia becoming thus converted into a hydremic oligemia. Oligemia vera occurs also in many cachectic conditions (carcinoma, tuberculosis, pernicious anemia, chronic suppurations, etc.). In pernicious anemia the cadaver in extreme cases may seem to be almost wholly devoid of blood.

Oligemia Hydremica or Serosa.—An oligemia with increase of water in the blood, the red cells and albumin being diminished, occurs after all hemorrhages, particularly in the case of oft-repeated or prolonged hemorrhages of slight degree, as in bleeding piles, excessive menstruation, etc., also in conditions characterized by loss of albumin, as in chronic nephritis, dysentery, chronic suppurations, prolonged lactation, tumor cachexias, scurvy, malaria, etc. The hydremic condition of the blood leads to pathological changes in the blood-vessel walls, favoring the passage of fluids and the increased production of lymph (edema). Hydremia is, however, not the direct factor in the production of edema, but only a favoring one.

Oligemia Sicca (*Inspissatio Sanguinis, Anhydremia*).—A thickening of the blood through loss of water may lead to a decrease of the total mass. Such a condition may occur in cholera, dysentery, severe diarrheas, excessive sweating, insufficient supply of water, etc. The highest degree of oligemia sicca occurs in Asiatic cholera. As a result of the circulatory disturbances thus produced, and an insufficient supply of blood to the nervous centers, the characteristic symptoms of severe anemia may arise, although the total number of red cells and total amount of salts and albumin in the blood are not decreased. The thickened blood is dark and tarry; the number of red cells is increased to 6,000,000 to 8,000,000 per cubic millimeter. As the result of the increased viscosity the circulation is impeded and the work of the heart increased. The blood serum is richer in albumin and in salts. The body tissues become very dry, and non-encapsulated serous exudates are resorbed.

Oligemia Oligocythemica.—A decrease in the total blood mass due to a diminution in the number of red cells (see *Oligocythemia*).

Oligemia Hypalbuminosa.—A decrease of the blood mass due to a decrease in the albumin of the blood. As a result of such loss of albumin the blood becomes more watery; the condition is therefore practically a form of oligemia hydremica. A marked reduction of the albumins of the blood occurs in carcinoma and septic infections. The fibrinogen may be lowered in pernicious anemia and hemophilia, so that there is a lessened fibrin formation (*hypinosis*).

ALDRED SCOTT WARTHIN.

Oligochromemia.—A decrease in the amount of hemoglobin in the blood. This is one of the commonest changes in the blood, and may occur either when the red cells are normal in number or in association with an oligocythemia. A simple loss of hemoglobin is the chief change in chlorosis and the secondary anemia, particularly those of carcinoma, tuberculosis, and nephritis. In chlorosis the number of the red blood cells may be nearly normal, while the hemoglobin may be greatly reduced, even to twenty or twenty-five per cent. or less. In the secondary anemias the number of red cells is also diminished, but the hemoglobin is reduced to a relatively greater extent; this, for example, if the number of red cells be diminished to 2,500,000, the hemoglobin is usually found to be lower than fifty per cent. The individual red cells are, therefore, deficient in hemoglobin. This is shown microscopically by the presence of a central clear area in the red cell. This area may be of varying size and shape; in severe cases the hemoglobin-containing portion of the cell may be reduced to a narrow ring, enclosing a clear and transparent central area. In very extreme cases some cells may contain no hemoglobin at all (the so-called blood shadows and pessary forms). In other cases the central clear area may not be enlarged, but small vacuoles occur throughout the cell protoplasm; the hemoglobin may be preserved in the central part, and around this there may be a clear ring of varying width. Often the central portion stains very dark with eosin, and such cells are sometimes mistaken by inexperienced observers for nucleated red cells. Inasmuch as the darker central area takes the eosin and not the nuclear stain the mistake is inexcusable. In still other cases no definite vacuoles or clear spaces are seen within the cells, but their deficiency in hemoglobin is shown by their lighter color and lighter staining. Macrocytes and poikilocytes poor in hemoglobin occur in these secondary anemias. The former represent young undeveloped red cells; while the latter are probably to be interpreted as degenerative forms, most probably of imperfectly developed red cells. On the other hand, in pernicious anemia the amount of hemoglobin is relatively higher than the red cells; as, for example, if the red cells are 2,500,000 the hemoglobin is fifty per cent. or higher. As a rule, however, both red cells and hemoglobin are greatly decreased in this disease. The explanation of the relatively high hemoglobin content is found in the presence of numerous large red cells (macrocytes) containing more hemoglobin than the normal red cell. This may be regarded as of a compensatory nature. A pathological oligochromemia occurs in all forms of anemia, whether due to hemolysis or deficient blood formation. In the latter case the individual red cells may contain a normal amount of hemoglobin, or even a greater amount. In severe anemias the hemoglobin may be reduced to ten per cent. or less, but it must be borne in mind that the estimation of the low percentages is attended by a greater or lesser error. A physiological oligochromemia occurs in the new-born during the nursing period, in the mature female after menstruation, and in the later months of pregnancy and the postpartum period.

ALDRED SCOTT WARTHIN.

Oligocythemia.—A diminution in the number of the red blood cells, due either to lessened production (insufficient erythropoiesis) or to an increased destruction of the same (hemolysis). The condition is of very frequent occurrence and may be due to a great variety of causes. Pathological hemolysis and diminished erythropoiesis may be combined.

A physiological oligocythemia occurs in hibernating animals during the winter sleep; observations made upon the marmot showed a diminution of the red cells from 7,000,000 to 2,000,000 during the period from November to February. There is also, according to some observers, a slight physiological variation in man, the number of red cells becoming slightly lower toward evening. According to Vierordt, Limbeck, and others, the red cells begin to diminish within one-half to one hour after the ingestion of a full meal, the number being reduced between 250,000 and 750,000 per cubic millimeter, remaining so for a short time, and after two to four hours gradually reaching normal again. The diminution is more marked after the ingestion of large quantities of fluids, and is therefore regarded as due to the dilution of the blood resulting from the absorption of fluid. According to some observers the red cells are increased in number during fasting or starvation, but Raum and Grawitz noted a definite diminution of red cells in healthy fasting men. Normal menstruation does not reduce the number of the red cells. After delivery there is usually found a diminution of red cells lasting for from ten to fourteen days. Under ordinary conditions the postpartum oligocythemia is slight.

Pathological oligocythemia occurs after hemorrhage, and in many infections and intoxications. It is found constantly in prolonged fevers, in leucemia, cachectic conditions, carcinoma, tuberculosis, nephritis, malaria, syphilis, poisoning with mercury or lead, and in carcinoma, particularly of the stomach. A condition of oligocythemia may also be produced by many poisons, the most important of which are: aniline, nitrobenzole, pyrogallic acid, toluylenediamine, potassium chlorate, amyl nitrite, phallin, helvellic acid, muscarin, arsenic, antimony, picric acid, carbon disulphide, sulphuric acid, glycerin, abrin, ricin, etc. In icterus the presence of the salts of the bile acids in the blood gives rise to oligocythemia. The venom of poisonous snakes causes extensive destruction of the red cells. In yellow fever there is also a very marked destruction of red cells. Pernicious anemia is characterized by marked oligocythemia resulting from the destruction of the red cells by some poison as yet unknown. It is not improbable that the disintegration of red cells and the setting free of hemoglobin may give rise to certain bodies or ferments having a hemolytic action. In the oligocythemia associated with infectious processes the specific poisons produced by the infecting organisms have in the great majority of cases a decided hemolytic action. In certain conditions of the bone marrow the formation of red cells may fall below the normal, hematopoiesis not keeping pace with hemolysis. On the other hand, in cases of increased hemolysis the bone marrow may present evidences of increased blood formation, and in very rare cases there is a similar compensation on the part of the spleen, liver and lymph nodes. Deficient hematopoiesis is shown by the lack of regenerative forms (normoblasts, polychromatic and basophile erythrocytes) in the blood when repeated examinations are made. Even when there is a myeloid metaplasia of fatty marrow, and when myeloid areas are found in spleen, liver, and lymph glands, such compensatory processes may not be sufficient to produce a normal supply of red cells. The diminution of red cells in the blood of man may be so great as a reduction to 500,000 or less per cubic millimeter. Such severe oligocythemia is characteristic of the later

stages of pernicious anemia, but may be caused by poisons. ALDRED SCOTT WARTHIN.

Olive Oil.—OLEUM OLIVÆ. *Sweet Oil. Salad Oil.*—"A fixed oil expressed from the ripe fruit of *Olea europæa L.* (fam. *Oleaceæ*)," U. S. P.

The olive is a small or medium-sized tree, with a much-branched trunk and numerous slender branches.

The fruit, the well-known olive, is an oval, pointed drupe, about two or three centimeters (one inch) long, consisting of a firm, very oily mesocarp, and a spindle-shaped, hard putamen, containing a single long and narrow, also oily, seed. Its color when ripe is dull blue or purple, its taste bitterish and oily.

This valuable tree is a native of Asia Minor, Palestine, and other parts of the Levant, where its cultivation is of the greatest antiquity. It is now extensively cultivated in nearly all subtropical countries. It is one of the most important vegetable products of Spain, Italy, and southern California.

The fruit of the olive has been improved in form and size, as well as flavor, by cultivation, and there are several well-distinguished varieties.

For the table, olives are gathered while still green, but fully grown, soaked in water or sometimes in lye to remove their natural bitterness, and finally pickled in a simple or flavored brine. For the oil, they are allowed to ripen, and then are ground and subjected to pressure.

The quality of the products depends upon nicety in every stage of the operation; for the best table oil, fine fruits of good varieties must be taken, and the pressing done at once, without heat; this yields a moderate quantity of very clear, light-colored, generally slightly greenish, pleasant-flavored oil, generally called "Virgin Oil," which is sold for table use. The remaining cake is then broken up and heated or mixed with boiling water and more strongly pressed, when a further product of darker and stronger tasting oil is obtained. This grade of oil, which is called "foots," can be used for cooking, soap, or fuel. An easy way, finally, for obtaining a large yield of oil is to lay the olives in heaps until decomposition begins, when a very strong-smelling oil (*huile fermentée*) results.

COMPOSITION.—No other fruit contains so large a proportion of fixed oil as this; it amounts generally to over one-half, and in good qualities to almost three-fourths. Besides, the fruit contains considerable *mannit*, diminishing as it ripens and the oil increases. Olive oil of the quality required for medicinal purposes is thus described: "A pale yellow, or light greenish-yellow, oily liquid, almost devoid of odor, having a nutty, oleaginous taste, with a faintly acrid after-taste, and a neutral reaction. Specific gravity, 0.915–0.918. Sparingly soluble in alcohol, but readily soluble in ether. When cooled to about 10° C. (50° F.), it begins to be somewhat cloudy from the separation of crystalline particles, and, at about 5° C. (41° F.), it begins to deposit a white, granular sediment; below 2° C. (35.6° F.), it forms a whitish, granular mass." The principal part, more than two-thirds, of olive oil is the liquid fat *olein*, or triolein; nearly all the rest is *palmitin*, with a little *stearin*, *butin*, and perhaps also *cholesterin*. Through the operations of the Federal Food and Drugs Act, the importation of adulterated olive oil has entirely ceased, although, owing to the carelessness of our states and municipalities in regard to such matters, it is largely adulterated after its arrival here.

ACTION AND USE.—This can be disposed of quite briefly, as far as its medical use is considered. Given internally it is chiefly a fatty food, and is emulsified and absorbed as other fats are. It is slightly, only very slightly, laxative, and has no other physiological action. Locally applied it is a neutral protective from the atmosphere, as are other fats; but in this application it has given place somewhat to cheaper ones—suet, lard, cotton-seed oil, etc.—and especially to the various *petrolatum* products.

It is rather frequently given as an injection, but *castor oil* is preferable for this purpose. Like most other fixed oils, it is destructive to insect life, and rectal injections and applications are often efficient in the treatment of ascarides. Many reports have been published of the efficacy of large quantities of olive oil, two to four gills at a dose, in favoring the removal of gallstones. A little cocaine may be added if there is a tendency to reject it. Its most extensive employment in medicine is perhaps in the composition of several liniments and of the pharmaceutical soaps; in this field it has also of late been replaced in this country by the cheaper oil from cotton seed.

ADMINISTRATION.—As a laxative, three or four tablespoonfuls are required—a dose that is apt to disturb the stomach of one unaccustomed to oils. This, as stated above, may often be prevented by the use of gr. $\frac{1}{4}$ of cocaine, given just before the administration of the oil. As an injection, one or two teacupfuls, injected warm, and retained an hour or so and then followed by soapsuds, make a very efficient composition for relieving an overloaded rectum. Ground olive stones have been enormously used to adulterate black pepper and other ground spices and drugs.

HENRY H. RUSBY.

Ollier, Louis Xavier Edouard Léopold.—Born at Lyons, France, on Dec. 2, 1830. After receiving the degree of Doctor of Medicine from the University of Paris, in 1857, he established himself in his native city as a general practitioner. In due course of time he rose to be Surgeon-in-Chief of Hôtel-Dieu, and Professor of the Surgical Clinic in Lyons, and he continued to hold both of these positions for many years. He died in 1900.

The majority of Ollier's published writings relate to resectious and to the regeneration of individual bones through the agency of the periosteum which surrounds them. Some of these writings were published in journals like the *Gazette hebdomadaire de médecine et de chirurgie*, while others were issued as independent treatises. The following are the titles of some of the more important of these writings: "Des moyens chirurgicaux de favoriser la reproduction des os après les résections, etc.," 1859; "Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux," 2 volumes, 1867; "Des résections des grandes articulations," 1870; and "Traité des résections et des opérations conservatrices," Paris, 1885. A. H. B.

Olympian Springs.—Bath County, Kentucky.

POST-OFFICE.—Olympia.

ACCESS.—Via Chesapeake and Ohio Railroad.

These springs are ten in number, and are of the saline-sulphureted variety. The waters are promptly diuretic in their action. Analysis was made by Dr. Robert Peter. Following is the result of the analysis of the salt sulphur spring:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	7.20
Iron carbonate	Trace.
Calcium carbonate	13.93
Potassium chloride	10.67
Sodium chloride	166.01
Magnesium chloride	55.39
Calcium sulphate	Trace.
Iron	Trace.
Alumina	Trace.
Silica	1.04
Water and loss	78.60
Total	332.84

Gases: Carbonic acid, sulphureted hydrogen, not estimated.

A re-examination of the waters showed essentially the same results. The following additional ingredients were found in minute quantities:

Baryta carbonate.	Sodium iodide.
Strontium carbonate.	Sodium sulphide.
Sodium carbonate.	Boric acid.
Calcium chloride.	Phosphoric acid.
Lithium chloride.	Manganese carbonate.
Sodium bromide.	

Examination of the two other springs showed the presence of sodium carbonate in the proportion of twenty grains per gallon. One of them contains a little less than two grains of iron carbonate to the gallon. EMMA E. WALKER.

Omentum, Pathology of.—The term omentum (epiploön) is applied to the folds of peritoneum which connect the stomach with its neighboring organs, the liver, colon, and spleen. In structure similar to the mesentery, each omentum may be regarded as a special mesentery connecting the stomach with the organs named. They are usually designated respectively as: *gastrohepatic* or *lesser omentum (omentum minus); gastrocolic* or *great omentum (omentum majus or epiploön)*; and the *gastrosplenic omentum.*

The *gastrohepatic* (stomach-liver) *omentum*, or lesser omentum, extends from the lesser curvature of the stomach and the adjacent first part of the duodenum to the portal fissure of the liver, enclosing between its two layers the hepatic artery, portal vein, bile duct, and associated structures, bound together by loose connective tissue. It consists of two portions, the *hepatogastric ligament* and the *hepatoduodenal ligament.*

The *gastrocolic* (stomach-colon) *omentum*, or great omentum, connects the greater curvature of the stomach and the adjacent first part of the duodenum with the transverse colon. It is the largest of all the peritoneal duplications, and is composed of four layers of peritoneum; it is much more voluminous than is necessary for the mere connection of the stomach and colon, and hangs down in front of the small intestines like an apron.

The *gastrosplenic* (stomach-spleen) *omentum* is a double fold of peritoneum passing from the dorsal surface of the stomach, near its left border, backward to the hilum of the spleen. It runs below into the gastrocolic omentum. It is usually called the gastrosplenic ligament. It contains the splenic vessels.

In structure the omental folds are composed of either two or four layers of the peritoneal membrane, a basement structure of very loose connective tissue, containing a remarkable number of blood-vessels and lymphatics, and more or less adipose tissue, the whole being covered with endothelium. Small lymph nodes are not infrequently found in the great omentum, less frequently in the gastrosplenic, but are almost constantly present in the lesser omentum. These usually show the structure of ordinary lymphatic glands, but hemolymph glands also occur. Accessory spleens are of common occurrence in the gastrosplenic omentum.

The great omentum is by far the most important, both physiologically and pathologically considered. That its function is of great importance, in so far as the protection of the peritoneal cavity is concerned, cannot be doubted. It usually contains a large amount of fat tissue, and this fact, taken in connection with its "coverlet" investiture of the small intestines, has led to the view, advanced by both Aristotle and Galen, and commonly accepted even to-day, that the organ is of service in preserving the heat of the body and protecting the intestines against chilling. Such function, doubtful as it appears, is of slight importance compared with the protective function of the omentum against intraperitoneal infection. The remarkable richness of the organ in blood-vessels and lymphatics—far in excess of the needs of the structure itself, if intended only for a protective covering—is structural evidence of the chief omental function. The vessels form a rich plexus throughout the connective tissue beneath the endothelial covering, the vessels themselves in many cases being separated from the peritoneal cavity by the endothelium alone. Numerous clinical observations tend to show that the transudation of lymph into the abdominal cavity or the absorption of lymph from the cavity is an important function of the omentum. Many writers hold that the omentum is a modified lymphatic ganglion. It has been shown experimentally that, after the removal of the omentum, animals are much more susceptible to intraperitoneal injections of microorganisms than control animals whose omentums have not been removed. The inference may be drawn that microorganisms obtaining entrance to the peritoneal cavity are taken up by the omentum and there rendered harmless or are killed.

In local traumatism, or after operations involving the peritoneum, in beginning peritoneal infection, local peritonitis from whatever cause, etc., the omentum is quite commonly found attached to the affected area, entirely surrounding it and shutting it off from the remainder of the peritoneal cavity. This occurs particularly in appendical and tubal disease, following the beginning of a local peritonitis, but it is also of very frequent occurrence over the surface of liver, spleen, intestines, etc. It would appear that the omentum is attracted to the diseased area; the location of such adhesions deep in the pelvis or in parts of the peritoneal cavity not usually occupied by the omentum would indicate such a movement of the omentum to the affected part. The slightest irritation in any part of the peritoneum is apparently sufficient to cause the omentum to attach itself to the affected area, and to shut off the focus of infection from the remainder of the peritoneal cavity. Even when microscopic changes are not visible, alterations of the intestinal wall permitting the passage of germs or of their products, are sufficient to cause such adhesions. The plastic exudate thrown out by the omentum at the point of lesion no doubt offers some purely mechanical protection against the spread of infection; it is also probable that the secretion poured out from the omental vessels has some bactericidal or antitoxic action. Furthermore, the bacteria received into the lymphatics of the omentum are either rendered less virulent or are destroyed.

MALFORMATIONS.—The great omentum may be entirely absent, or only incompletely developed. Variations in size and shape are common; partial defects of large size are not infrequent. Misplacements of portions of the organ are found in connection with congenital hernias. Congenital cysts of the omentum are of very rare occurrence.

CIRCULATORY DISTURBANCES.—The vascular relations of the omentum are such as to make the circulatory conditions of this organ dependent upon that of neighboring structures. Inflammations of the gastrointestinal tract, hernias, obstructions, tumors, disturbances of the portal circulation affect the vessels of the omentum to a more or less marked degree.

Active hyperemia of the omentum occurs in the early stages of epiploitis, also after the sudden diminution of abdominal pressure after the removal of ascitic fluid or of a tumor of large size.

General passive congestion of the omental vessels follows portal obstruction, as the result either of hepatic disease or of pulmonary or cardiac affections. The vessels of the great omentum may be markedly congested in advanced stages of cirrhosis, or in

failure of compensation in valvular disease of the heart. In such cases the congested omentum plays a large part in the production of the associated ascites.

Advantage has been taken of the dilated condition of the omental vessels in cirrhosis of the liver, and of the fact that the omentum readily forms adhesions with other structures, by an attempt to set up a collateral circulation between the portal and the systemic veins by means of "*Morrison's operation.*" This consists in the establishment of an anastomosis between the vessels of the omentum and those of the anterior abdominal wall through artificially induced adhesions. The peritoneum is first rubbed, and the omentum sutured to the area so treated. It is at present too early to speak of the value of this procedure; but very favorable results have been reported. In a case operated upon by Lens, venous channels were demonstrable in the adhesions that had formed between omentum and peritoneum. Animal experimentation shows the possibility of the establishment of such a collateral anastomosis. Similar results may be obtained by adhesions formed between the diaphragm and the liver or spleen.

Hemorrhage.—Small ecchymoses occur into the omental tissues in extreme active or passive congestion, in severe cases of the acute infections, in sepsis, in epiploitis, fat necrosis, secondary carcinoma, hemophilia, etc. Large hematomata are rare; they may occur in association with fat necrosis in cases of acute pancreatitis, or in severe epiploitis associated with appendicitis or salpingitis, or very rarely in hemophilia.

Infarction.—Incarceration or torsion of the omentum may, by shutting off the blood supply, give rise to an anemic necrosis. Ligation or thrombosis of the epiploic artery will produce the same result. In cases of resection of the omentum in herniotomy a thrombosis may be induced in the omental vessels which may extend to the gastric arteries. In cases in which the ligations arene ar the epiploic artery, anemic ulceration of the stomach or hepatic infarction may occur as the result of the extension of thrombosis into the gastric and hepatic vessels.

Edema of the omentum is of frequent occurrence. It may be due to general or local passive congestion, obstruction of the portal circulation, epiploitis, etc. In acute epiploitis associated with general peritonitis and ascites the omentum may be very much swollen. As a rule, edema of the omentum is manifest in the resulting ascites; the free interchange of fluid between the lymph spaces of the omentum and the peritoneal cavity relieves the omentum, so that it does not become swollen through the accumulation of fluid in its tissue spaces, until the collection of ascitic fluid in the peritoneal cavity reaches a certain degree of tension.

Ascites.—The omental function of lymph production and lymph absorption is directly connected with the development of ascites. All conditions favoring an increased formation of lymph by the omentum, as well as those preventing the absorption of peritoneal fluids, lead directly to ascites. Malpighi was perhaps the first to suggest that ascites may be caused by a pouring out of fluid from the omental vessels. In a case reported by Landgraf, an ascites intractable after fourteen tappings disappeared after the sloughing of a part of the great omentum which presented itself in an omental hernia. Similar cases have been observed. Eitel reports an interesting case of marked ascites which had been repeatedly tapped. A large tumor was found to be present in the upper part of the abdomen. On operation this was discovered to be the great omentum tightly rolled upon itself, its veins constricted and its circulation impeded. It was unrolled and the ascites was cured. The cause was attributed to the fact that the patient, a worker in a quartz mill, was in the habit of carrying a heavy box of mill product pressed against his abdomen. Other cases of a similar nature point to the omentum as a direct factor in the production of ascites.

Hydrops Omenti.—The collection of fluid between the layers of the great omentum is so designated. This condition occurs more frequently in cases of ascites in children than in old individuals.

Chylous Ascites.—In cases of secondary carcinoma of the omentum or in chronic fibroid omentitis, the ascitic fluid may be white or milky, due to fat or albumin in suspension. The presence of these substances may be due to the fatty degeneration of desquamated endothelium or tumor cells, or may result from the obstruction of chyle vessels. In the former case, when little fat is present in the fluid, the condition may be designated as *pseudo-chylous ascites.*

Retrograde Changes.—Atrophy of the omentum, as shown by total or marked disappearance of its adipose tissue, occurs in cachexias and wasting diseases as a part of the general marasmus. Atrophy of the fibrous trabeculæ may also occur. Cases have been observed in which the atrophy of portions of the organ gives rise to large open spaces between its coarser trabeculæ.

Necrosis of the omentum may be caused by incarceration or torsion, by ligation or thrombosis of omental vessels, or it may be associated with gangrenous conditions of the intestines.

Fat necrosis of the omentum occurs in acute pancreatitis, in pancreatic carcinoma, and in association with fat necrosis of the abdominal fat elsewhere. The necrosed areas are yellowish white, slightly elevated and opaque, and usually circular in outline. The omentum may look as if it had been touched with a hot iron. The necrotic areas may be hemorrhagic. In cases of longer standing lime salts may be deposited in the necrosed cells.

Amyloid has been reported as occurring in the walls of the omental blood-vessels.

Hyaline change of the walls of the omental arteries is found in chronic fibroid omentitis, in association with omental tuberculosis, in the neighborhood of inflammatory adhesions, etc.

Calcification may follow fat necrosis, or occur in old tubercles. In two cases of splenic anemia associated with hepatic cirrhosis (Banti's disease) numerous small nodules of calcification were found by the writer throughout the abdominal fat.

Inflammation (*Omentitis* or *Epiploitis*).—Inflammation of the omentum is essentially a part of a more or less general peritonitis in the great majority of cases; but in certain instances the omental inflammation preponderates, or appears to be primary; and further, as mentioned above, localized peritonitis is almost always associated with a localized epiploitis, the omentum adhering to and shutting off the inflammatory process (see *Peritonitis*). The character of the epiploitis is the same as that of the general or local peritonitis with which it is associated, viz., *fibrinous, purulent, gangrenous,* etc. The omental process is, however, in all cases characterized by a greater tendency to proliferation and formation of granulation tissue than is the case with the other portions of the peritoneum. This is especially true of the localized forms of epiploitis with adhesion; the inflammatory process is essentially plastic in character (*omentitis adhæsiva*). As a result of very active inflammations there may be formed such large masses of granulation tissue in the omentum as to produce tumors which may be mistaken clinically for neoplasms.

Inflammatory Tumors of the Omentum.—As the result of such excessive production of granulation tissue in the inflamed omentum, there is not infrequently found a tumor-like thickening of the

omental tissues. This may occur in any part of the abdomen, but is most frequent in the appendix region. The thickening of the omentum may be diffuse or nodular, often limited to the portion adherent to the peritoneum about the primary focus. In other cases the omentum may be rolled up tightly above the level of the umbilicus, forming a firm cylindrical mass extening across the abdomen. The tumor mass may develop very rapidly in acute processes, but more gradually in chronic inflammations. After the inflammation has subsided the tumor may disappear through the resorption of exudates and the contraction of the granulation tissue, and the omentum may become detached. In other cases, after the inflammation has disappeared, the tumor remains and the omental adhesions become hard and organized. In purulent cases the inflammation may persist, and a chronic tumor then remains, composed of an inflammatory focus (abscess) surrounded by thick omental adhesions of granulation tissue. In other cases, after the termination of the inflammation, the omentum becomes detached, the granulation tissue is converted into fibrous tissue, and the omentum is greatly changed in form by the production of diffuse or nodular fibroid thickenings (*omentitis fibrosa*). If there is much retraction of portions of the new fibrous tissue the omental tumor may be very small and irregular (*omentitis fibrosa retrahens*).

Inflammatory tumors of the omentum also follow laparotomy, in which either the normal or the inflamed omentum has been ligated and in part removed. Torsion of the omentum may also give rise to an omental tumor. In some cases, after an operation for strangulated hernia, the omentum has become inflamed, though not involved in the strangulation. In all these cases the inflammatory tumor develops slowly; in one-half of the recorded cases the period of development varied from one to four months, and in some cases the interval was much longer. The tumor is usually on the same side of the body as that upon which the operation was performed, its location depending upon the amount of omentum removed. It may or may not be adherent to the abdominal wall. The tumor is usually about the size of an orange, but may be much larger. When adherent to the wall the tumor is immovable; if non-adherent it may be moved upward or laterally, but not downward. The surface of the mass is usually smooth, the consistence firm. It is tender on pressure. It usually does not move with respiration, or only slightly. Percussion gives a dull tympanitic note, often completely dull. In the center of the tumor may be found the ligatures used to tie off the omentum, and it is believed by some that the use of silk ligatures in such operations plays an important part in the development of the tumor.

Clinically, the inflammatory tumors of the omentum may be mistaken for ovarian tumors, misplaced liver or spleen, malignant growth of the intestines, etc. In certain cases they have been regarded as malignant neoplasms (sarcoma) even after microscopical examination. Coley mentions a case in which a portion of the omentum had been excised on account of its presence in a left inguinal hernia. The stump became inflamed, withdrew, and gave rise to a mass in the region of the splenic flexure. Malignant disease was suspected, the abdomen was opened, and a portion of tissue removed for examination. The diagnosis was "probable spindle-celled sarcoma." The patient died after a radical operation. The autopsy showed that the inflamed omental stump had become attached to the splenic flexure, and the section for microscopical examination had been cut from the very abundant inflammatory tissue.

In two cases in the writer's experience there were found, in the region of the appendix, large tumor masses that clinically presented characteristics of malignancy. Microscopical examination of tissue removed for diagnosis showed a very cellular granulation tissue, rich in blood-vessels, having relatively thick walls. In one case the diagnosis of "omental granulation tissue" was given. The patient recovered, and the tumor completely disappeared. In the other case the first sections examined were prepared by a quick method for immediate diagnosis. The section showed a neoplasm-like structure of round and spindle cells grouped around blood-vessels, suggesting an endothelioma. Study of the sections showed large numbers of plasma cells present, and the fact that all of the blood-vessels had relatively thick walls. A diagnosis of omental granulation tissue was then given. A year afterward the tumor was reported as having entirely disappeared. There can be but little doubt that some of the so-called disappearing malignant tumors of the abdomen belong to this class. The microscopical appearances of small bits of tissue removed for diagnosis may on first glance strongly suggest a sarcomatous growth. In the relatively thick sections obtained by means of the freezing microtome or by quick embedding methods the finer points necessary to a differential diagnosis are usually not sufficiently clear for a safe diagnosis, and it is from such sections that the diagnosis of sarcoma is usually made. The writer holds that in carefully prepared sections the differential diagnosis between such forms of richly cellular granulation tissue and sarcoma may be made without great difficulty. The presence of numerous plasma cells, the prominence of the small vessels, both in number and in size, their relatively thick walls, the hypertrophic character of their endothelium, the marked endothelial proliferation, the typical character of the mitosis, the presence of fibrin and small pus collections, are all points establishing the diagnosis of subacute or chronic development of granulation tissue. The presence of adipose tissue and coarse trabeculæ of fibrous tissue are also of service in fixing the origin as omental.

Omental Abscess.—An acute omental abscess may develop without the association of a general peritonitis or of any discoverable local change. In the majority of cases, however, the appendix is the seat of primary infection. Omental abscess may be associated with salpingitis, and very frequently follows laparotomies or herniotomy. In those cases in which the omental abscess is apparently of cryptogenic origin, or overshadows the primary lesion, it may be inferred that the resistance of the omental tissues had been lowered, or that the organ, through circulatory disturbances or for other reasons, has been unable to overcome the virulence of the bacteria taken up. The abscess may be found in any part of the abdominal cavity, but as the omentum is commonly rolled up, it lies usually above the level of the umbilicus. It may develop around ligatures which are used in tying off the omentum. The organ is reddened, thickened, and is usually adherent to the abdominal wall by a fibrinous exudate, which is most marked over the abscess. The latter not infrequently forms an encapsulated pocket of pus between the omentum and the anterior abdominal wall, and may extend into the tissues of the latter. The clinical symptoms are those of sepsis, with local pain and tumor. In many cases the abscess becomes chronic, a large amount of fibrous tissue is formed about the encapsulated area, the adhesions become hard and firm, and a gradual healing of the abscess may take place. A more or less generalized peritonitis may accompany the abscess. Occasionally the pus may break through into the intestine and recovery follow. Rupture into the peritoneal cavity may cause a severe general peritonitis which may be fatal.

Sequelæ of Omental Inflammation.—As a result of inflammatory conditions of the omentum there may

arise adhesions between the organ and the various abdominal viscera; these may cause stenosis, or snaring off of portions of the bowel, obstruction of the ureter, pressure upon the common duct or pylorus, abnormal position of the pelvic organs, etc.

Progressive Changes.—Either fibrous or fatty *hyperplasia* of the omentum may occur in the portion of the organ included in hernial sacs. The hyperplasia may take on the character of a lipomatous growth. Cases have been reported of such hyperplasias in hernial sacs which reached half-way to the knees.

The remarkable capacity for *proliferation* possessed by the omentum has been taken advantage of in plastic operations in the abdomen.

Tumors.—Primary neoplasms of the omentum are rare. *Fibroma*, *neurofibroma*, and *lipoma* have been described. In the former class of cases the actual disease may in reality have been a localized fibroid thickening resulting from an inflammatory omental tumor. The so-called lipomatous growths have been, in the majority of cases, localized or diffuse fatty hyperplasias.

Of the primary malignant tumors reported as occurring in the omentum *endothelioma* and *myxosarcoma* are the forms whose origin in this organ is supported by observation; but it must be observed that the rarity of such cases, and the imperfect descriptions given, leave us very much in ignorance as to the occurrence and nature of primary omental tumors. In the older literature there are occasional reports of "*primary cancer*" of the omentum, "scirrhus of the omentum," and "primary colloid disease," "vesicular degeneration," "hydatid disease," etc. The exact nature of this peculiar growth of the omentum, apparently primary in some cases, cannot at present be stated. Primary epithelial growths (carcinoma) of the omentum of course do not occur. In some cases the growth may have been secondary to colloid carcinoma of the stomach or intestine, or to cystocarcinoma of the testis or ovary. In typical cases the omentum is greatly thickened; its surface is uneven, flocculent, and shreddy, this appearance being due to the projection of rounded villus-like masses of gelatinous material attached by shreds of tissue. The appearance strongly suggests hydatid disease of the placenta. On microscopical examination the mass of the omentum has a finely spongy texture of connective tissue enclosing masses of gelatinous material. Swollen cells are occasionally found in the spaces. If we exclude the cases of true *colloid cancer* or *cystocarcinoma, secondary* to primary tumors in other organs, there still appears to be a peculiar myxomatous growth of the omentum, which according to the most careful reports (Eve and others) must be classed as a *myxoma* or *myxosarcoma*. No proof of its endothelial origin exists. Matas has reported a case of primary myxosarcoma of the omentum with secondaries in peritoneum and accompanied by a mucoid ascites. It is probable that some of these conditions were in reality pseudo-myxoma peritonei resulting from ruptured ovarian cyst adenomata or carcinomata.

The flat or warty growths, originating from endothelium, may be primary in the omentum as well as in the peritoneum. Microscopically, the primary endotheliomata of the peritoneum consist of cords or strands of cells in the connective tissue beneath the endothelial covering. The cords of cells appear to follow the lymph vessels. The growth may originate from the superficial layer, or from the endothelium of the lymph vessels. Some writers believe these growths to be epithelial in type, arising from the surface mesothelium, and therefore class them with the carcinomata.

Omental *cysts* have also been reported, and have been interpreted as "*simple serous cysts*," "*distended lymph vessels*," "*congenital multilocular cystoma*," etc. It is not improbable that the latter variety was a primary tumor of the ovary, which after becoming adherent to the omentum, had been freed from its original attachments. Such a process has undoubtedly occurred in the case of the so reported *dermoid cysts of the omentum*. Though primary dermoids of the omentum may occur, it is highly probable that those observed have originated from primary ovarian dermoids in the manner described. Fibroma and myofibromas of ovary, broad ligament and uterus may become attached to the omentum, and as the result of traction become detached from this original situation and adherent to the omentum ("omental parasites").

Implantations of ovarian papillomata or papilliferous cystadenomata upon the omentum are not rare; and are usually associated with a marked ascites, or pseudo-myxoma peritonei.

Secondary malignant growths of the omentum are of very common occurrence; they represent most frequently carcinoma metastases from primary growths in stomach, intestine, gall-bladder, pancreas, ovaries, testis, uterus, and prostate. All varieties (medullary, scirrhous, mucoid, etc.), may occur. Miliary nodules may be strewn throughout the omentum, or the organ may be more or less uniformly thickened, indurated, and contracted. The writer has seen the omentum strewn with innumerable pearly metastases of a horny squamous-celled carcinoma primary in ovarian dermoids in a woman of twenty-two years. A number of cases of melanotic sarcoma of the omentum have been reported While the growth, in several of these instances, was regarded as primary, it undoubtedly was metastatic from primaries in the skin or choroid.

Pseudo-myxoma.—The omentum as well as the general peritoneal surface may be involved in the process known by this name. It is due to rupture of an ovarian cystoma, the discharge of mucoid or colloid material into the peritoneal cavity, and the organization of the latter by proliferation of the peritoneal tissues.

Parasites.—*Echinococcus* of the omentum has been reported. After rupture of a primary hydatid cyst into the peritoneal cavity the omentum may be secondarily involved in connection with the remainder of the peritoneum. *Cysticercus cellulosæ* of the omentum has also been observed.

Tuberculosis of the omentum is of relatively common occurrence. In many cases the infection of the peritoneum appears to be primary in the omentum. The thickened omentum may be tightly rolled up, forming a tumor-like mass which may be mistaken for a neoplasm or numerous miliary nodules may be strewn over its surface or through its substance. In primary tuberculosis of the female genital tract, large tubercles may be fouin tnd he omentum. (See also *Peritonitis.*)

Syphilis.—A fibroid omentitis has been observed in congenital syphilis, and in connection with syphilitic cirrhosis and fibroid splenitis.

Foreign Body.—Encysted needles, projectiles, gallstones, the dead fetus from an ectopic gestation (lithopedion), masses of mucus, fecal material, fibrin, necrotic epiploic appendages, etc., may be found in the omentum. Gauze, sponges, ligatures, or foreign bodies left in the peritoneal cavity during laparotomy may become included in omental adhesions.

Aldred Scott Warthin.

Onchosphere.—Onchophore. The six-hooked embryo of tapeworms which hatches from the egg and bores its way into a secondary host where it becomes a bladder-worm. See *Cestoda.* A. S. P.

Oocyst.—A stage in the sexual phase of the malarial parasite in which it becomes encysted on the wall of the mosquito's stomach and forms a number of spores. See *Protozoa.* A. S. P.

Ookinete.—The name given to the zygote formed after conjugation of gametes. See *Protozoa.* A. S. P.

Ophthalmia.—See *Conjunctiva, Affections of.*

Ophthalmia, Sympathetic.—This term includes two quite distinct diseases—sympathetic inflammation, or sympathetic ophthalmitis; and sympathetic irritation. These conditions are liable to arise in a previously healthy eye, after the fellow-eye has been injured and has become the seat of chronic inflammation due to such injury. In addition to these two definite forms of disease, to be described below, there are cases in which a blind degenerated eye seems to exert an unfavorable influence upon the fellow-eye.

Many surgeons believe that any blind and degenerated eyeball should be removed, if the fellow-eye becomes impaired by chronic progressive disease. Thus, if one eye presents an absolute glaucoma and the other a beginning glaucoma, the prospect of arresting the process in the latter may sometimes be improved by removing the blind eye. Or if one eye be blind with general detachment of the retina and softening of the globe, it is thought that choroidal degeneration or cataract affecting the other may be favorably influenced by removal of the blind eye. Such a belief in the dangers of sightless, degenerated eyeballs is not universal and should not be acted upon unless there is some evidence of disease in the second eye or danger of sympathetic inflammation. But if other disease of the better eye arises, the possibility of influencing it favorably by removal of a sightless degenerated stump should be carefully considered.

It is possible that in some cases inflammation of the uveal tract not caused by injury may extend from one eye to the other. But this is not certainly established. It is convenient to speak of the injured and primarily inflamed eye as the *exciting eye*, and of the other as the *sympathizing eye.*

Sympathetic Ophthalmitis.—*Synonyms:* Sympathetic uveitis, Cyclitis, or Iridocyclitis, Malignant uveitis, or Migratory ophthalmia). This is an inflammation involving chiefly the uveal tract of the eye, but liable to extend to all the tissues of the eyeball, running a chronic course marked by repeated relapses, and ending in the majority of cases in complete blindness.

Causes.—Sympathetic inflammation is caused by non-purulent traumatic inflammation in the uveal tract of the fellow-eye. Injury of one eye unattended with uveal inflammation does not cause sympathetic uveitis. Uveal inflammation not due to traumatism does not excite this disease. Injuries to the eyeball, which are followed by severe purulent uveitis or panophthalmitis, are not likely to excite sympathetic inflammation. Disease in other organs may cause metastatic inflammation of the eye, but not the form of inflammation now under consideration. The character of the wound of the exciting eye greatly influences the liability to sympathetic disease.

The lodgment of a foreign body within the eyeball constitutes the most dangerous form of injury, unless the eye be promptly destroyed by suppuration. Yet the character of the foreign body and the structure in which it is lodged modify its evil influence. Minute aseptic foreign bodies sometimes remain in the eyeball indefinitely, without causing serious impairment of the injured eye or danger of sympathetic ophthalmia in its fellow. They are least dangerous when lodged in the crystalline lens or in the corneoscleral coat. They are most dangerous when suspended in the vitreous or embedded in the ciliary processes or choroid. Comparatively small or punctured wounds are more to be feared than extensive cuts or lacerations.

Wounds that pass through the anterior chamber are less dangerous than those which enter through the sclera directly into the vitreous. When the body which inflicts the injury reaches the eyeball only after passing through the lid, the danger is lessened. Wounds attended with free hemorrhage or an abundant flow of aqueous humor are less dangerous. Wounds in the ciliary region have long been recognized as especially dangerous. They are made by bodies which have not passed through the lids. They enter directly into the vitreous chamber. The track of the wound is likely to be obstructed by a prolapse of the ciliary body into it or by swelling of the injured margin of the lens. These wounds, furthermore, involve the most complex and functionally active part of the uveal tract. However, any perforating wound of the sclerocorneal coat, even the incision of a smooth, clean operation, may be followed by sympathetic ophthalmitis. Perforations of this coat by disease, as by corneal ulcer, may also cause it. Cases are reported in which injury without perforating wound, such as bruise of the eyeball with dislocation of the crystalline lens, has given rise to sympathetic ophthalmia. But it is not certain that such injuries cause sympathetic uveitis.

The form of inflammation after injury, which makes an eyeball dangerous to its fellow, is a plastic uveitis. In its typical form it is characterized by marked involvement of the ciliary body, prolonged pericorneal redness, tenderness of the ciliary region, punctate deposits on the back of the cornea, diminished tension of the eyeball and, shrinking of the globe. There are also apt to be marked involvement of the iris, posterior synechia, alteration of color or appearance from degenerative changes, and with these more characteristic symptoms may occur changes in any part of the globe. Sight is usually entirely lost.

But it must be remembered that in rare instances the changes in the exciting eye may be comparatively slight yet equally dangerous. In numerous cases sympathetic ophthalmitis has been excited by an eye which retained useful or even good vision. The redness and ciliary tenderness may be transient, the diminution in the tension of the eyeball but slight, and the changes in the iris and deposits on the cornea barely perceptible, and still sympathetic uveitis may arise and destroy the other eye. On the other hand, free suppuration is not sure to prevent an eye from exciting sympathetic ophthalmitis. Neither is mechanical traumatism essential. An eye that has had the cornea perforated by an ulcer, especially if this has been followed by prolapse of the iris, or an eye that contains a tumor, especially sarcoma or glioma, may also be the seat of a uveal inflammation that will cause sympathetic ophthalmitis. All eyes, the coats of which have been perforated either by mechanical violence or by ulceration, must be objects of suspicion.

Premonitory Symptoms.—Previous to an outbreak of sympathetic ophthalmia, the exciting eye is noticeably red and tender. Either it has failed to become entirely quiet or symptoms of irritation and inflammation have reappeared. In the sympathizing eye there may be undue sensitiveness to light, decided loss of the power of accommodation, and quick tiring of the eyes with ordinary use. Symptoms of this kind should be watched for, when there is reason to fear sympathetic ophthalmia, and their presence should excite alarm. But they cannot be wholly relied upon to foretell an outbreak of sympathetic inflammation. They may be so slight as to occur unnoticed, or all of them may be absent.

Symptoms and Course of the Disease.—The actual beginning of sympathetic inflammation is insidious. Slight photophobia, increased lacrymation, or a little redness of the eye is noticed. But it is difficult to fix the exact time at which it began. As happens with other forms of uveitis, the hyperemia may at first seem general, involving the conjunctiva as much as the pericorneal or deep scleral vessels. There may be slight discoloration of the iris and sluggishness in its reaction to light, or even one or two minute posterior synechiæ, by the time it is realized that the eye is inflamed. A little impairment of vision and faint haziness of the dipotric media may be present at the first examination.

From day to day the symptoms of uveitis become more severe and unmistakable. The lacrymation becomes excessive, the pericorneal and deep redness predominate. The photophobia becomes severe, the iris assumes the greenish or brownish tint of iritis, loses its luster, and becomes distinctly thickened. It yields slowly and imperfectly to a mydriatic. The posterior synechiæ become more numerous and broader. The vitreous grows noticeably cloudy and the vision is greatly impaired. Points of tenderness appear in the ciliary region, and the tension of the eyeball is perceptibly diminished. There may be the severe pain of an acute iritis, but generally the pain is not great as compared with the tenderness, photophobia, and impairment of vision.

After a period of from two to six weeks the symptoms cease to grow worse, and some days later improvement is noticed. The pain and photophobia become less and vision may slightly improve. But some hyperemia and ciliary tenderness remain, and after a remission, which may vary from a few days to several months, all the symptoms grow worse again, vision sinks lower than it had been before, the media become more obscured, and the tension of the eyeball still further diminished. Other remissions and relapses may occur, and it may be two or three years before the eye reaches its final condition of complete blindness, with greatly lowered tension, degenerated iris, and shrinking of the globe. The retina, vitreous, and lens directly suffer from the disease of the nutritive coat of the eye. The lens and vitreous become opaque. The latter shrinks and the retina becomes detached and completely altered. The cornea, besides the deposits of opacity on its posterior surface, becomes more or less opaque and shrunken. This condition may be reached in a few weeks, before the first remission has occurred, the subsequent relapses being marked merely by increased pain, soreness, and hyperemia in the sightless and shrunken eyeball.

Atypical Cases.—The course of the disease as altered by treatment will be discussed under that head. In a few cases impairment of vision is at first the only symptom noticed. Ophthalmoscopic examination reveals hyperemia, haziness, and slight swelling of the head of the optic nerve, with haziness and change of color, and perhaps swelling of patches of the choroid and retina. Cases of this kind usually develop later the more characteristic symptoms of sympathetic uveitis. They have been described as cases of sympathetic neuroretinitis. But they are probably essentially uveal, the choroid being at first chiefly affected.

As with the other forms of uveitis, structures outside the uveal coat, and not directly dependent on it, are liable to be involved. Quite apart from the usual deposits on the posterior surface and the opacity due to degeneration, the cornea may be early affected with interstitial or ulcerative inflammation; or severe conjunctivitis may be present. So prominent are these complications in certain cases that they have been reported as cases of sympathetic keratitis or conjunctivitis. But in all cases in which the sympathetic character of the disease can be regarded as demonstrated there has also been distinct evidence of uveitis.

Diagnosis.—The symptoms presented by the sympathizing eye are not in themselves a sufficient basis for the positive diagnosis of sympathetic ophthalmia. They are merely those of a severe uveitis which tends to become chronic, to relapse, to go on to complete blindness and degeneration of the eyeball. This uveitis is especially insidious in its manner of beginning and progress, and it exhibits a special tendency to cause great diminution in the vision and in intraocular tension. But these features are not alone sufficient to distinguish it from other forms of uveitis. The history of traumatism and uveal inflammation of the other eye are essential to the diagnosis; not traumatism alone, for this does not cause sympathetic disease, unless it has been followed by uveal inflammation.

The time which has elapsed since the injury must also be considered. Sympathetic inflammation rarely arises within three weeks from an injury. Usually the interval is six weeks or more. On the other hand, it rarly begins more than two or three months after the injured eye has become entirely quiet and free from inflammation. Cases beginning more than six months after the exciting injury are unusual, and more than a year afterward are quite rare. Still a few cases are recorded in which the exciting eye has remained quiet for many, sometimes thirty or forty, years before causing an outbreak of sympathetic ophthalmitis. Eyes that have been so long injured are more apt to canse sympathetic irritation. The diagnosis between these two conditions will be considered in connection with the latter.

An attack of iritis or other form of uveitis occurring years after an injury to the other eye should not be regarded as necessarily one of sympathetic inflammation, although that should be suspected. If the injured eye remains free from tenderness and irritation, even though it be entirely blind, and especially if its tension is normal or nearly so, and the attack does not show the special characteristics of sympathetic uveitis, the case is probably not one of sympathetic disease.

Pathology.—The anatomic changes which mark sympathetic ophthalmia are those of plastic uveitis. There are exudates which become organized into connective tissue, which may in time ossify, while the characteristic elements of the ocular tissues degenerate and atrophy. But although the transmission of disease from one eye to the other has been observed with especial interest for 200 years, the method of transmission is still unknown. MacKenzie, in 1844, suggested transmission along the optic nerve. Müller, in 1858, suggested transmission by the ciliary nerves. A morbid functional activity was assumed, a reasonable hypothesis to explain sympathetic irritation, which was then confused with sympathetic inflammation. In 1881 Snellen argued that this was a specific inflammation, caused by organisms transmitted through the lymph spaces of the optic nerves. Berlin suggested that microorganisms causing it might be carried to the exciting eye by the blood current, and find conditions suitable for their development only in the uveal tract of the sympathizing eye. Reflex influences through the ciliary nerves may predispose the uveal tract of the sympathizing eye to infection through the blood. Deutschmann claimed to have produced sympathetic ophthalmia in the rabbit, and to have demonstrated its extension along the optic nerve. Gifford and others failed to confirm his experiments, and showed that the probable explanation of his results was a general infection rather than a sympathetic ophthalmia. Randolph, using dogs, which are less liable to general infection, found that the fellow-eye was unaffected. Brown Pusey suggested that cytotoxins produced in the damaged uveal tract of one eye may act upon the cells of the uveal tract in

the other eye and thus produce sympathetic ophthalmitis. Elschnig believes that antigens from the diseased uveal tract cause a hypersensibility of the uveal tract in the other eye making it a favorable point of attack, and that sympathetic inflammation is an anaphylactic iridocyclitis.

That nerve influences starting from the exciting eye may powerfully affect the sympathizing eye is demonstrated by sympathetic irritation and its immediate relief by the removal of the exciting eye. It is equally certain that such nerve influences do not alone cause sympathetic ophthalmitis. In this disease some other factor must be added. Infection with a distinct period of incubation is the factor that best accords with our present ideas of such inflammations. The period of incubation may cover the two or three weeks that always elapse between injury of the exciting eye and sympathetic ophthalmia, or during which sympathetic inflammation is liable to occur after the removal of the exciting eye.

Prevention.—With a disease which tends to cause complete blindness, and which often goes on to this termination in spite of all treatment, prophylaxis is of the highest importance. In timely enucleation of the injured eye we have a certain preventive. The only questions that arise in connection with it are: In what cases should it be applied and have we any other equally or sufficiently reliable prophylactic?

It cannot be said in any case of injury that enucleation is demanded to prevent sympathetic disease until a plastic uveitis has been set up. But with regard to an eye known to contain a foreign body of more than the most minute size that cannot be extracted, it may be assumed with almost absolute certainty that such dangerous uveitis will occur; and if an eye be so injured that future vision with it is impossible, immediate enucleation will so shorten the period of disability that it will often be justified. When the eye has become the seat of uveitis due to injury, and the inflammation does not begin to subside within three or four weeks, especially if the tension of the globe is much below normal, if blind it should be promptly enucleated. If not blind, but with vision no longer useful and diminishing, the eye should be enucleated if the patient cannot remain under observation. If the eye be blind with greatly diminished tension from an injury that has occurred within two years, even though it be free from hyperemia or tenderness, it should be enucleated if the patient cannot remain within reach of competent professional assistance. The location of a wound in the ciliary region is an added reason for enucleation. Any blind eye that is known to contain a foreign body should be enucleated.

None of the substitutes for enucleation are so certain to prevent sympathetic inflammation. They have a field of usefulness, but not for this purpose. Nevertheless, if a patient absolutely refuses enucleation, but will allow evisceration, it may be proper to do the latter operation rather than decline further care of the case. In doing evisceration the sclera should be freed from all remains of its contents and mopped with a strong germicide, as carbolic acid or a solution of formaldehyde.

Enucleation of an injured eye does not instantly confer immunity from sympathetic uveitis. In a good many cases the inflammation has appeared within two or three weeks after the removal of the exciting eye, and in a few cases as late as four weeks. But in a majority of cases sympathetic inflammation arising in this way has yielded to treatment and has ended in recovery.

Treatment.—The first step is removal of the exciting eye. The only exception is when the exciting eye retains useful vision. There are a number of cases on record in which the sympathizing eye became entirely blind, while the exciting eye retained useful vision for many years or throughout life. It has sometimes been thought that removal of the exciting eye was followed by increased violence of the sympathetic inflammation. But probably the same increase would have occurred had the exciting eye not been removed. On the other hand, the cases in which the exciting eye has been removed especially if removed early, show a much larger proportion of recoveries than do those in which the exciting eye was allowed to remain. The strong tendency to recovery in cases of sympathetic inflammation arising after enucleation also attests the value of this measure.

The sympathizing eye should be placed under the influence of atropine as soon as possible. A strong solution, two per cent., may be instilled, one drop every ten minutes for an hour; or after the use of cocaine a small crystal of atropine sulphate may be placed in the conjunctival sac, near the external canthus. Until this crystal is dissolved, or while instilling the strong solution, we should guard against atropine poisoning by everting the lacrymal puncta through traction on the skin at the side of the nose, and holding in contact with them a little absorbent cotton, thus keeping the atropine solution from getting into the tear passages. After this first mydriatic attack the strong solution of atropine should be instilled three to five times a day.

Before each instillation of atropine, or at more frequent intervals if the eye is painful, it should be bathed with very hot water, not longer than five minutes at a time. Dry heat, best from the electric coil, may be applied for periods of one-half hour to two hours. If the hyperemia is severe, and especially if there is pain, one or two fluidounces of blood may be taken by leeches or by the artificial leech applied to the temple. Subconjunctival injections of sodium chloride solution may be made at intervals of two or more days. These should be placed rather deeply within the capsule of Tenon. On going out in daylight the eye should be protected by very dark glasses or an opaque shade; but it should not be kept continuously covered by thick dressings.

As in other forms of uveitis, general treatment is of great importance. Mercury should be given freely up to the point of causing tenderness of the gums or other evidences of its poisonous action. At first, calomel may be given until it acts as a purgative, with large inunctions of mercurial ointment twice daily. Later, any form of mercurial that will sustain the mercuric influence without symptoms of poisoning may be employed. Nothing will be gained by carrying the action of mercury beyond the point indicated. But its administration should be continued until all symptoms of inflammation have disappeared.

Next to mercury, the most important drug is sodium salicylate. This should be given in the largest doses that will be tolerated; from twenty to forty grains, three or four times a day, in an adult. But such doses need not be continued more than a few days. Later, it may be given in smaller doses or discontinued. Should this drug cause serious disturbance of the stomach, other salicylates or aspirin may be substituted. Recently atophan in doses up to a grain per day for each pound of body weight have been strongly recommended by Gifford. Salvarsan and neosalvarsan have also been credited with some recoveries. For a chronic case or at a late stage, the iodides may be beneficial.

It is very important that the patient should be kept in as good a state of general health as possible. On this account the administration of mercury and the salicylates must be closely watched. The patient must not be confined to a dark room. The use of alcohol in any form should be forbidden. Diet and rest must be carefully attended to, and general tonics, especially iron, may be indicated. After apparent

cure the patient should be kept under observation, and should avoid excessive use of the eyes or indulgence in alcoholic drinks for many months.

When the attack of inflammation has been finally subdued, it may leave the pupil closed by exudate, with or without an opaque lens. This condition might require for its relief an operation, but the eye should be allowed to remain quiet for years before any such operation is attempted. If done within a year or two after the inflammation has subsided, it will almost certainly cause a recurrence of the disease. Nothing will be gained by the attempt, and much will be lost.

Prognosis.—Sympathetic inflammation, untreated, ends in blindness; and, excepting those cases which arise after the enucleation of the exciting eye, less than half can be checked by treatment The nature of the injury or the violence of the inflammation in the exciting eye has little influence over the prognosis when once sympathetic disease has actually occurred. Attacks beginning with lesions in the fundus show a rather better proportion of cures than those commencing with marked iritis. The first remission must not be mistaken for a cure. But when recurring exacerbations grow less severe and the sight is left not worse by them, an ultimate cure with partial or complete restoration of vision may be hoped for. Not until the eye has been free from inflammation for a year should the case be considered cured.

Sympathetic Irritation, or Sympathetic Neurosis.—This is a condition set up by disease in the fellow-eye and characterized by extreme irritability, photophobia, excessive lacrymation, moderate general hyperemia, and inability to use the eye, sometimes equivalent to complete temporary blindness.

Cause.—This is disease in the fellow-eye, generally of long standing and marked by very extensive degenerative changes. The exciting eye may show no symptoms of present inflammation, no hyperemia or tenderness. Its condition may be the result of injury, or it may be the result of disease quite independent of traumatism. Intraocular tumor, without perforation of the ocular coats, may cause it. Ossification of the choroid is a quite common cause.

Symptoms.—It begins with inability to use the eyes for ordinary work, photophobia, and increased lacrymation. The symptoms vary in severity from time to time, but tend on the whole to grow worse, until any use of the eyes becomes impossible. On close examination the cornea will be found free from deposits, the pupil small but reacting well, the iris normal; and if photophobia does not prevent an ophthalmoscopic examination, the media are found clear and the fundus is normal. The hyperemia is quite general, may disappear when the eye is kept quiet in a dark room, but increases rapidly on attempting to use the eyes or even with examining them.

Diagnosis.—Sympathetic irritation has to be distinguished from eye strain and from sympathetic inflammation. Hyperopia, astigmatism, or presbyopia may cause apparent lack of accommodation, excessive irritability of the eye, lacrymation, photophobia, and difficulty with near work. Therefore the refraction and accommodative power should be carefully measured before adopting the diagnosis of sympathetic irritation, even though the fellow-eye presents all the conditions that would make it the cause of this neurosis. By placing the suspected eye under the influence of a mydriatic, eye strain can be excluded.

To differentiate between sympathetic inflammation and sympathetic irritation is often of great practical importance. Their chief points of difference may be contrasted as follows:

Inflammation.	*Irritation.*
1. Follows perforation of the sclero-corneal coat, usually by traumatism, especisily if the wound is in the ciliary region or if a foreign body is lodged in the eye.	1. Follows extensive degeneration of the fellow-eye, with or without traumatism, especially if the eye contains a foreign body or new-formed hone.
2. Occurs at from three weeks to six months after injury is rare after one year.	2. Occurs usually many years after injury, or disease, of the exciting eye.
3. The exciting eye is almost always red or sore before the outbreak.	3. The exciting eye may be entirely quiet and free from irritation.
4. There are deposits on the posterior surfsce of the cornea, the iris is discolored, its reaction impaired. There are posterior synechiæ; the vitreous is hazy; vision is permanently diminished.	4. The cornea is free from deposits, the iris normal; the vitreous clear, and the eye may for a short time be capable of normal vision.
5. There are always marked organic changes.	5. There are no organic changes.
6. There are relapses at intervals of many days, weeks or months.	6. The severity of the symptoms may vary from hour to hour.
7. It terminates in alow recovery under treatment; or, more frequently, in complete blindness.	7. It tends to continue indefinitely; hut ends in immediate restoration to normal after removal of the exciting eye.

The differential diagnosis is difficult only at the outset before the organic changes of sympathetic inflammation have had time to occur.

Pathology.—No anatomical changes occur, and the morbid influence is undoubtedly transmitted from the exciting to the sympathizing eye through the ciliary nerves.

Prevention is of little importance. The only effectual preventive measure is removal of the eye that is liable to cause it, and this is equally efficient after the condition of sympathetic irritation has actually developed. And since a degenerated eyeball may be retained many years without causing sympathetic irritation, the possibility of that event at some future time does not justify enucleation.

Treatment.—This is enucleation of the exciting eye or one of the substitutes for enucleation. Where sympathetic irritation alone is to be feared, probably evisceration or even optico-ciliary neurotomy will be as efficient as the removal of the eyeball. If preferred by the patient or operator, resort to one of them, preferably evisceration, in place of enucleation, is entirely proper. If the patient strenuously objects to operation and the case is clearly not one of sympathetic inflammation, palliative measures may be tried. Avoidance of close work and keeping the eye under a mydriatic, as atropine sulphate 1, distilled water 100, instilled twice a day, will often give partial or temporary relief. The internal administration of bromides is also useful. In a few cases freedom from irritation is thus secured, and it may last for months or years. But in nearly all cases the return of the symptoms, and the continual annoyance and disability which they cause, will in time overcome the strongest objections to operative treatment.

Prognosis.—Without treatment the irritation continues or recurs indefinitely. With removal of the exciting eye the prognosis is entirely favorable. Donders reported a case in which the patient had believed himself entirely blind for two years, but was proved to possess normal vision two hours after the removal of the exciting eye. Edward Jackson.

Ophthalmometer.—This term (from ὀφθαλμός, eye, and μέτρον, measure) denotes an instrument for measuring the eye, latterly an instrument exclusively for measuring the curvature of the cornea.

Thomas Young (1801) was the first investigator to attempt accurate measurements of the curvature of the cornea in the living eye. By measuring the diameter and the prominence of the cornea, he found the

chord and versed sine of an arc of a corneal meridian; from these data he calculated the radius of curvature. Young's estimate of the curvature of the cornea agrees very closely with the results which have since been obtained by more refined methods.

Kohlrausch (1840) measured the image of a distant object viewed by reflection at the anterior surface of the cornea, as in a convex mirror, and thus laid the foundation of ophthalmometry in the modern sense. The object used by Kohlrausch was a pair of candle flames placed behind small openings in an opaque screen. The images of the two bright points were viewed through a small astronomical telescope, constructed for observing at a distance of from two to three feet, and their positions marked by two adjustable spider lines in the eyepiece. The length of the image (distance separating the images of the two points of light) was then read, through the telescope, on a finely divided scale placed as nearly as possible at the distance at which the image had been observed.

The results obtained by Kohlrausch, also by Senff (1846), who carried the investigation somewhat further, correspond very closely with measurements which are now generally accepted. The later development of ophthalmometry has been in the direction of perfecting the instrument for purposes of scientific investigation, and of adapting it to clinical use.

The ophthalmometer was perfected, as an instrument of scientific research, by Helmholtz (1854). With the addition of a large graduated circle, arranged to carry lamps, it was employed by Donders and Middelburg to measure the curvature of the cornea in different meridians.

The ophthalmometer of Helmholtz is essentially an adaptation of the heliometer of Clausen (1841). A divided plate of thick glass with parallel surfaces is mounted in a cubical box fixed in front of the objective of a small astronomical telescope constructed for observing at a distance of from 0.5 meter to 1 meter, so that each half of the glass plate covers half of the objective. The two halves of the divided plate are arranged to turn in opposite directions on a common axis at right angles to the axis of the telescope, and the amount of rotation is read to tenths of a degree on a graduated disc fitted with a vernier. So long as the two halves of the glass plate are in the same plane, perpendicular to the axis of the instrument, an object seen through the telescope appears without displacement and single; but any rotation of either half of the plate gives rise to a displacement of the image formed by the corresponding half of the objective, and this displacement increases with the rotation. As the two halves of the plate are rotated simultaneously in opposite directions the displacement of the images is also in opposite directions, and the total displacement is double what it would be if either half of the plate were rotated separately through the same angle.

The object (three points of light disposed in a row) as seen by reflection at the surface of the cornea is focussed by the telescope through the glass plates in the zero position—*i.e.* with both plates set at right angles to the line of vision. The graduated disc is then turned until the two images are seen touching each other, but not overlapping, in which position of the plates the displacement of each image is exactly equal to half the length of the image. The amount of displacement (x) of either image depends on the index of the refraction (n) of the glass of which the plate is made, the thickness (h) of the glass plate, and the angle (ϕ) through which the plate has been rotated as expressed in the equation

$$x = h, \frac{sin(\phi - \phi')}{cos\ \phi}$$

the value of ϕ' being dependent on that of ϕ, as expressed in the equation

$$sin\ \phi = n.\ sin\ \phi';$$

as the displacement of each image is equal to half the length of the image, we have

$$\text{length of image} = 2x = 2h, \frac{sin(\phi - \phi')}{cos\ \phi'}.$$

In practice all calculation is dispensed with by making use of a table of successive values of $2x$ corresponding to different readings of the ophthalmometer, as ascertained by experiment.

As the distance of the object is quite large in comparison with the radius of curvature of the cornea, it is admissible to calculate the latter by the use of the simplified equation

$$r = 2f, \frac{\text{length of image}}{\text{length of object}}.$$

The size of the image is determined by the amount of rotation of the plates as indicated by the reading of the graduated disc, and is independent of the observing distance; also the measurements may be made with great accuracy and without being materially impeded by slight movements of the observed eye.

Helmholtz also made direct measurements, with his ophthalmometer, of the real image of a pair of lights as seen by reflection at the posterior surface of the crystalline lens, and by an ingeniously devised indirect method he measured with the same instrument the much fainter virtual image formed by reflection at the anterior surface of the lens. By repeated measurements made upon the same eye in a state of accommodative relaxation and in accommodation for the near, he obtained the necessary data for calculating the radii of curvature of both surfaces of the lens in each of these two conditions. The measurements of Helmholtz were repeated with some modifications of the technique by H. Knapp (1860). Knapp also measured the curvature of the cornea, mostly in the horizontal and vertical meridians, in a series of cases of astigmatism (1862).

To adapt the ophthalmometer to the measurement of the curvature of the cornea in any required meridian, Donders and Middelburg (1863) added a graduated circle, bearing lamps. They measured the curvature of the cornea in a large number of eyes in twelve meridians, thereby adding greatly to what had been previously known regarding the different forms of astigmatism.

Coccius (1867) substituted a fixed plate cut from a doubly refracting crystal of Iceland spar for the movable glass plates used by Helmholtz. The amount of displacement of the image formed by the extraordinarily refracted rays is determined by the thickness of the plate, and is constant; the size of the object (distance separating the lights) is therefore varied, until the two images are seen to touch each other without overlapping. The radius of curvature of the cornea is found from the simplified equation:

$$r = 2f, \frac{\text{length of image}}{\text{length of object}}.$$

The ophthalmometer of Javal-Schiötz (1881) was especially designed for the clinical investigation of the curvature of the cornea in all meridians, and is admirably adapted to its purpose. Two strongly illuminated targets (*mires*) of white enamel replace the lights, and the doubling of the image is effected by means of a doubly refracting prism of Iceland spar, which is achromatized, and at the same time a little more than neutralized for the ordinary rays by the addition of a prism of flint glass turned in the opposite direction. With this construction of the prism, the two images of the pair of targets, formed, the one by the ordinary and the other by the extraordinary rays, are displaced equally in opposite directions; the aggregate displacement of the images for the distance at which the eye is observed is three millimeters. The two targets are arranged to slide on a graduated arc of 0.35 meter radius, turning with the tube of the telescope. The

head of the patient is supported by the head-rest, so that the center of curvature of the cornea shall lie approximately at the center of curvature of the arc. A more exact adjustment of the distance is then secured by moving the telescope, with its stand, until the doubled images of the two targets are seen sharply defined by reflection at the surface of the cornea;

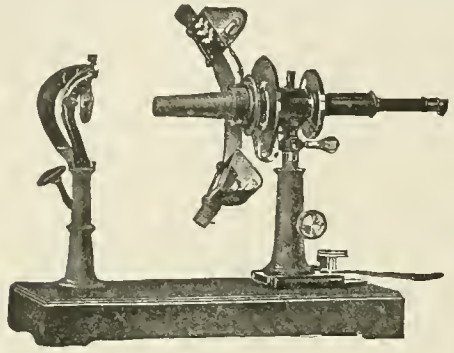


Fig. 4177.—Ophthalmometer of Javal-Schiötz, Meyrowitz 1907 Model.

the teleseope is eonstructed for distinct vision at the distance of the image, which is formed about four millimeters behind the center of the cornea. The doubly refracting prism is in the tube and the meridian in which the arc and targets stand is read on a graduated disc. The eye under examination is directed upon the end of the telescope; the other eye is covered by a pivoted sereen.

The ophthalmometer depends for its results upon the magnitude and form of reflections from the surface of the cornea which acts as a convex mirror. These reflections vary in size with the radius of curvature of the cornea, the size of the image varying directly with the radius of curvature.

The eye to be observed is placed at the center of curvature of a horizontal arc which holds two illuminated objects, called mires, that can be moved along it so as to alter the distance between them. This arc can be rotated around a horizontal axis coincident with the visual axis of the eye so as to bring the mires into any corneal meridian. If now one can measure the minute distance between two reflections on the cornea, one can compare this distance with the actual distance separating them and thus readily compute the corneal curvature.

For the purpose of making these delicate measurements, there is placed in the axis of orientation and of vision a telescope containing a birefringent prism. This divides the luminous rays into two sets, so as to double the image formed by the pair of mires. This doubling is constant, and does not vary with the separation of the mires. Therefore, if we know the doubling power of the prism, we may, from the separation of the images as seen through the telescope, obtain the required data. The amount of separation is the amount of overlapping of the ordinary prismatic image of one mire with the extraordinary image of the other. The ophthalmometer is so proportioned and graduated that direct readings in dioptres are available, and no calculations are necessary.

The theory of corneal reflections is approximately that of a convex mirror and is shown diagrammatically in Fig. 4178 which is the cross-section of an ophthalmometer taken through the centers of the mires, M, N. The visual line also lies in this plane, as can readily be seen. EE is the anterior surface of the cornea concentric with the arc at C. The radius of curvature of the arc AHB, AC, is taken at twenty-seven centimeters so that when divided into degrees each degree shall be an even length in millimeters. This diagram is not drawn to scale, but for convenience and clearness.

The inner edges of the mires, A and B, are the points of reference in our consideration, and the *distance between them* is the index to the *size of the image* hereinafter referred to. According to the theory of convex mirrors, the various rays from the point A are reflected as if they came from a point A′ on the axis AC, which point is therefore the conjugate focus or virtual image of A. If A be infinitely removed so that the rays emanating from it may be considered parallel, A′ becomes the principal focus, and the distance $A'C = \frac{1}{2}$ the radius of curvature r of the

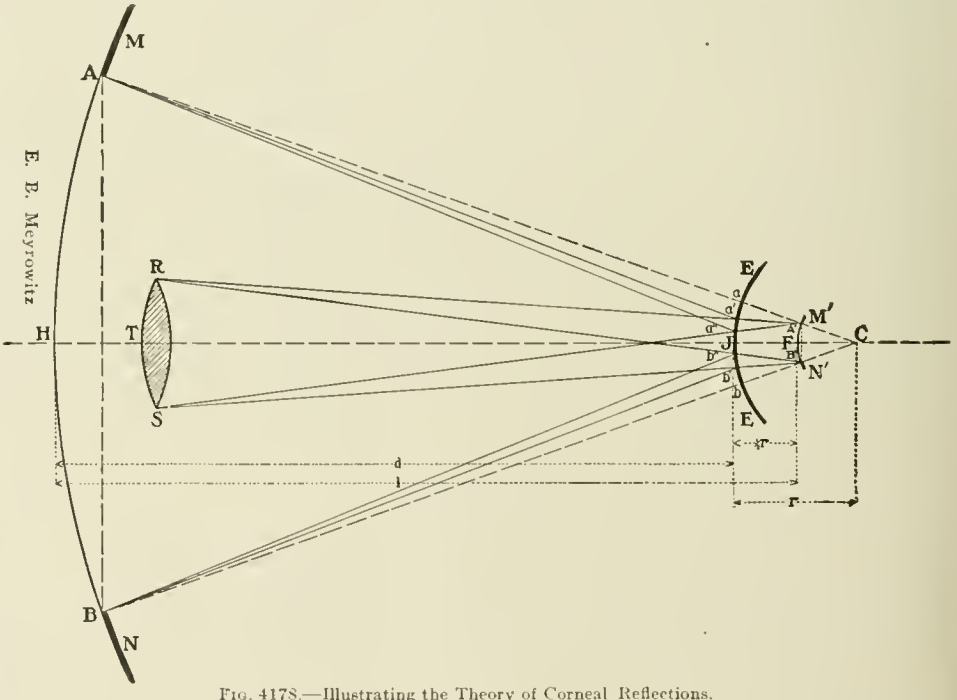


Fig. 4178.—Illustrating the Theory of Corneal Reflections.

mirror. In our analysis we shall regard A as infinitely removed from C and the rays from it parallel.*

In the same manner that A′ was found we may locate B′ and F, the conjugate foci of B and H, they being also the principal foci. The arc AHB is then represented by A′FB′, its virtual image. Only in

*Strictly speaking, this applies only to parabolic surfaces, but the error is entirely negligible.

case of an arc concentric with the mirror, as at present, is the image similar to the object.

Let AHB, the object, be designated as O; A′FB′ the image, as I; the distance HJ = Aa = Bb of the object from the mirror, by d; the distance AA′ = HF = BB′ by l.

Now it is readily seen that the arc AHB is to its image A′FB′ in proportion to their respective radii, or

$$\frac{O}{I} = \frac{l + \frac{1}{2}r}{\frac{1}{2}r} = \frac{2l + r}{r}$$

Now discarding r because of its smallness in relation to 2l, we have

$$\frac{O}{I} = \frac{2l}{r}$$

Sulzer remarks that the rigorous exactitude of the measurements is assured by the regulation of the instrument. Since, however, the use of the Ophthalmometer covers a comparatively narrow range of curvatures, the simple formula will prove highly accurate within those limits if the instrument be suitably adjusted to that particular range.

It is important to bear in mind that the formula showing the relation between the size of the object and image is equally true whether we consider the arc *AHB A′ F B′* or the rectilinear distance—the imaginary chords *AB A′ B′*. If, however, there was a visible chord its image would not, as pointed out previously, be a straight line.

means hereafter to be described for doubling the reflections by a constant amount, we establish a definite visible standard by which the distance of separation between the contact images may be measured at any time.

This necessarily brief treatment of a very important subject will, it is believed, be of some practical assistance to those users of the instrument who have not the time to make these studies themselves. Obviously the curvature of the cornea cannot be measured by any simple mechanical means, and the process therefore through which these measurements are arrived at, with mathematical accuracy, will naturally interest scientific users of the instrument.

"Since the appearance of the Javal-Schiötz instrument many changes have been made in the design of the instrument for the dual purpose of simplifying its manipulation and securing greater accuracy. Thus the addition of electric illumination as well as a change in the model of the head-rest itself, were closely followed by an important change in the raising and lowering adjustment, credit for which is due to Dr. Frank D. Skeel of New York, at whose suggestion the perpendicular movement of the entire body of the instrument was added. Then came the transillumination of the mires, by means of small electric lamps, first suggested by Dr. Southard of San Francisco, and the employment of colored mires to eliminate irisation of the images by Dr. Wm. S. Dennett of New York; the gear movement and the supplemental dial of Dr.

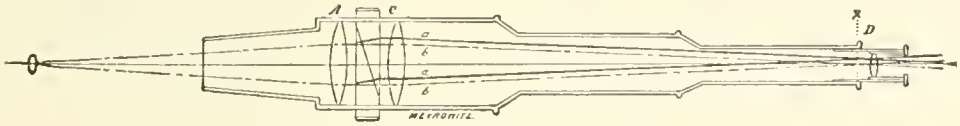


Fig. 4179.—Diagram Illustrating the Javal System.

The telescope *T* is of twenty-seven centimeters anterior focal distance and must be focused upon the points *A′ B′* of the reflected image.

Of the rays from any points reflected by the cornea, only a small pencil finds its way into the telescope. If we connect *A′* with *R* and *S*, the extreme points of the objective, as shown in the section and designated by *a′* and *a″* the points where these lines cut the cornea, then *a′ R* and *a″ S* will be elements in a cone that envelops the reflected pencil. So *A′ A a″* is the effective incident, pencil, *a′a″* being the only part of the corneal surface utilized as a mirror for the point *A*. Similarly *b′b″* is the portion used for reflecting *B*. If *A* and *B* Francis Valk of New York, for the easy rotation of the arc and telescope; the rack and pinion movement of the mire, and the double movable mires by Dr. A. E. Davis, of New York; the laterally swinging eye shield of Skeel, and the artificial cornea of Dr. John Morgan of Boston."

Two distinct optical systems are employed in the telescopes of ophthalmometers. One is the Javal-Schiötz, in which the doubling of the images is effected by a Wollaston birefringent quartz prism; the other is the Kagenaar in which simple glass prisms are used.

The Javal system is shown in Fig. 4179. The prism *B* is a rectangular parallelopiped consisting

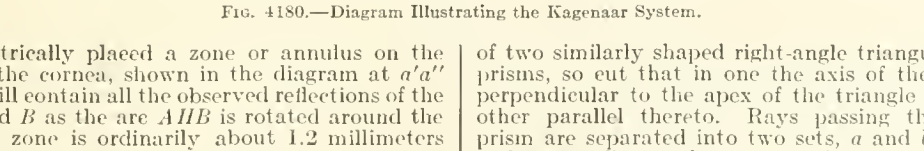


Fig. 4180.—Diagram Illustrating the Kagenaar System.

are symmetrically placed a zone or annulus on the surface of the cornea, shown in the diagram at *a′a″* and *b′b″*, will contain all the observed reflections of the point *A* and *B* as the arc *AHB* is rotated around the axis. This zone is ordinarily about 1.2 millimeters from the visual line.

A zone somewhat broader, but still relatively narrow compared with its diameter, will comprise all the reflecting surface utilized during the movements of the mires within the ordinary limits of change in position for an astigmatic determination.

As already indicated the size *O* of the image—that is to say, the distance between the inner edges of the mires—varies with the radius of curvature. To determine the actual amount of astigmatism, we need only compare observations of the relative positions of the mires in the principal corneal meridians. Through of two similarly shaped right-angle triangular quartz prisms, so cut that in one the axis of the crystal is perpendicular to the apex of the triangle and in the other parallel thereto. Rays passing through the prism are separated into two sets, *a* and *b*, ordinary and extraordinary, the amount of separation depending on a number of factors, including the angle of the prism. This prism is placed between two similar biconvex achromatic lenses each twenty-seven centimeters principal focal distance. When the lens nearest to the patient's eye is twenty-seven centimeters from the virtual image thereof, the rays passing through this lens will be rendered parallel and thus enter the prism. In spite of their mutual separation by the prism, the two sets of rays—ordinary and extraordinary—preserve practical parallelism as they emerge from the prism and enter the rear lens, to be focused

thereby at approximately twenty-seven centimeters, thus reproducing *in size* the virtual image on the patient's cornea.

The determined amount of doubling, three millimeters, is true only for a front focal distance of twenty-seven centimeters, which renders the rays of light parallel before entering the prism, hence the great precautions for securing accuracy in this particular.

In the Kagenaar system (Fig. 4180) the Wollaston birefringent prism is replaced by two ordinary glass

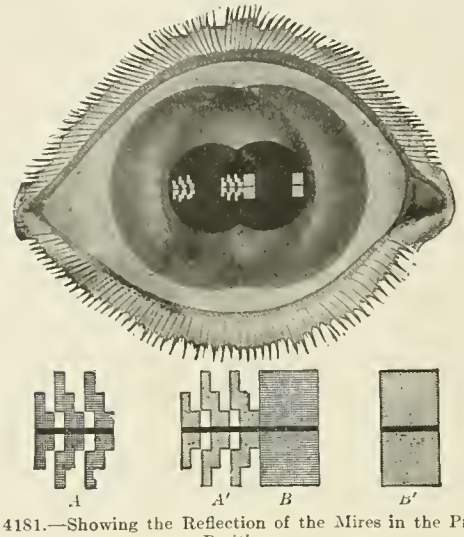


Fig. 4181.—Showing the Reflection of the Mires in the Primary Position.

prisms joined together at an angle, so that the line of junction exactly bisects the field of vision. Similar object lenses and eye pieces are used.

The fundamental difference between the two systems lies in the fact that in the Javal system the doubling is not primarily dependent on the angle of the prism nor on its position, but rather on the natural refracting qualities of the media itself; while in the Kagenaar system the doubling is effected by looking through both prisms at once.

One objection made against the Kagenaar system is that a slight movement to the right or left will cause one of the images to disappear, and slight movement of the patient's head will cause some difference in the reading.

The mires which travel on the arc are two targets, one a parallelogram and the other a figure consisting of steps arranged so as to show the extent to which a step image overlaps a plain image. Both mires have horizontal black lines running through the center, the purpose of which will appear hereafter.

As seen through the telescope, the mires are doubled, as shown in Fig. 4181. Only the two central mires are considered, however, the outer images being neglected. A and B represent the ordinary images and A' and B' the extraordinary. If the mires are spaced about twenty centimeters apart (equal to 40D on the scale) the distances between the inner edges of the same pairs, A and B (or A' and B'), is three millimeters, equal to the doubling element of the prism and the extraordinary image of the steps will be tangent to the ordinary image of the parallelogram. This position of the mires is shown in Fig. 4181.

For the sake of demonstration, we will presume the cornea under examination to be astigmatic "with the rule." Then when the arc is turned ninety degrees to the right into the secondary position, the image will appear as shown in Fig. 4182, the extraordinary image of the steps and the ordinary image of the parallelogram overlapping—the white of the superimposed area being of greater intensity.

Two facts to which attention has previously been called must now be borne in mind, (1) the doubling element of the prism remains three millimeters as long as the eye is placed at the center of the curvature of the arc; (2) the size of the image (*i.e.* the distance between the inner edges of the same pair AB) varies as the curvature of the cornea.

In other words, the distance between A and its extraordinary image A' and likewise the distance between B and B' may be considered fixed, while the distance between A and B varies with the curvature of the cornea, as explained above.

In the case shown in Figs. 4181 and 4182, the curvature in the vertical meridian being less than in the horizontal, the size of the image is decreased and the two central images overlap. If, on the contrary, the eye under examination were astigmatic "against the rule," the mires would separate in the secondary position. Each "step" of overlapping represents one diopter, and the reading was formerly made from the image in this way.

In the present model the readings are taken from a scale to which all movements of the mires are transmitted.

The very brilliant illumination secured by transillumination results in a rather annoying irisation at the edges of the mires, which makes it somewhat difficult to determine the exact instant of contact. After the mires have been brought quite close the "ghost" that extends beyond the edges of the mires seems to fill the intervening space. To overcome this trouble in the present model a red glass is placed before the "parallelogram" mire and a green glass before the other, the colors selected being complementary.

The boundaries of these colored mires are very sharp and the irisation is effectually suppressed. In addition, when the mires are overlapped the superimposition of the complementary colors produces an area of nearly pure white which, offering a contrast to both the red and the green, assists in the determination of the position of the mires.

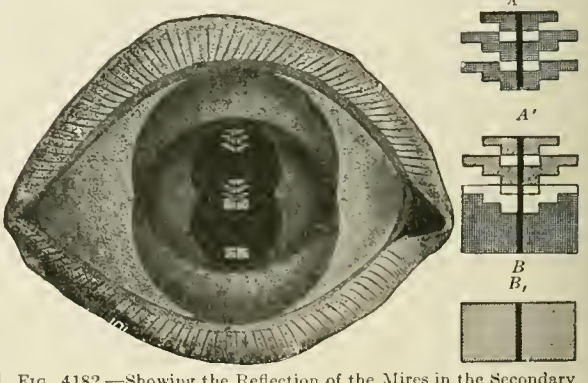


Fig. 4182.—Showing the Reflection of the Mires in the Secondary Position.

The arc along which the mires move has a radius of curvature of twenty-seven centimeters, and the value of each degree measured along this arc is obtainable from the simple formula:

$$\frac{27 \text{ cm.} \times 2 \times 3.1416}{360^\circ} = 5 \text{ mm. (nearly)}$$

Furthermore with an arc of this radius each diopter subtends one degree of the arc.

In the present model of the Meyrowitz ophthalmometer a direct reading scale is placed at the rear of the instrument and the graduating of the arc is therefore unnecessary. One so graduated, however, is shown in Fig. 4183 to help a mathematical analysis of the instrument. The graduations will be best understood by considering for a moment the arc on an ophthal-

mometer with but one movable mire. The zero is in the center directly under the center of the telescope and the graduations proceed outward from here in both directions. The smaller graduations on the inner

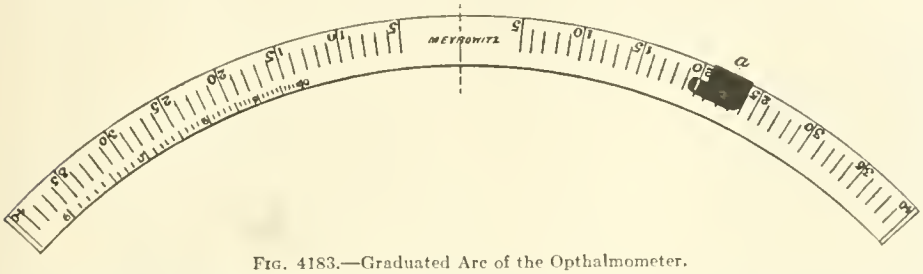


Fig. 4183.—Graduated Arc of the Opthalmometer.

right edge show the corresponding radii of curvature of the cornea in millimeters. One of the mires is stationary at 20 D. If then the movable mire is adjusted

Fig. 4184.—Mires of the Hardy Ophthalmometer.

to secure tangency *in the image* and its distance from the center in degrees be added to the twenty degrees, the result not only gives the number of degrees separating the mires, but also the refraction of that meridian of the cornea in diopters. For example, if it be found that when the mires just touch in the image, the movable mire stands at 25, the refraction of that meridian is 20 + 25 or 45 D.

The principle involved in graduating an arc where both mires move simultaneously is the same, but certain changes are necessary. If we bear in mind that while one mire is moving ten degrees the other one has moved a similar distance, it is easy to see that each degree on arc has a value of two diopters, and the arc must be graduated accordingly.

The Hardy ophthalmometer consists of a metal base on which the telescope and targets are operated and on which is the head rest for the patient. A large bowl-shaped blackened disc forms a dark background for the targets and shuts off reflection of surrounding objects.

The rotating telescope is of high power and short focus and contains an eyepiece, two objective lenses and a birefringent prism placed between the two objectives. Attached to the telescope are two mires, (see Fig. 4184) one of which is triangular and is bisected by a black space, the other arranged in steps and spaces on either side of a longitudinal white space. The mires are fixed on the large disc at a certain distance apart, are stationary, and are in the same plane as the deviation of the birefringent prism. They are translucent and are illuminated from behind by incandescent lamps, contained within the cups on the back of the large disc, thus shutting out the light from the eyes of the operator and avoiding the heat generated by the large lamps. They may also be sufficiently illuminated by daylight if the instrument is placed near to and facing a window.

A stationary graduated disc is fixed at the back of the instrument and two index-fingers are attached to the telescope to indicate on the disc the two principal meridians, the perforated one indicating the meridian being measured. Operating on the stepped mire is a slide actuated by a rack and pinion which enables the observer to see, on the cornea, both meridians at the same time. There are two scales on the slide, one of which shows the radius of curvature, the other the refractive power of the principal meridians.

Fig. 4185 represents a view of the eye with the mires reflected on it, as seen through the telescope. As shown therein, the eye, with the mires reflected thereon, appears doubled, giving the appearance of one eye overlapping another. The amount of this overlapping is constant, viz., three millimeters, but the images of the mires will vary in their distances from each other, according to the curvature of the cornea, from which they are reflected. The mires being fixed in one position on the disc, their images, as reflected from different eyes, will vary in size and distance apart, according to the curvature of the cornea.

There is no normal curvature of the cornea, but from statistics a radius of curvature of 7.8 millimeters has been settled upon as that of the average cornea. Accordingly the mires have been set so that when the cornea is of average curvature (7.8 millimeters radius) their central images will overlap centrally. If the cornea is of lesser curvature than the average (longer radius than 7.8 millimeters) the triangular mire will overlap on the plus end of the stepped mire as shown in Fig. 4185.

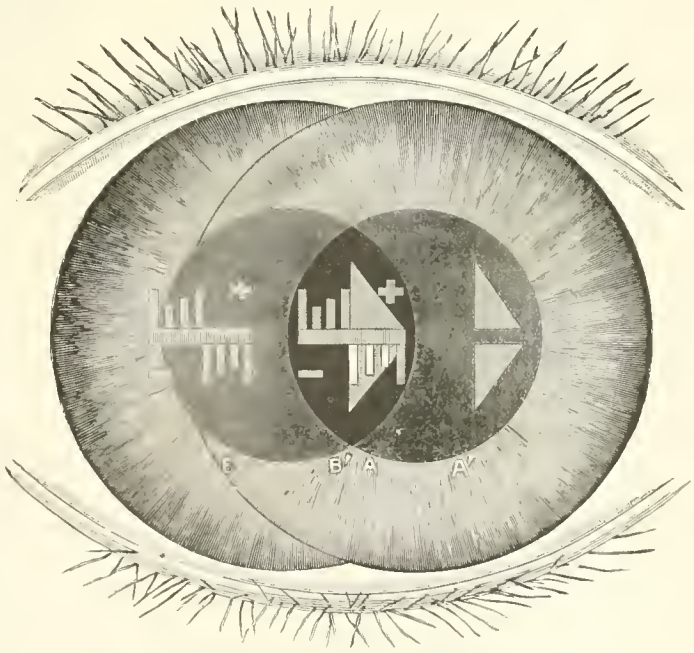


Fig. 4185.—Reflection of the Mires of the Hardy Ophthalmometer.

When the corneal curve is greater than the average (shorter radius than 7.8 millimeters) the triangular mire will overlap on the minus end of the stepped mire, but the amount of this overlapping will vary according to the curvature of the cornea being examined.

Fig. 4186.—Reflection of the Mires When They Are Not Parallel to One of the Principal Meridians in a Case of Corneal Astigmatism.

Each of the steps and intervening spaces in the stepped mire represent 1.00D, so that on either side of the central portion there is indicated 7.00D, making a total range of 14.00D for the instrument. Its two ends are marked plus and minus for the purpose of indicating whether the cornea under examination has a radius of curvature greater or less than the average, and is not meant to indicate positively the use of a plus or minus lens.

In corneal astigmatism the curves of the cornea vary in different meridians, and the meridians of greatest and least curvature are usually at right angles to each other. When the telescope is rotated to a position where the mires lie in the plane of one of the principal meridians of the cornea, that is, either the meridian of greatest or least curvature, the displacement of the images on the cornea by the prism is exactly in the same plane as the plane of the mires. But when the telescope is rotated so that the mires are in other meridians than the principal, the displacement is not exactly in the same plane; hence, in addition to the longitudinal displacement of the images in relation to each other, there is then a slight movement at right angles to the plane of the mires. This movement is rendered visible by the relative positions of the broad black space on the triangular mire and the broad white space on the stepped mire. They are exactly in the plane of the displacement, so that when the mires are not parallel to one of the principal meridians of the cornea, these spaces will not overlie exactly, but will appear as shown in Fig. 4186. When the mires are parallel to one of the principal meridians, the black and white spaces will exactly overlie, as shown in Fig. 4185. By this means the positions of the principal meridians are determined.

The difference between the curvature of the two principal meridians is read upon the scale at the side of the instrument in diopters or millimeters.

The C.-I. ophthalmometer consists of a metal base upon which is mounted adjustably a high-power short-focus telescope, a head rest, and eye cover, and a large black bowl-shaped disc upon which are mounted rigidly four mires; a pair to be used in each principal meridian of an astigmatic cornea. These mires are illuminated from behind by electric lamps, contained in cups, which exclude the light and heat from the eyes of the operator.

The telescope contains one achromatic objective, two weak achromatic prisms, mounted base to base, and a microscopic eyepiece. The objective is fixed in the telescope, but the prisms are adjustable in relation to the objective by a rack and pinion. The prisms may also be rotated inside the telescope through an arc of exactly ninety degrees, so that their doubling effect may be adjusted to the exact plane of either pair of mires. The rotation of the prisms, instead of the mires themselves, make this a one position ophthalmometer, for after the primary meridian has been located, no adjustment has to be made that will attract the attention of the patient. Therefore, the eye under examination is held in a fixed position while the radius of curvature of both principal meridians is being measured.

The position of the images of the mires as seen by the operator is effected by the position of the prisms in the telescope. The prisms are fitted in an inner tube and are carried back and forth by means of a finely adjusted rack and pinion. To the right end of this pinion is attached rigidly a wheel having two scales on it—one on its side, showing the radius of curvature in millimeters and tenths of a millimeter—and the other on its face, showing the refracting value of the radius of curvature—the graduations being in diopters and fractions of a diopter.

To the left end of this pinion is attached a wheel which may be adjusted on the pinion so that *O* on its face will coincide with the indicator, showing the radius of curvature; and on the side of this wheel, to the left of *O*, is stamped the words "with the rule"—while the words, "against the rule" are to the right of *O*.

Fig. 4187.—The C.-I. Ophthalmometer, Front View, showing the mires, the head rest, the eye cover, the vertical adjustment and the prism adjustment wheel from which may be read the radius of curvature and the refracting value of each of the principal meridians.

The scales on the fixed wheel enable the operator to read the radius of curvature in each principal meridian

to one-fortieth of a millimeter, and the total refracting value of the curvature in each of its principal meridians to one-eighth of a diopter; while the scales on the adjustable wheel enable him to read the exact power of a cylinder, which, if placed in contact with the surface of the cornea, would exactly correct the corneal astigmatism, and also to determine whether the astigmatism is with or against the rule.

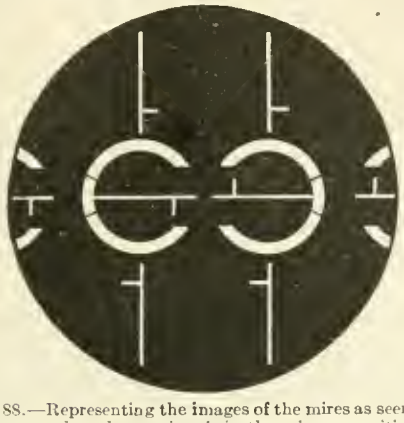


FIG. 4188.—Representing the images of the mires as seen reflected from a cornea when the eyepiece is in the primary position. They are shown as widely separated, but are in perfect alignment as when reflected from a perfectly spherical cornea or an astigmatic cornea at an exact axis.

The instrument will measure a cornea having a radius as long as eight and six-tenths millimeters, or as short as six and six-tenths millimeters. The dioptric value registered being from thirty-nine to fifty-one diopters. The principal meridians are indicated on a fixed disc by two pointers, a perforated, and a solid one; these pointers being fixed exactly ninety degrees apart.

The eyepiece is made to rotate with the prisms. It is stamped "primary" and "secondary." When it is

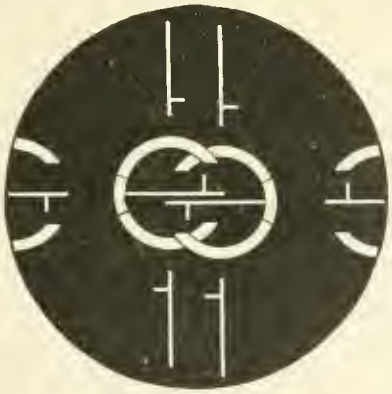


FIG. 4189.—Representing the images of the mires as seen reflected from an astigmatic cornea when they lie midway between its two principal refracting meridians. The toric surface of an astigmatic cornea displaces one mire above and the other below the central plane of the two, *except* when they lie exactly in the plane of one of its principal meridians.

in the primary position, the vertical meridian, or the meridian most nearly vertical may be measured, and when in the secondary position, the opposite meridian may be measured. If there be the slightest corneal error, it will be shown when the eyepiece is rotated to the secondary position.

The instrument and the mires are shown in Figs. 4187–4191.

The universal ophthalmometer consists of a heavy metal base which supports the telescope, with its bowl-shaped target containing the mires, and the head rest.

The doubling element is a Wollaston birefringement quartz prism mounted between two achromatic objectives, this being the Javal-Schiötz optical principle of a constant doubling element. The mires are the parallelogram and steps likewise devised by Javal and Schiötz some years ago. The telescope is supported in a sleeve at the upper end of the column, in which it may be racked back and forth for focusing

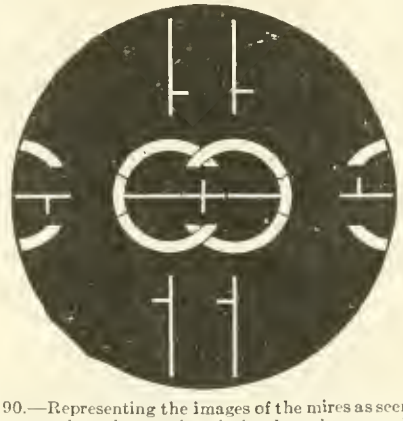


FIG. 4190.—Representing the images of the mires as seen reflected from a cornea when the eyepiece is in the primary position after the adjustments for both axis and radius have been made, or after a perfect cross has been formed. The reading in the primary position is made at this point. The solid meridian pointer indicates the meridian that has been measured.

by means of a milled wheel at side. It is raised or lowered to bring it to the level of the patient's eye by means of a lever concealed in the base and operated by the milled wheel and vertical shaft placed near the end of the instrument.

The head rest is of an entirely new form. The part presented for the reception of the patient's face is the slightly lipped edge, having the proper contour. It is more comfortable and cleaner than the old style with

FIG. 4191.—Representing the images of the mires as seen reflected from an astigmatic cornea, after the eyepiece has been rotated to the secondary position, but before the adjustment to form a cross has been made. After the latter adjustment has been made the readings in the secondary position may be noted. These readings are the radius of curvature in the secondary position; the dioptric value of that radius; the location of both principal meridians, the exact amount of corneal astigmatism, and whether it be with or against the rule.

flat sides and top. The chin rest is rubber enamelled covered metal, and is raised and lowered by means of a horizontal shaft, and can be operated from the examiner's end of the instrument.

The mires are controlled through an entirely new method. The large dial is made to revolve inde-

pendently of the telescope and arc, and has mounted on its concave face two spiral tracks (Fig. 4192). On the back of each of the mire boxes is a groove-like attachment engaging one of these spiral tracks. As the dial is revolved, therefore, the mires, following the spiral, are moved along the arc to or from the center, according to the direction of the rotation of the dial. Small posts are mounted at short intervals near the periphery of the dial on its convex side so that it may be conveniently revolved from any point—the operator is relieved of the necessity of visually locating this control. Other advantages of this method are the relatively large movement of the dial to small movement of the mires—a "fine" adjustment, the large open diopter scale and the great mechanical simplicity; there are no small moving parts.

From the outer scale is obtained the amount of astigmatism in diopters. It is graduated to quarter diopters. Two pointers (with double oval openings) are provided, one of them indicating the focus of the

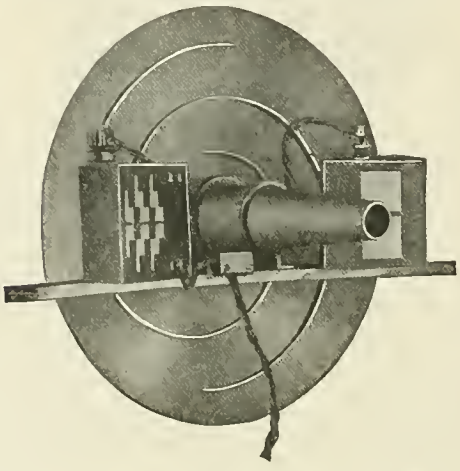


Fig. 4192.—Mire Mechanism of the Universal Ophthalmometer.

primary position, the other one the focus of the secondary position, the difference being the astigmatism. The primary pointer is stationary with regard to the scale. It does not change its reading unless moved by hand. The secondary pointer changes its reading with every movement of the mires.

The inner circle shows the axis scale. The small pointer moves with the telescope and records the position of the mires.

A new ophthalmometer designed by Souter can, it is claimed, be used for measuring not only the astigmatism of the cornea, but also both anterior and posterior surfaces of the lens. The optical system consists of the birefringent quartz prisms and achromatic objectives of Javal and Schiötz. The prisms may be moved to or from the eye, according to whether the cornea, or anterior, or posterior surface of the lens is to be examined. This has the effect of altering the doubling value.

The mires are of a new design, specially adapted to this work. In measuring the lens surfaces, the glass front of the mire is raised. This discloses lamps with circular filaments, which are intercepted by a tongue of metal at one point of their peripheries, forming letters C with the openings toward each other. This is the image greatly magnified by the cornea which is seen on the lens.

The method of measuring the lens curvatures is almost identical with the procedure for measuring corneal astigmatism, and the instrument is provided with three scales, indicating respectively the corneal, anterior surface, and posterior surface readings. The amount of the astigmatism can be estimated by the overlap of separation of the mires or by reference to these scales. Nelson Miles Black.

Ophthalmoreactions.—Allergic reactions developed in the conjunctiva have been used in diagnosis in the same manner as those applied to the skin. They have not become popular, however, since an active reaction produces a serious disturbance in the eye and may even lead to loss of sight.

The best known is the conjunctival tuberculin reaction of Calmette. In this test it is necessary that the two eyes shall be similar in appearance and not inflamed. One drop of a one per cent. solution of Koch's old tuberculin is applied to the lower lid at the inner canthus. It is useless to attempt the test in weeping or resisting children. In a positive reaction the conjunctiva begins to redden in from six to eight hours and reaches its maximum in from twenty-four to forty-eight hours. It disappears usually in from four to six days. A strongly positive reaction may result in permanent injury to the cornea. If there is no response a drop of a five per cent. solution of the tuberculin may be placed in the other eye. Any existing inflammation of the eye is an absolute contraindication to its application. It should never be repeated in the same eye and is best not given to arteriosclerotic individuals. It should not be applied to manifestly tuberculous children or where there is any skin lesion on the face near the eye.

This test is sometimes used in veterinary practice since it will give a reaction in cases where, prior to the test, dishonest dealers have injected tuberculin. The purified tuberculin is preferred, two or three drops of a four per cent. solution being instilled into the eye. The conjunctival test is one of the less sensitive of the tuberculin reactions and an individual reacting to it will usually give all the others.

An ophthalmic mallein test may be of value in the diagnosis of glanders since, as in the ophthalmic tuberculin test, one can obtain a reaction in animals which have received an injection of mallein. Two or three drops of a five per cent. solution of ophthalmic mallein are dropped into the inner canthus of one eye. In case of a positive reaction this is followed by a marked conjunctivitis, associated with a purulent exudate extending from the inner canthus. Only one dose is to be applied.

An ophthalmic reaction in typhoid fever has been recommended by Austrian. A "typhoprotein" is prepared by cultivating a number of strains of typhoid bacilli, precipitating the protein with alcohol, drying the precipitate and redissolving in water so that one-third to one-half milligram is contained in each drop. In typhoid fever patients the reaction reached its maximum in six hours and usually subsided within forty-eight hours. It was positive in ninety-four per cent. of the cases of typhoid and negative in 190 persons not suffering with the disease. Austrian is convinced of its specificity and recommends it because of its simplicity and the absence of any discomfort to the patient. Ralph G. Stillman.

Ophthalmoscopy.—The ophthalmoscope, (from ὀφθαλμός, eye and σκοπέω, I view), German, *der Augenspiegel*, is an optical device by means of which the interior of the eyeball is rendered visible.

Ophthalmoscopy, in its wider meaning, includes whatever pertains to the objective examination of the eye; in a narrower sense, it is restricted to the examination of the interior and background of the eye by the aid of the ophthalmoscope.

Principle of the Ophthalmoscope.—In order to obtain a view of the background of an eye, light must be projected by the aid of a suitable apparatus through the pupil and upon the fundus, the light reflected from the fundus of the examined eye must be received

by the observer's eye and the rays converged to form a sharp image upon his retina.

Helmholtz, the originator of the ophthalmoscope (1851) succeeded in doing this in the following manner: By means of a plate of glass (Fig. 4193, *PP*), held in an oblique position before the eye being examined, (*A*), part of the illumination emanating from a light source (*L*) placed at one side of the eye is reflected through the pupil into its interior. The light reflected from the fundus (*a*) again reaches the glass plate and a part is reflected to the source of illumination and part passes through the glass plate into the observer's eye (*B*) behind the plate where the rays are united into a well-defined image upon the retina (*b*). In order to increase reflection at the surface of the plate and thereby illuminate the background of the eye more intensely, Helmholtz placed three such plates one behind the other. A later modification consisted in increasing the reflecting power of the glass plate by lining its posterior surface with a mirror coating, a round hole through the plate or at least through the mirror coating enabling the observer to see through it.

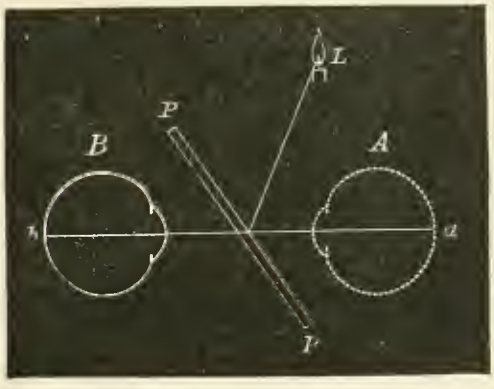


Fig. 4193.—Diagram Showing the Principle of Helmholtz's Ophthalmoscope.

Plain mirrors project only a small portion of the incident illumination into the interior of the observed eye. Perforated concave mirrors (first employed by Ruete in 1852), converge the incident rays of light into a cone which results in a much more intense illumination of the fundus. By placing a series of convex and concave lenses back of the perforation in the mirror the light reflected from the fundus of the observed eye may be brought to a focus upon the retina of the observer's eye, thus producing a sharper image.

The sources of illumination formerly used were the Argand burner and gas burner, at the present time where electricity can be obtained it has been substituted for oil lamps and gas.

Method of Examination.—The examination is conducted in a darkened room. The patient sits opposite the physician, and has on the side of the eye to be investigated the source of illumination. There are two different methods to be employed for seeing clearly the fundus of the eye. In order to make the explanation of them simpler, we first presuppose that both the observed and the observer have a normal refraction (emmetropia). In the examination with the erect image (direct method), the observer places himself and his mirror directly in front of the eye that he is examining. If now he holds the mirror obliquely in such a manner that he throws the light of the lamp into the pupil of the observed eye, he will immediately get a view of the interior of the eye. For a certain portion of the fundus of the eye, *A* (Fig. 4194), is illuminated by the mirror, *SS*. The rays reflected from any point, as *a*, of this illuminated region of the retina, leave the eye in parallel direction, pass through the central aperture of the mirror, and fall into the observer's eye, *B*. Here they are again united at a single point, *b*, upon the retina of this eye, so that here there is produced a sharp image of the point *a*. Since the same process is repeated for all the other points of the illuminated region of the retina of the eye, *A*, a sharp image of this portion of the retina is formed in the eye of the observer.

The examination with the inverted image, or by means of the indirect method (Ruete), is conducted

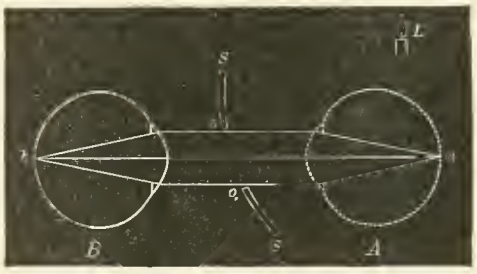


Fig. 4194.—Ophthalmoscopic Examination with the Erect Image. The eyes are drawn of the natural shape of an emmetropic eye having an axial length of 24 mm. The rays that are reflected from the mirror, *SS*, into the patient's eye are not shown, but only the rays that emerge from the latter.

with the aid of a strong convex lens of about six centimeters focus. This lens, *L* (Fig. 4195), is held at a distance of about six centimeters from the eye (*A*) under examination. The fundus of this eye is now illuminated by means of the mirror *SS*. The rays reflected from the illuminated region, *a*, of the retina pass out in a parallel direction, fall upon the lens and are united at the focus, *f*, of the latter. Thus there is formed at this spot an image of the point *a*. In like manner images from the other points of the illuminated region of the retina are produced in the focal plane of the lens, so that there is formed here an inverted image of this portion of the fundus. The observer's eye, *B*, now (through the aperture, *o*, of the mirror) examines this image at the ordinary reading

Fig. 4195.—Ophthalmoscopic Examination with the Inverted Image. The illumination of the fundus is accomplished by means of the source of light, *L*, from which the cone of rays, *k*, falls upon the mirror, *SS*, and from this is thrown into the eye, *A*. In order not to confuse the representation, these rays are not shown, but only those which pass out of the eye, *A*, again.

distance (about thirty centimeters), for which purpose the observer, unless he is myopic, must use a certain accommodative effort, or else a corresponding convex glass.

Each of these two methods has its advantages. The erect image is highly magnified—about fourteen times—as opposed to the inverted image, which is magnified but little (about four times). The direct method is therefore particularly adapted for the recognition of the finer details. The indirect method, on the other hand, affords a larger field of view, and there-

fore gives a better general prospect. The indirect method gives a more luminous image, and hence, when the refracting media are turbid, we still render the fundus visible when it is no longer to be seen in the direct image; and in myopia of high degree the indirect method is the only one practicable. In most cases, both methods are applicable, and then it is advisable to conduct the examination with the aid of both.

The ample field of view, conjoined with as strong an illumination as can be utilized, the convenient degree of enlargement of the retinal picture, the fact that the conditions of visibility of the fundus are not materially affected by hypermetropia, or by any but the highest grades of myopia, and the facility with which the disturbing influence of astigmatism may be annulled by giving an oblique position to the lens, all combine to render the indirect method particularly available whenever we wish to obtain a general view of a large area of the fundus. On the other hand, for the examination of the details of the fundus under a greater magnifying power, and especially for measuring the refraction of the observed eye, the direct method offers advantages which are entirely its own. The two methods are, therefore, to be cultivated side by side, each supplementing the other; the two together affording the means of studying the fundus with a thoroughness not so perfectly attainable by the use of either method alone.

In order to be able to use both methods equally well so as to obtain from each the best service of which it is capable, it is of the first importance that the observer eliminate any sources of error growing out of the uncontrolled exercise of his own accommodation. This can be attained only by the observer training himself to make all examinations, as well by the indirect as by the direct method, under the uniform condition of complete accommodative relaxation. And here the learner has, first of all, to suppress an instinctive tendency to accommodate for the short distance at which he knows that the object, or its image, actually lies. Hence, in practising the direct method, the learner should be made to feel that he must look not so much into the observed eye as through it, as if viewing an object lying far away. If myopic, he should accustom himself always to use the weakest concave correcting glass, or if hypermetropic, to use the strongest convex correcting glass through which he can obtain a distinct view of the details of the fundus; if emmetropic, he should learn to observe the fundus of an emmetropic eye without a correcting glass, and, in examining a myopic or a hypermetropic eye, to find and make use of the particular concave or convex correcting glass which exactly measures its myopia or hypermetropia.

In practising the indirect method the learner should also acquire the habit of viewing the inverted image with relaxed accommodation, which he will accomplish, if emmetropic, by looking through a convex lens of about five diopters power (twenty centimeters focus) placed immediately behind the hole in the mirror; or, if hypermetropic, by substituting for this lens such other lens of greater power as shall, in addition, correct his manifest hypermetropia; if myopic, he should similarly employ a convex or concave lens which accurately adjusts his own far point (r) for the distance of twenty centimeters; and only in the particular case in which his far point lies at this distance (M = five diopters) should he practise the indirect method without a correcting glass.

A fairly large pupil is always desirable in ophthalmoscopic examination, and in employing the direct method it is often indispensable; nevertheless, it is not always either necessary or advisable to make use of a mydriatic. As the pupils contract both under the stimulus of strong light and in connection with the exercise of the accommodation, it is best to conduct all ophthalmoscopic examinations in a completely darkened room of considerable size, and preferably with walls of a dark color. The general darkness of the room is favorable to the dilatation of the pupils, and the consciousness that he is in a room of some size makes it easier for the patient to relax his accommodation when he is asked to direct his gaze toward a large and faintly lighted object upon the opposite wall. By observing these precautions the causes which incite to contraction of the pupils are in a great measure eliminated, with the exception of the direct influence of the light reflected into the eye by the mirror. Light reflected from the concave mirror of silvered glass and concentrated upon the region of the optic disc ordinarily excites but little pupillary contraction, and, in fact, most of the routine examinations by the direct method may be made by the aid of this mirror without having recourse to artificial mydriasis. In searching for minute changes in the region of the macula lutea it is, however, not infrequently advisable to make use of a weak mydriatic, such as cocaine or euphthalmine, first determining there is no reason to suspect glaucoma in which case mydriasis might have disastrous results.

In order to permit the patient to direct his gaze upon a somewhat large object, it is important that his view, with the eye not under examination, be not cut off by the head of the observer. Hence the very useful rule, of general application, that the observer accustom himself always to use his right eye in examining the right, and his left in examining the left eye.

Under favoring conditions of refraction in the observed and in the observing eye, the minuter details of the fundus are distinctly visible, both directly, in the erect image, and indirectly, in the inverted image.

In the direct method of examination the visibility of the details of the fundus is affected in different ways according as the refraction of the observed eye is normal (emmetropic) or abnormal (myopic or hypermetropic). The details of the fundus of the myopic eye viewed through a concave lens placed behind the ophthalmoscopic mirror, are seen somewhat more magnified than in the case of the emmetropic eye. The details of the fundus of the hypermetropic eye, viewed through a convex lens placed behind the ophthalmoscopic mirror, are seen somewhat less magnified than in the case of the emmetropic eye.

In viewing the details of the fundus in the erect image the cornea and lens of the observed eye perform the function of a simple microscope. If we adopt the conventional rule of referring the magnified virtual image to a distance of eight Paris inches (about 217 millimeters), the enlargement will be represented very nearly by the ratio 217:15, or about 14.5 diameters, in the case of an emmetropic eye of average dimensions (Helmholtz).

Ametropia in the eye of the observer plays an important part in affecting the distinctness of the view of the fundus in the erect image. Thus a myope, who with the unaided eye, can focus only divergent rays upon his retina, does not see the details of the fundus unless the observed eye is hypermetropic to a degree equivalent to or somewhat in excess of the measure of his own myopia.

A hypermetrope, on the other hand, can, with relaxed accommodation, obtain a clear view of the fundus of a myopic eye in which the myopia does not exceed the measure of his own hypermetropia, and, by exerting his accommodation, he may be able to see the fundus of an emmetropic or even of a hypermetropic eye. A hypermetropic observer enjoys, therefore, a certain advantage in respect of the facility with which he can adjust his accommodation so as to see clearly under different refractive conditions of the observed eye, but he labors under a special disadvantage when he attempts to measure its refraction, and this for the reason that it is generally impossible for him either to estimate the degree to which he

exerts his accommodation, or to control its exercise so perfectly as to hold it with even approximate accuracy at the point required to make him virtually emmetropic.*

To obtain trustworthy measurements of the refraction by means of the ophthalmoscope by the direct method, the hypermetropic observer should first neutralize his manifest hypermetropia by means of the appropriate convex glass or else should subtract a quantity equal to the measure of his hypermetropia from the value of the strongest convex glass, or add the same quantity to the value of the weakest concave glass through which he is able to see the details of the fundus distinctly. Similarly, the myopic observer should first correct his myopia by means of a neutralizing concave glass, or else should subtract a quantity equal to the measure of his myopia from the value of the weakest concave glass, or add the same quantity to the value of the strongest convex glass, through which he is able to see the details of the fundus. If the observer is astigmatic in any notable degree, he will see the fundus in the erect image under the same imperfect definition as if astigmatism were present in the observed eye. It is, therefore, essential to the highest accuracy, in measuring the refraction by this method, that the observer correct any astigmatism that may exist in his own eye by means of the appriate cylindrical glass.†

In the ophthalmoscopic examination of the eye we invariably proceed by carefully investigating the eye by means of lateral illumination first, next testing the transparency of the refracting media with the ophthalmoscope, and not going on to the examination of the fundus itself until last of all. If the pupil is small, the beginner will do well to dilate it with cocaine or homatropine.

For test of the transparency of the refracting media light is thrown by the ophthalmoscope, held at the ordinary reading distance, into the eye under examination. If the refracting media are perfectly clear, the pupil shines with a uniform red luster. If there are places in the refracting media that are opaque, such stand out upon a red background of the illuminated pupil as dark points or spots. This is the case even when the opacities are actually, as seen by light thrown directly upon them, light colored—that is, white or gray.

In making a systematic examination of the fundus we begin at the papilla. In order to bring the latter into view at once, we make the patient look, not straight in front of him, but a little inward (toward his nose), for the entrance of the optic nerve does not lie at the posterior pole of the eye, but on the nasal side of it, and hence is brought directly opposite the observer only after a corresponding rotation of the eye inward. It then comes into view as a bright disc whose color is a light grayish or yellowish red, contrasting strangely with the red of the fundus. The shape of the papilla is circular or oval; in the latter case generally an erect oval. Its size apparently varies quite a good deal, which, however, is due to the varying degree of enlargement under which the papilla is seen. The true size of the papilla, measured in enucleated eyes, is, as a matter of fact, almost always the same—that is, about 1.5 millimeters in diameter.

* The principle underlying the method of measuring the refractive condition of any eye, by means of a concave or convex lens placed behind the ophthalmoscope mirror, is clearly set forth in the first publication of Helmholtz (1851), but the practical employment of the method on an extensive scale began with E. Jaeger (1856). It was also early cultivated by Donders, and especially by Mauthner (1867). Its general adoption, as a part of the daily work of the ophthalmic practitioner, dates from the introduction by Loring (1869), of an instrument provided with a series of especially selected correcting lenses arranged to admit of easy and rapid changes.

† With the introduction of skiascopy, or the shadow test, estimation of the refraction of an eye by ophthalmoscopy except roughly is not attempted as a rule in correcting refractive errors.

On account of this constancy we use the papilla for taking measurements in the fundus; we say, for example, that a diseased area is two disc diameters in size +.

Circumscribing the papilla, we very often (especially in making the examination with the erect image) recognize two rings distinct in color. The inner ring, next the border of the papilla, is white, and is called the scleral ring, because it owes its white color to the fact that the sclera is here exposed to view. It is present when the canal in the sclera, through which the optic nerve passes, is narrowest, not as is often the case, at its anterior orifice, but somewhat farther back, so that the foremost portion of the canal forms a funnel with the base forward. The wall of this funnel, which is formed of white sclera, appears when seen with the ophthalmoscope in perspective foreshortening, as a narrow white ring. At the margin of the aperture in the chorioid that gives passage to the optic nerve, the chorioid is often marked by a larger accumulation of pigment, by which the second, exterior ring is formed. This is apparent as a black, narrow, sometimes complete, sometimes incomplete, ring, which is designated as the chorioidal ring or pigment ring. The demarkation of the outline of the papilla, produced in this way, is generally much less sharp on the nasal than on the temporal side; for at the nasal side a greater number of nerve fibers pass over the margin of the papilla and thus obscure it. For the same reason the inner half of the papilla looks redder, the outer half paler, because the layer of nerve fibers in the latter situation being thinner, allows the lamina cribrosa to show through more.

The optic disc under normal conditions lies in the plane of the retina, and does not therefore form a projection upon it as the name papilla would lead one to suppose. On the contrary, it very frequently contains in its center a depression, which is produced by the fibers of the optic nerve separating from each other comparatively early and thus leaving a funnel-shaped space between them. The central vessels ascend on the inner wall of the funnel. The color of the vascular funnel seems white to us because we see the white lamina cribrosa at its bottom. Often, instead of a small funnel-shaped depression, a large excavation (physiological excavation) is present. This is situated at the outer half of the papilla, to whose external border it often reaches. The blood-vessels come out upon the inner border of the excavation and at the bottom of the latter are seen grayish dots, the lucunæ of the lamina cribrosa. With the brilliant white of the excavated exterior half of the papilla the grayish-red hue of the unexcavated interior half is in vivid contrast. Sometimes the physiological excavation is so large that it takes in the larger part of the papilla, but it never takes in the whole; there is always a part (though it may be a small part) of the papilla that escapes it. By this circumstance the physiological is distinguished from the pathological excavation, which affects the entire papilla.

The central vessels of the optic nerve divide at the head of the nerve into a number of larger and smaller branches, which pass over its edge into the retina, where they keep on branching after the fashion of a tree trunk. They can readily be distinguished into arteries and veins. The former are of a brighter red, narrower, and run a straight course; the latter are darker, of greater caliber, and more crooked. The arrangement of the vessels in the retina is not always the same; most frequently it happens that two main branches run upward and two downward, while only small and short twigs pass to the outer and inner sides of the disc. The region of the macula lutea is devoid of the larger vessels; the larger trunks, running to the outside above and below, encircle it and send finer branches in toward it.

In the larger vessels we notice a shining white

streak running along the center of the vessels. This streak, which is more distinctly visible in the arteries than in the veins, is called the reflex streak.

A pulsation is frequently observed in the vessels at the spot where they first come to view upon the papilla. A venous pulse is a physiological occurrence; in the same eye it is sometimes present, sometimes absent. In the latter case, slight pressure upon the eye with the finger suffices to produce it.

An arterial pulse is present under pathological conditions only. In order to produce it artificially in a healthy eye, no inconsiderable pressure must be exerted upon the eyeball. When this is done, the person under examination notices a simultaneous obscuration of the field of vision, amounting finally to complete abrogation of sight, as a result of the obstruction to the retinal circulation produced by the pressure. In like manner a rise in pressure produced by pathological conditions (glaucoma) causes an arterial pulsation. An arterial pulsation is observed in general anemia and when syncope is imminent; also in local compression of the central artery within the optic nerve (*e.g.* in optic neuritis). Lastly, in some cases—*e.g.* in insufficiency of the aortic valves and in Basedow's disease—the presence of an arterial pulse in the eye is but one of the symptoms of an abnormally extended diffusion of the pulse wave in all parts of the body.

Since in healthy living eyes the retina is transparent, we see no part of it with the ophthalmoscope except the blood-vessels. At most we find the red fundus in the immediate neighborhood of the papilla covered by a delicate gray veil which shows a radiating fine striation at which is the representative of the layer of nerve fibers of the retina, which in this situation is still quite pronounced. In children vivid reflexes often exist which are especially pronounced along the vessels, change their place with every movement of the mirror, and give the retina a luster like that of watered silk. We must avoid regarding these as pathological opacities of the retina. The region of the retina that is most important for vision, the macula lutea, with the fovea centralis, is just the part that has very few distinctive ophthalmoscopic features. We find it with the ophthalmoscope, if we go a distance of one and one-half to two disc diameters outward from the outer border of the papilla. Here we come upon a region devoid of vessels which is somewhat darker than the rest of the fundus. Directly in its center, corresponding to the situation of the fovea centralis, we see a bright point or a small, crescentic spot. In the inverted image the macula lutea is represented by a fine white line which forms a horizontal oval of about the size of the papilla. The region enclosed by the line is colored a dark brownish red and sometimes has in its center a little bright dot. These appearances are nothing more than reflexes produced by the light on the inner surface of the retina, and are by no means constantly present. When the pupil is dilated they become less marked or disappear altogether.

The red background on which the appearances above described are visible is made by the chorioid. This owes its red color to the blood circulating in the chorioidal vessels, and especially in the capillaries. That the individual vessels are not themselves recognized, that on the contrary the fundus appears uniformly red, is due to the fact that the pigment epithelium covers the chorioid like a murky veil. The pigment epithelium, too, has a marked effect upon the brightness of the red color of the fundus. In very dark-hued men the pigment epithelium scarcely allows the red of the chorioid to shine through, so that the fundus appears almost dark gray. The less pigmented the person is, the brighter the red of the fundus. In such cases a finely granular condition of the chorioid is often perceived in the erect image, which is caused by the cells of the pigment epithelium.

Under certain circumstances, however, the vessels also of the chorioid are visible. We observe this chiefly under two conditions: (1) In many eyes the interspaces between the chorioidal vessels (the so-called intervascular spaces) have an especially profuse pigmentation, so that they stand out as dark elongated islands; the bright red striæ running between them and anastomosing everywhere with each other, correspond to the chorioidal vessels which are chiefly veins. Such a fundus is said to be tessellated; it is often confounded with chorioiditis by beginners. (2) In other eyes, on the contrary, it is the abnormally scanty pigmentation of the fundus that permits the vascular system of the chorioid to be seen; the epithelial layer, on account of the unduly small amount of pigment which it contains, allowing the chorioidal vessels to appear through it. This is in the greatest degree the case in albinos, who are entirely devoid of pigment. In these the whole network of chorioidal vessels down to the most delicate ramification stands out upon a pale red background. The retinal vessels run over the chorioidal vessels, but are easy to distinguish from them. The chorioidal vessels are broader, less sharply defined, and look flat and ribbon like; they lack the reflex streak. In opposition to the retinal vessels, which branch after the manner of a tree and do not anastomose, they form by their numerous anastomoses a dense network with elongated meshes.

The Ophthalmoscope.—The ophthalmoscopic armamentarium, in its simplest effective form, includes (1) a perforated concave mirror, of about 33 millimeters diameter and 23 centimeters focus, mounted on a handle of about 13 centimeters length, and fitted with a rotating disc or other mechanism by which any required

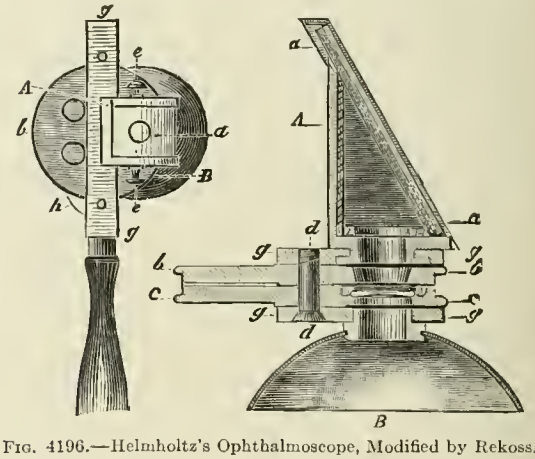


Fig. 4196.—Helmholtz's Ophthalmoscope, Modified by Rekoss.

concave or convex correcting glass may be easily brought into place behind the hold in the mirror; (2) a convex lens, of diameter of about 3.5 centimeters and a focal length of 5 or 6 centimeters; and (3) a good light which should be so mounted as to admit of the easy adjustment to about the height of the observed and of the observer's eye. This simple apparatus, used in a well-darkened room, affords the means of exploring the eye, from the anterior epithelium of the cornea back to the retina and the optic disc.

The ophthalmoscopes which have won a permanent place in the armamentarium of the ophthalmic practitioner are all based directly upon the simple reflecting ophthalmoscope of Helmholtz and the compound ophthalmoscope of Ruete. A few typical forms must be briefly noted.

The ophthalmoscope of Helmholtz (1851), perfected in some of its details by the instrument maker

Rekoss, is shown in Fig. 4196. The two revolving discs (*b* and *c*), at the back of the mirror, have each five openings, in four of which are mounted concave glasses,

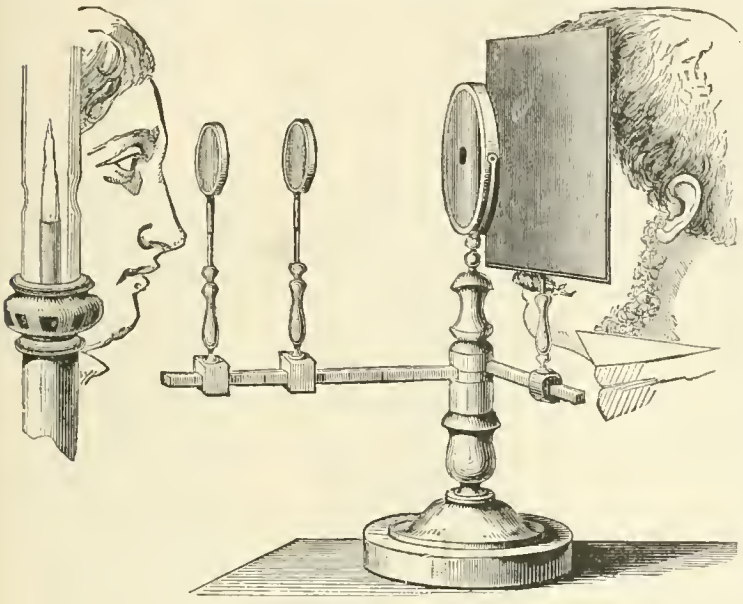


Fig. 4197—Ruete's Ophthalmoscope.

giving twenty combinations ranging from −3 dioptres to −13 dioptres. The mirror, made up of three layers of very thin glass, is set at an angle of fifty-six degrees to the plane of the revolving disc.

In 1851, Epkens, of Amsterdam, published an account of a new form of ophthalmoscope, in which this plan was followed. A small mirror with some of the silvering removed from an oval space in the center was substituted for the series of glass plates of Helmholtz. The illumination was further improved by Ruete (1852), of Gottingen. To him belongs the honor of having been the first to use a concave mirror with a hole drilled through the center. He had the mirror mounted on a stand in such a way that it was movable in all directions. On one side of the stand a screen was fastened to shield the observer's eye from the rays of the lamp; on the other side was a movable arm on which slid two lens-holders. The lenses could be changed with ease, and lifted, lowered, or taken out entirely, as occasion demanded. Ruete's instrument (Fig. 4197) was more or less stationary on a small table, and he himself admits that "for irritable and inflamed eyes he prefers Helmholtz's simpler form to that of his own designing."

Coccius, in 1853, elaborated Epkens's instrument by adding a movable and adjustable arm on which could be fastened lenses of different strengths (Fig. 4198). This enabled him to put the lens between the mirror and the patient's eye, or between the mirror and the light, as he thought best for correct examination. The mirror was movable on its handle, and the little screw at its back kept it at any desired angle. It was a portable instrument, and, with the lens-holder removed, was conveniently carried in a pocket-case six inches long.

Ulrich published in 1853 a new form of ophthalmoscope. It consisted of two tubes fastened to each other at an angle of forty degrees. The longer one, the "observation tube," was five inches in length and one and two-thirds inches in diameter; the shorter one, the "illumination tube," was only two inches in length and somewhat narrower. The interiors of the tubes were blackened. The small tube had at its open end a movable arm that held a small candle as the source of illumination. One end of the large tube contained a concave perforated mirror and a convex lens four and one-half inches in focal length; the other end held a convex lens one and one-half inches in focal length; the latter was movable by means of a screw, so that the image of the fundus could be brought to a focus at the observer's eye behind the mirror. To shield the eyes of both patient and physician from the direct rays of the candle, one screen was fastened to the tube between the light and the patient, another between the light and the observer. The special advantage claimed for this form of ophthalmoscope was that it could be used in daylight, whereas all other instruments needed a darkened room for the examination of patients.

In 1854, Stellwag von Carion described his modified form of ophthalmoscope, and it is remarkable that after this almost perfect style of instrument had been devised so many new and cumbersome improvements followed in the succeeding four years. Stellwag's instrument consisted of a concave perforated mirror fastened to a holder by a ball-and-socket joint, an arrangement that permitted it to be placed at any desired angle to the light. Behind this mirror was placed a Rekoss disc with eight lenses, usually +2, +4, +8, +10, +12, −2, −6, and −12. The whole instrument could be placed in a box six inches long and two inches wide, and was, therefore, of a convenient size.

Zehender (1854) substituted a convex mirror of sixteen centimeters radius of curvature for the plane mirror in the instrument of Coccius thus making it possible to obtain from a single convex mirror the effect also of a plane, or of a concave mirror.

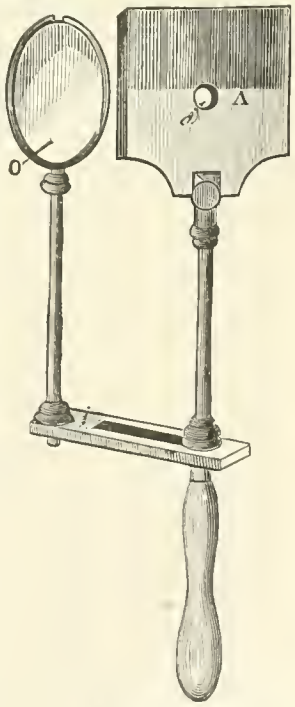


Fig. 4198.—Epkens's Ophthalmoscope Modified by Coccius. *A*, Perforated mirror; *O*, lens.

Examples of elaborate and cumbersome ophthalmoscopes are those of Liebreich and the so-called Epkens-Donders instrument.

Liebreich described in 1855, a "new ophthalmoscope" as follows. Two telescoping tubes, adjustable by means of screws, are supported by a stand fastened to the edge of a table. At the observer's end is a small, concave, movable, perforated mirror, and a section of a tube is removed to allow the light of a lamp to fall upon it. The other end of the tube at the patient's eye holds a concave lens of two-inch focal length. The patient's chin rests on another adjustable stand, and the head receives additional support from a "claw," attached to the tube, in which the forehead rests. The light of a lamp reflected from the mirror along the tube into the patient's eye gives the observer the opportunity to examine the fundus

through the hole in the mirror. Shades are placed on the sides of the lamp in such a manner as to protect the non-used eyes of the patient and physician. By placing a camera lucida in the tube at the observer's end, a correct picture of the fundus can be drawn on the table. It may be noted that Liebreich was the first to photograph the interior of the eye by the aid of this instrument.

Another elaborate instrument was that of Epkens-Donders. A cubical box held diagonally a plain mirror perforated in the center; this mirror could be rotated by means of screws. The box had openings on three sides—one opposite the reflecting surface of the mirror for the patient's eye, one behind the mirror for the observer looking through the lenses of a Rekoss disc and a central perforation into the fundus of the eye, and the third for the tube that admitted light to the mirror. The whole instrument was fastened by an adjustable stand to the corner of a table, so that observer and patient could sit opposite and facing each other, with the instrument between them. The light-tube had at its extremity a convex lens of small focal length, to collect the rays of a lamp placed opposite. These rays struck the mirror and, after adjustment of the instrument, were reflected into the patient's eye, illuminating the fundus. A micrometer screwed into the end of the light-tube had, when properly focused, its two sharp points pictured on the fundus, and, as the tube with micrometer could be turned on its own axis, an exact measurement of all spots, changes, etc., could be obtained. Then, knowing the distance between the micrometer points and the length of the tube, the exact size of blood-vessels, nerve-head, and disc colorations could be determined. A camera lucida could also be placed at the observer's end of the tube, permitting a correct drawing of any desired part of the fundus.

Of all the old styles of ophthalmoscopes only one has survived unchanged and is made and sold to-day in exactly the same form which it had when first invented. Liebreich's small ophthalmoscope consists of a concave perforated mirror fastened to a handle. On the side of the mirror is a movable arm with a lens-holder fastened in such a way that the lens can be swung close behind the opening in the mirror. A large convex lens accompanies the instrument for the examination of the inverted image, and other smaller ones correct the refraction-error of the observer.

While the discovery of the ophthalmoscope stimulated research on the physiology and pathology of the eye by means of artificial illumination, the knowledge that the fundus is visible when the eye is immersed in water, although ignored for one and one-half centuries, came in for its share of attention. Czermak devised a cup for this purpose, which he called the orthoscope. Two of its sides were made of metal, and two of glass. He surrounded the eye to be examined with a thick layer of dough, filled the cup with water of 85° or 90° temperature, had the patient lean forward and close the eye, then the edges of the cup were pressed into the dough to prevent leakage. After this the eye was opened and a clear examination of the fundus was obtained.

Arlt modified Czermak's orthoscope by making it of soft rubber, with one glass side; this simplified the instrument by doing away with the cumbersome dough, and yet allowed it to be closely applied to the eye. Coccius devised a cup the rim of which was made to fit tightly around the eye and the bottom of which was made of glass; this could be held to the eye close enough to permit an examination. It was said that the use of the orthoscope required less skill than that of the ophthalmoscope, although more disagreeable to the patient; and that in cases in which corneal opacities were to be studied carefully, or when the fundus was obscured by an irregularly shaped cornea, the examination under water gave the best results. These instruments are of little interest except from an historical standpoint.

The ophthalmoscope of Helmholtz, with the two Rekoss discs, includes all that is required for the convenient measurement of the refraction by the direct method, provided only that the discs are made larger, so as to contain a few more glasses, and that the selection of the glasses is made with reference to this use. This seemingly obvious development was, however, long deferred. Meanwhile a few exceptionally careful observers had opthalmoscopes made with a large clip, to receive any one of the series of glasses in the oculist's trial case (Donders), or with two such clips, intended to hold a spherical and a cylindrical glass (Noyes); others contented themselves with a smaller series of glasses, fitted to a cell or small clip at the back of the mirror (Jaeger).

Loring (1869) was the first to fit the ophthalmoscope with revolving discs containing a series of glasses sufficient for the accurate measurement of the refraction. One of these discs carried seven convex and eight concave lenses. The other lens container was the quadrant of a disc containing two plus and two minus lenses, each of 0.5 and 16 D respectively. With this combination any strength of lens that could possibly be called for in ophthalmic practice might be obtained. Wadsworth (1876) substituted a small mirror of fifteen millimeters diameter, for the larger concave mirror in ordinary use, setting it at a fixed angle of twenty degrees to the plane of the lens-bearing disc, and mounting it in such a manner as to admit of its being turned in any required direction. Following out this suggestion, Loring devised two modifications of the mirror, one in which a segment is cut off from one side of the mirror, which is hinged at this border to a revolving setting; the other, the so-called tilting mirror, in which a segment is cut off from each side, and the mirror is swung on pivots at the two extremities of its vertical diameter (Fig. 4199). The ophthalmoscope of Loring, as perfected by its inventor, is the type of a thoroughly good instrument for all practical uses. From the time that Loring succeeded in giving a practical instrument to the ophthalmic world but little change was made in the ophthalmoscope until the attempt was made to make the apparatus contain its own source of illumination, the outcome of which is the present-day electric ophthalmoscope.

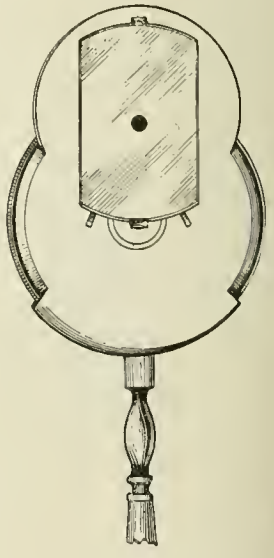


Fig. 4199.—The Loring Ophthalmoscope with Tilting Rectangular Mirror.

Before describing these instruments mention must be made of Morton's adaptation of Loring's ideas. Recognizing the limitations of the single as well as of the double disc, he discarded both, and substituted for them a series of twenty-nine lenses, mounted separately in a metal ring or "shell" and arranged in such a manner that they just touch each other. One ring is left without a lens, and the whole series of eighteen convex and eleven concave lenses forms an endless chain which is turned backward and forward with the greatest ease by the operator's finger, by a system of ratchet wheels, to bring the right lens before the sight-hole and mark its strength at the same time on an index in

numbers, white for concave and red for convex lenses. The advantage of this form of instrument is apparent. It allows the insertion of a practically unlimited number of lenses of large diameter and thick glass, and yet retains the simplicity of movement and indexing of the single disc. A second disc is now added to Morton's ophthalmoscope, containing two minus lenses, of 10 and 30 D and two plus lenses, of 0.5 and 20 D, for the sake of obtaining higher power and a larger number of combinations. For practical

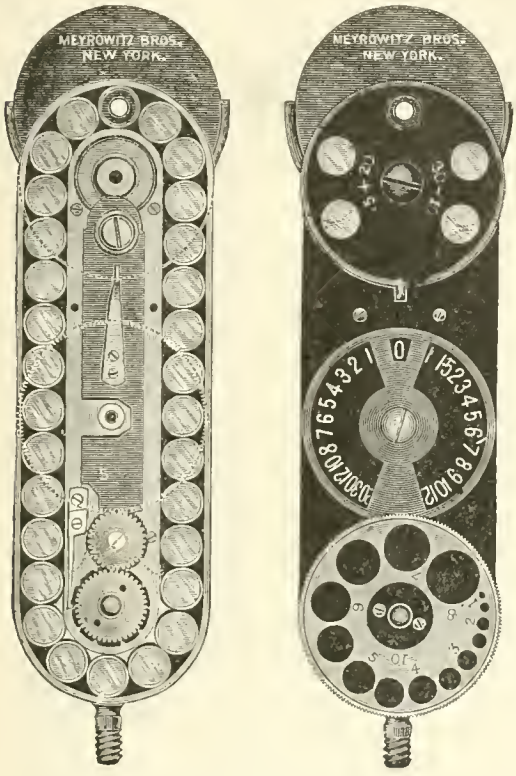


Fig. 4200.—Morton's Ophthalmoscope.

purposes these are not often necessary. The lower ratchet wheel has round perforations from one to eight millimeters in diameter, forming a convenient pupillometer (Fig. 4200).

Among the instruments which are an improvement over the final reflecting Loring ophthalmoscope is Roth's (Fig. 4201). In the construction of this ophthalmoscope the general plan and dimensions recommended by Loring have been adhered to, and the object of the improvement is mainly to overcome the difficulty experienced in obtaining and reading the higher combinations, which formerly necessitated the removal of the instrument from the eye to bring the quadrant lenses before the sight hole, thus interrupting the examination. In this instrument the combination of the higher numbers is effected automatically by a continuous revolution of the disc, which also moves a pointer which indicates the number of each lens, or combination of lenses, plainly upon a dial. In addition to the lenses contained in the disc and quadrant a + 0.50 D lens is mounted in a slide attached to the front of the instrument, directly behind the tilting mirror, in such a manner that it can instantly be brought into combination with any of the lenses contained in the series by an easy and natural movement of the index-finger.

Another model is Knauer's ophthalmoscope which is an instrument of novel design and its main features are the great range of foci, its compactness, ease of manipulation and simplicity of construction. The lower disc is operated by the small driving-wheel, and this disc again acts automatically upon the upper disc in such a manner that the consecutive combinations are effected automatically in intervals of one diopter from +1 D to +20 D and from − 1 D to − 39D. There is besides, situated behind the tilting mirror, a slide containing a +50 D lens, which can be brought in instant combination with any of the lenses in the series. For the purpose of rapidly changing the lenses, the upper disc can be revolved independently by means of two small projecting pins, each slight turn of the same causing a change of ten numbers in the series.

Another model is the Meyrowitz automatic ophthalmoscope. To operate the instrument it is only necessary to rotate the main disc, as the quadrant lenses are, by an ingenious yet simple mechanism, brought automatically into play as soon as the series in the main disc is exhausted, and the actual value of each lens, or combination of lenses, is indicated through a small square opening. To effect a rapid change of lenses, the quadrant can be moved independently of the lower disc by an easy pressure against the small pin projecting from the quadrant, each resulting combination being accurately shown at the index hole.

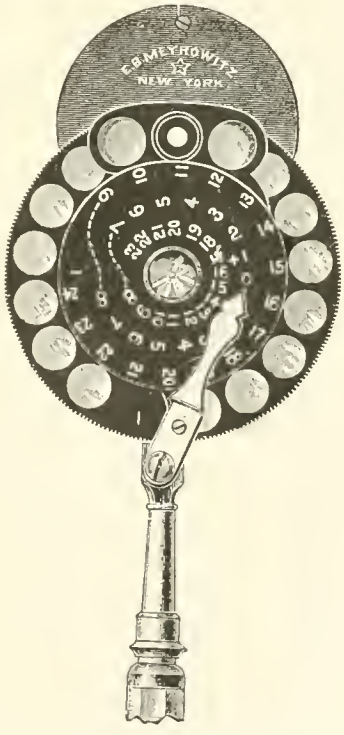


Fig. 4201.—Roth's Ophthalmoscope.

The first electric ophthalmoscope was devised by Dr. Wm. S. Dennett of New York and shown before the American Ophthalmology Society in 1885. The electric lighting system consisted of a hollow tube, containing the small incandescent lamp, and serving likewise as the handle of the instrument. A Loring ophthalmoscope was used and the ordinary mirror was replaced by one set at an angle of forty-five degrees, both as to the axis of illumination and the line of sight. In order to permit a free view by the operator, the mirror was cut off at about the center of the lens aperture. This had the effect of diminishing the reflecting surface and of making it somewhat difficult to see the lower part of the fundus.

Wolff of Berlin devised an electric ophthalmoscope and skiascope in 1896.

DeZeng of Camden, an optical instrument manufacturer, in 1901 introduced a modification of the Dennett instrument in which the light within the hollow tube handle was, by means of a condensing lens, focused upon a perforated mirror, through which the observer looked. This mirror was later improved by inserting a quill-like attachment in the perforated mirror to obviate the corneal reflex.

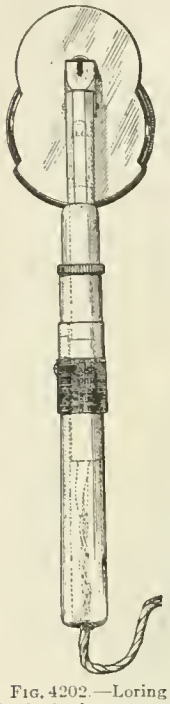


Fig. 4202.—Loring Ophthalmoscope with Marple Electric Light Attachment.

At about the same time the DeZeng instrument was introduced Chambers Inskeep and Company, Chicago instrument manufacturers, placed upon the market an instrument differently constructed but upon the same principle.

Suker in 1903 utilized the principle of partial reflection at the surface of a piece of plain glass to secure multiple images, by which a demonstrator and three students can simultaneously view the fundus in the inverted image, while the demonstrator can control the direction of the patient's eye.

Thorner in 1903 devised an ophthalmoscope, by means of which the fundus could be photographed.

An improvement was made in the Dennett instrument by Dr. Wm. B. Marple, of New York, in 1906. He devised a mirror of approximately twice the height, but left a U-shaped opening, through which the observer viewed the fundus. This had the effect of adding reflecting surface and of uniformly illuminating the entire fundus; furthermore, there being no upper edge to the U-shaped opening, there is no annoying reflex from the aperture. The reflection of the lamp as seen in the mirror should be vertical and not horizontal; to obtain this the handle is to be turned, the body of the instrument being stationary. At the same time, Dr. Marple added another improvement for focusing the illumination. The small lamp was movably mounted, so that its distance from the mirror could be altered and the focus of the emerging rays controlled. This adjustable focus is of great value in the location of minute opacities anywhere in the media and for correcting any slight inequalities in luminosity of the lamps.

Up to this time the electric ophthalmoscopes were connected with cords to lamps in series or rheostats or large unwieldly dry batteries. Dr. Crampton of Philadelphia introduced the battery handle which added largely to the utility of the instrument especially its bedside use. This battery handle consisted of small dry cells enclosed within a fiber case to which was screwed the ophthalmoscope head containing the incandescent lamp. In the latest models of battery handles there is a small rheostat by which the amount of illumination may be controlled. The introduction of the tungsten lamps which are made much smaller than the old carbon lamps allows a much neater and less bulky instrument to be made and the use of smaller battery handles.

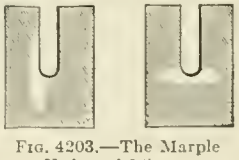


Fig. 4203.—The Marple U-shaped Mirror.

The electric lighting system for ophthalmoscopes originated by Dennett may be applied to any form of instrument. Some to which it has been applied are the Morton, the Ziegler, the Marple-Hare, and others differing only in the mechanism controlling the lenses in the ophthalmoscope head.

Baum in 1909 devised the ophthalmic fundoscope. In a general way it is a development of the large demonstrating ophthalmoscope and gives some of the advantages of the Thorner ophthalmoscope. But it is used with the freedom of the ordinary hand instrument. A tube four inches long, like the tube of a microscope, carries at one end an achromatic object lens, half of which is cut away to make place for the electric light illuminator. At the other end is an ordinary microscope eyepiece, in an adjustable tube. The higher magnification necessarily reduces the field visible at any one time and exaggerates any unsteadiness of the instrument. In using it the tube is grasped by the thumb and the index- and middle fingers; and the hand steadied by resting the ring and little fingers against the brow of the patient. The fundus image is focused by running the eyepiece in or out.

Thorner in 1910 applied the optical principles of his reflex-free, fixed ophthalmoscope to a hand apparatus to be steadied against the patient's brow. The corneal reflection is avoided by separating the illuminating opening from the aperture for observation, by a neutral zone. The patient's eye is correctly placed when he looks at an auxiliary mirror showing a red light. Thorner claims the instrument can be used by one who is not an expert ophthalmoscopist.

Fig. 4204.—Marple-Hare Ophthalmoscope with Battery Handle.

Priestly Smith in 1910 described a simple ophthalmoscope which has a mirror made on a new principle. The silvered reflecting surface is plane. The mirror is made to act as a plane, or a condensing, or dispersing mirror, by making the front surface plane, convex, or concave. After silvering has been applied a sight-hole is scratched in it, and a plate of glass cemented over the silvered surface. This gives a sight-hole free from reflections, and free from the liability to collect dust. The ametropic surgeon may have his correction ground on the back of the mirror.

A pocket ophthalmoscope was devised by Claiborne in 1910 using the discs of the Loring instrument without a tilting mirror. The handle is furnished by a disc that snaps over to protect the mirror when not in use. The whole can be carried in a soft buckskin case in the waistcoat pocket.

Golowin in 1910 described an ophthalmoscope without a central opening.

Various efforts have been made to work out mechanically a reflexless ophthalmoscope. Gutstrand has removed the corneal reflex from the center which is left free for the transmission of light returned from the ophthalmoscopic image. The instrument consists of a vertically disposed illuminating device and a horizontal viewing system. The illuminating apparatus includes a Nernst lamp, and a full-size image of the filament is projected upon a slit. A lens attached to the lower end of the illuminating tube forms an image of the bright slit on the pupil of the patient, the requisite deflection at right angles being effected by an unsilvered glass wedge carried at an inclination of forty-five degrees by an attachment to the observation tube. Immediately in front of the glass wedge the

tube contains an ophthalmoscope lens, which, together with the optical system of the patient's eye, furnishes an image of the fundus oculi. This image can be viewed by means of a monocular or binocular magnifier of a telescopic type.

DeZeng's amplifying ophthalmoscope consists of an ophthalmoscopic mirror, a telescope, a miniature electric lamp and condenser, so connected and mounted as to form a small, hand, self-luminous amplifying ophthalmoscope. The position of the mirror with respect to the light source directs the

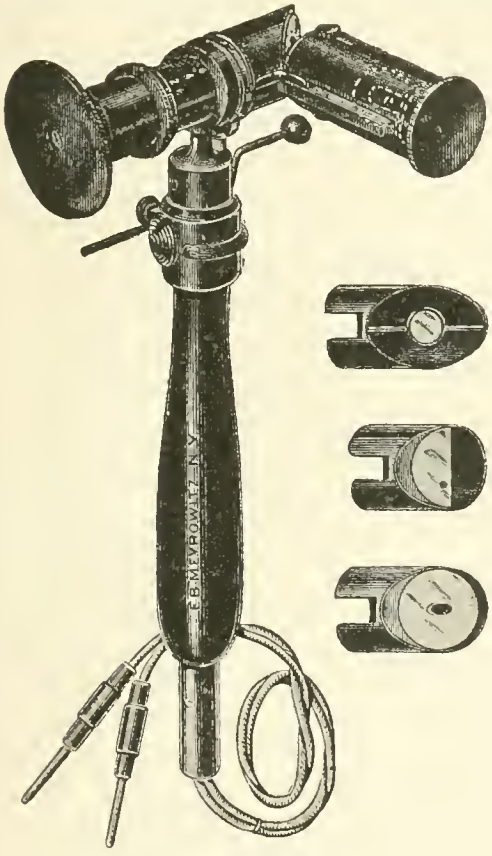


Fig. 4205.—DeZeng's Amplifying Ophthalmoscope.

illuminating rays into the eye under observation in a line parallel with the optical axis of the telescope. The light emanating from the observed eye, in passing through the telescope to the observer's eye, causes the objects in view to be magnified in accordance with the amplifying power of the telescope, times the usual magnification as seen with the ordinary ophthalmoscope while employing the direct method of examination. The telescope has an amplifying power of three diameters, and is provided with a graduated focusing adjustment for estimating the ametropia.

A fixed ophthalmoscope for practice of the indirect method has been worked out by Ando in 1911 to employ either a small electric lamp or an acetylene flame; and in another form adapted for use of direct sunlight. Wessely in 1911 proposed a relatively simple fixed ophthalmoscope for purposes of demonstration.

Marquez in 1911 devised an ophthalmoscope with a plane mirror arranged to give the effect of a concave mirror, when desired, by placing a +2 D lens in front of the mirror.

An ophthalmoscope to examine both eyes at once was devised by Ohm in 1911 to facilitate his study of miners' nystagmus. It is used by the indirect method. The light from an electric lamp is reflected from the ophthalmoscope mirror passes through a 10 D object lens, behind which are placed two mirrors. The pencil of light thus divided is reflected from two other mirrors into the two eyes and illuminates the fundus of each. The emergent rays pass in the opposite direction along the same path, entering the observer's eye from the sight-hole. By this instrument Ohm was able to observe simultaneously, brought into close proximity, the nystagmic movements of the two eyes, as shown during ophthalmoscopic examination.

A demonstration ophthalmoscope, while of value for studying minutely, or exhibiting lesions that have been discovered, is less useful for the discovery of abnormal conditions in ordinary clinical work. Appreciation of this fact is shown in the effort of Wolff to adapt his reflexless ophthalmoscope for ordinary clinical use, while still claiming for it advantages in stereoscopic ophthalmoscopic photography, and as a demonstration instrument. His instrument consists of a large tube to which are attached rests that steady it by pressing upon the margins of the orbit above and below the eye. In this tube a convex lens is mounted so that it can slide to or from the observed eye sufficiently to bring the principle focus to the plane of the pupil, its motion being limited. Extraneous light is shut out by a cone which can be extended by a screen for monocular ophthalmoscopy. The illuminating apparatus is placed in a tube which slides within another tube. It consists of an incandescent lamp and condensing lenses with a plane mirror by which the rays are reflected upward upon the prism that in turn reflects them into the lower part of the pupil. In general size and shape, Wolff's instrument approaches the ophthalmofundoscope of Baum.

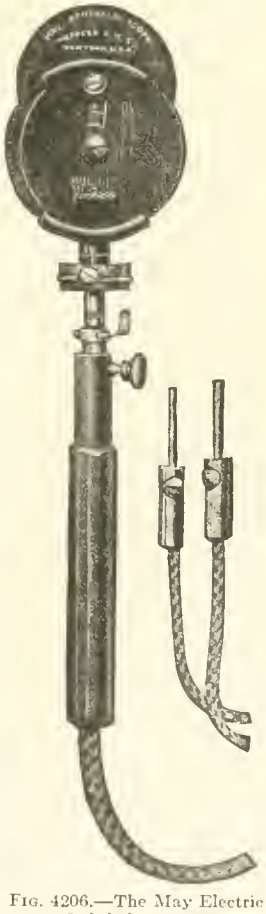


Fig. 4206.—The May Electric Ophthalmoscope.

Baum appreciating the larger field of vision obtained by approximating the eye of the observer to the observed eye, and the advantages of a simpler instrument has devised a form closely resembling the ordinary hand ophthalmoscope.

Crampton describes the modification of the Loring ophthalmoscope, which he finds has been previously used by Zentmayer. For the −1 lens in the complete disc a strong convex lens +16 is substituted. The minus lenses from 1 to 7 are each displaced one hole and the −8 eliminated. The object of the change is convenience in using a convex lens to inspect the media. In moving the disc back and forth the blurring of the fundus caused by the strong convex also informs the observer where he is in the lens series. Ziegler has worked out a double disc ophthalmoscope. Each disc carries thirteen lenses; in one all convex, except one 16 D concave; in the other all concave, except a 16 D convex. The

plus disc is turned by a small meshed wheel, the other by the milled margin of the disc.

To the large ophthalmoscope of Gullstrand, Henker has added an apparatus to secure fixation of the eye that is not under examination. It consists of a tube one end of which, placed before the eye, carries an oblique mirror that reflects a collimator, on which the eye is to be fixed. The tubes slide upon an arc like a perimeter arc, which permits fixation in any part of the field, within twenty-five degrees of the primary position. He has devised an apparatus for drawing the fundus, consisting of a prism eyepiece, and a screen illuminated from behind by an electric lamp, and attached at the proper angle to the stand of the instrument. He has also arranged a demonstration eyepiece allowing two observers to view the fundus simultaneously. The modification suggested by Polack includes a prism to assist in directing the instrument, a compass to measure the interpupillary distance, and a tracing of squares drawn to scale, so that the size of the image projected on them can at once be shown.

An electric ophthalmoscope described by May has the electric light in the handle, controlled by rheostat; but with the light emitted through a glass rod, one end of which is convex serving as a condensing lens, while the other end of which is ground at an angle of forty-five degrees is silvered to reflect the light into the patient's eye. The lower half of the sight-hole is used for illumination, and the upper half to transmit light emerging from the patient's eye. The divergence of the illuminating rays is controlled by varying the distance of the lamp from the convex end of the glass rod. The lens discs are those of May's ophthalmoscope, and can be removed in emergency and used with the ordinary handle, if the light gives out. The electric light handle may also be used as a transilluminator.

Ziegler has also devised an electric attachment for his two-disc ophthalmoscope.

The electric ophthalmoscope suggested by Armaignac uses lens discs similar to those of the Badal instrument. The electric lamp is in the handle, the light reflected into the eye from a mirror set at forty-five degrees; and having the ordinary sight-hole, in which a tongue of metal shields the eye of the observer from direct rays. The divergence of the rays from the lamp is controlled by movable convex lens.

Naito has described an electric ophthalmoscope on the same general plan as the Dennett-Marple instrument. NELSON MILES BLACK.

Opisthorchis.—A genus of flukes, two species of which are found in man. One of these, *O. felinus*, normally inhabits the bile ducts of the cat; the other, *O. noverca*, is usually found in the fox or dog. See *Trematoda*. A. S. P.

Opium.—(U. S. P.; B. P.; P. G.) *Succus thebaicus, Lachryma papaveris, Extractum thebaicum, Meconium.*

DEFINITION.—Officially considered, under the authority of the United States Pharmacopœia, opium is "the concrete milky exudation obtained by incising the unripe capsules of *Papaver somniferum* L. (*P. officinale* Gmel.; *P. album* Mill., fam. *Papaveraceæ*), and yielding, in its normal moist condition, not less than nine per cent. of crystallizable morphine" when assayed by the United States Pharmacopœia process. This definition is to be read in connection with the description given below, which more closely delimits the article. It is also to be considered in connection with the provisions for *Opii Pulvis* (see the section on Preparations), which has a different alkaloidal standard, and with those for the alkaloidal standardization of the preparations made from the latter.

The British Pharmacopœia permits any grade of opium of a strength not less than 7.5 per cent. to be used for the extract and tincture, but for other preparations its strength must be between 9.5 and 10.5 per cent. In view of the standardization of the preparations, it would at first thought appear superfluous to impose rigid standards for the drug, but important commercial and tariff considerations are involved, aside from the fact that large downward variations in morphine percentages are liable to be accompanied by important upward variations in the percentage of other, perhaps undesirable, alkaloids.

Origin.—All opium is now regarded as the product of the one species named in our definition, though some botanists have been inclined to regard its varieties as distinct species. Although the plant grows abundantly in a wild state about the eastern Mediterranean, and in adjacent regions, opium is wholly the product of cultivated plants. Although the *var. glabrum*, having red flowers and usually dark seeds, is preferred and more largely grown in Turkey, and the *var. album*, with white flowers, is more commonly grown in Persia, such distinctions are not rigid, since flowers of all intermediate colors may usually be seen in a Turkish plantation. The opium plant is an annual herb, nearly a meter (a yard) high, somewhat branched above and bearing from five to twenty large flowers and capsules. The capsule is about as large as a small apple, and yields the opium by the process described below. (See section on Production.)

Almost every country possessing a suitable climate has yielded opium of fair to good quality, including Europe as far north as Sweden and North America as far north as New England, though most of these operations have been purely of an experimental character. Financial success in opium production requires a special combination of conditions affecting soil, climate, population, and cost of labor, and has been attained, to a noteworthy extent, only in Turkey, Persia, India, China, and Egypt. Of these products that only of Turkey answers perfectly to the official description, and it supplies practically the entire medical demand, except for purposes of morphine manufacture. For this, any product rich in morphine and easily worked is selected, the most of it, with the exception of Turkish opium, being Persian, so far as United States manufacturers are concerned. All other opium is consumed in the vicious practices of smoking and chewing. Of this, the Egyptian product is probably somewhat greater than the whole of the Turkish product, though smaller now than formerly. That of India is probably from ten to twenty times as great as that of Turkey, and that of China at least double that of the rest of the world, including even the Indian. It will thus be seen that the vicious use of opium is about fifty times as great as its medicinal use, in connection with which it must be remembered that probably more than half of that usually classed as medicinal is in reality vicious.

Production and Preparation.—The best climatic conditions for poppy culture are those which prevail in the warmer wheat-growing sections—conditions under which it is practicable to sow in September, to trust to a covering of snow for the protection of the young plants through the winter, and to gather in the crop late in the following summer. More precarious, and generally less successful, is the production of a crop during the summer of the same year, the sowing being done in February or March. The capsules are ready for incision when just beginning to turn yellow, at which time the dense network of milk tubes ramifying through the entire thickness of the pericarp is charged with a thick milky juice. In Turkey the incisions are made in a somewhat obliquely or spirally transverse direction, in India vertically. In both cases the knife possesses two or three blades set near to one another, and

the incision is made as deeply as possible, care being taken that it shall not penetrate the central cavity. This work is performed in the late afternoon, *i.e.* at a time when the sun will not interfere with the flow of juice. In the morning, the exudation will be found to have thickened sufficiently to admit of its collection. It is considered that the quality of the Indian product is injuriously affected by the prevalence of very heavy dews. The opium is removed by a blunt scraping instrument, to which it is prevented from adhering in a troublesome degree by various devices; in Turkey, by the use of the saliva of the collector, in Persia by the application of a small quantity of oil. Owing to slight differences in the use of the scraper, portions of the epidermis of the capsule may or may not be removed with the opium. The collection of the Smyrna product naturally adds from five to eight per cent. to the weight of the opium from this source, and this amount is usually very largely added to. (See section on Adulteration.) As gathered, the opium is transferred to a poppy leaf held in the left hand, and the mass, when of convenient size, is laid away in the shade for a day's drying, which, if it has not advanced too far, will permit of the moulding of the product. When sufficiently dry it is enwrapped in the poppy leaf, and such masses may then, without further modification be packed in Rumex capsules, to prevent their adhesion to one another, and marketed. They may, on the other hand, be subjected to very varied processes for various purposes. Considerable of the Persian opium is subjected to a long-continued kneading or beating process, with exposure to the atmosphere, so as to cause it to assume a resemblance in appearance to Constantinople opium. The latter variety is said to be similarly beaten up, so as to make it of a more homogeneous and finer structure. Much of the high-grade Turkish opium, and almost all of that of similar grade of other countries, is beaten up with that of lower percentage, to increase its bulk and weight. It is even said that some medicinal Turkish opium has thus mixed with it that of other countries. None of the operations above considered, though designed to reduce the morphine strength, can be regarded as acts of adulteration, so long as they do not result in reducing the morphine strength below official standards. Persian and Indian opium, instead of being wrapped in the poppy leaf, are usually wrapped in paper, and, since they are designed chiefly for exportation to China, they frequently bear inscriptions in native characters. The masses are of varied forms, being in squares, cakes, cylindrical sticks, balls, or in masses similar to those of the Turkish article. Instead of being packed, like the Turkish, in Rumex capsules, they are usually packed in "poppy-trash," consisting of the chopped, dried capsules and other parts of the plants.

Adulteration.—All forms of adulteration of opium have been reduced to a minimum, so far as this country is concerned, by the operations of the Food and Drugs Act. The dilution of a high-grade, by the addition of a low-grade opium has been already considered. That by the addition of an excessive amount of the epidermis of the capsule or of the chopped capsules, or possibly of other parts of the plant similarly chopped, sometimes amounting to a third of the weight of the opium, or of an extract of the capsules, or of starchy substances, all of which are in themselves practically inert, may be considered, when they do not reduce the morphine strength below the official standard, as on the borderland between dilution and adulteration. The use of an extract made from the herbage of the plant is clearly adulteration, and was formerly rather common, as was that of various gummy substances of an extraneous nature, and of earthy substances, some of them effervescing with acids. The use of such heavy bodies as stones, nails, and bullets, scarcely requires mention. The custom still prevails to a greater or lesser extent, of diluting opium, after arrival in this country, so that it barely meets the official requirement, the product being known as *Pudding* or *Boston Opium.*

Description.—In irregularly globular, usually more or less flattened masses, weighing from 250 to 1,000 grams ($\frac{1}{2}$ to 2 lb.), the surface marked with the impression of a poppy-leaf used for wrapping, and frequently bearing fragments of this, with some rumex fruits; of a chestnut brown or reddish brown, changing to dark or blackish brown with long keeping; plastic and rather soft, or gradually hardening from without inward, with age; fractured surface exhibiting more or less tissue fragments, together with small tear-shaped particles of opium and, under the microscope, some acicular crystals, especially visible after moistening with benzene; of a heavy narcotic odor and taste, the latter disagreeable and bitter.

The required morphine percentage has been stated under Definition. Although the official definition would permit the employment of the higher grades of opium from any country, it will be seen that the description, in view of what has been said concerning the different methods of wrapping and packing, would, in general, exclude all but the Turkish variety. Persian opium is light colored and characterized externally and internally by an oily appearance. Egyptian opium is packed much like the Turkish, but is dark colored and is almost if not quite invariably below the official standard in morphine yield. Indian opium is also dark colored, usually possesses a peculiar odor, said to be due to fermentation during the long process of curing required by the peculiar conditions to which it is subject, and is commonly encased in coverings made by glueing together poppy leaves or petals by a substance made partly from a dark-colored exudation from the curing opium and partly from an extract of the plant. Very little of it is exported, except to China (*Provision Opium*), and this small quantity is restricted almost wholly to the Patna product. Chinese opium is mostly of very low grade, though of late some of much better quality has been produced. It is not of interest in materia medica.

Since it is required that the determination of the morphine percentage be accomplished by the official method, it is important that this process be here given:

Introduce eight grams of opium, which if fresh should be in very small pieces, and if dry in fine powder, into an Erlenmeyer flask having a capacity of about 300 mils, add 80 mils of distilled water, stopper the flask, and agitate it every ten minutes (or continuously in a mechanical shaker) during three hours. Then pour the contents as evenly as possible upon a wetted filter having a diameter of not over twelve centimeters, and, when the liquid has drained off, wash the residue with distilled water, carefully dropped upon the edges of the filter and its contents, until 120 mils of filtrate have been obtained. Carefully transfer the moist opium to a mortar by means of a spatula, and rub to a smooth paste, then rinse into the original flask with 50 mils of distilled water, agitate it thoroughly and return the whole to the filter. When the liquid has drained off, wash the residue with 57 mils of distilled water. Evaporate the filtrate and washings on a water bath to about forty grams. Transfer the extract to a 50-mil graduated flask and wash the evaporating dish with sufficient distilled water to make the entire volume exactly 50 mils when cooled to room temperature. Place in a small mortar, four grams of freshly slaked lime (see Part II), add about 10 mils of the opium solution and rub to a smooth paste, then add the remainder of the solution and rinse the flask with exactly 10 mils of distilled water, adding the rinsings to the mortar, and stir frequently during fifteen minutes.

Filter through a dry filter, about ten centimeters in diameter, and transfer exactly 30 mils of the filtrate, representing *four grams* of opium, to an Erlenmeyer flask of suitable capacity. To this add 2 mils of alcohol and 15 mils of ether, and, after shaking the mixture, add one gram of ammonium chloride, stopper the flask and shake it frequently during half an hour, then set it aside in a cool place for twelve hours or over night. Remove the stopper and brush any adhering crystals back into the flask. Decant the ethereal layer into a small funnel, the neck of which has been previously closed with a pledget of purified cotton. Rinse the flask and contents with 15 mils of ether, and, when the ether has passed through, wash the funnel and cotton with a small quantity of ether, and then pour the aqueous liquid into the funnel without trying to remove the crystals. Wash the crystals in the flask and the contents of the funnel with distilled water, previously saturated with morphine, until the washings are colorless. Then add a few drops of distilled water to replace the morphinated water. Incline the edge of the funnel over the mouth of the flask and by means of a glass rod carefully transfer the cotton with adhering crystals to the flask. Insert the funnel into the neck of the flask and wash the funnel with 20 mils of tenth-normal sulphuric acid V. S., followed by 10 mils of distilled water, applied drop by drop around the edge of the funnel. Remove the funnel, replace the cork, warm gently, and agitate until the crystals are dissolved. Rinse the cork with distilled water and titrate the excess of acid with fiftieth-normal potassium hydroxide V. S., cochineal T. S. being used as indicator. Each mil of tenth-normal sulphuric acid V. S. consumed corresponds to 0.0285 gram of anhydrous morphine.

Constituents.—Not all of the alkaloids of opium here described occur in all the varieties of opium, the presence or amount of some of them depending upon varying conditions of production or preparation. Of the twenty naturally occurring alkaloids, the identity of which has been established, morphine and codeine, as well as their derivatives, apomorphine and apocodeine, and also narcotine, are considered under those titles. Although several of the others are somewhat used in medicine, they are not sufficiently employed to be entitled to separate consideration, and they are briefly discussed here and in the section on Properties and Uses. Besides these, quite a number of alkaloids have been obtained artificially by treatment of the others.

Morphine occurs in different kinds and grades of opium in amounts varying from a small fraction of one per cent. up to nearly twenty-five per cent. Its ordinary percentage varies from six to seven to twelve or fourteen per cent. In the medicinal Turkish opium, probably as the result of manipulation with that object in view, it occurs almost uniformly in from nine and a half to ten and a half per cent. It occurs in the drug as a compound with sulphuric acid or as one with meconic acid.

Codeine, which exists similarly, rarely if ever reaches one per cent. in amount and sometimes does not exceed one-fifth of one per cent.

Narceine ($C_{23}H_{29}NO_9 + 2H_2O$) resembles narcotine in appearance, though the crystals are finer and more slender and are slightly bitter. It melts at 145.2° C. (291.6° F.), is insoluble in ether, but is somewhat soluble in water and in alcohol. Nitric acid colors it yellow, though the color is evanescent; iodine, in small amount, gives it a blue color; Erdmann's reagent produces a deep yellow tint, becoming brownish, then orange; finally, Frohde's reagent produces a brownish-green color which first turns yellow and then red. Like narcotine, narceine is but weakly basic. Its salts are crystallizable and are mostly incompatible with water, being precipitated or decomposed by it. Its hydrochloride is mostly employed and is strongly basic.

Thebaine ("paramorphine" $C_{19}H_{21}NO_3$) usually occurs in strongly lustrous scales, but sometimes in prismatic crystals. It is soluble in alcohol, benzene, and chloroform, and to a considerable extent in ether, and is insoluble in water. Its melting point is 193.4° C. Sulphuric acid colors it blood red, changing to yellow, nitric acid colors it red, Erdmann's reagent orange red, Frohde's orange yellow, slowly disappearing. It is decomposed quickly by diluted acids, with a production of the two isomeric uncrystallizable alkaloids *thebenine*, and *thebaicine*. It yields readily crystallizable salts.

Papaverine ($C_{20}H_{21}NO_4$) occurs in colorless acicular or prismatic crystals, soluble in hot alcohol, chloroform, and benzene, only slightly so in ether and cold alcohol, and insoluble in water. Its melting point is 147° C. (296.6° F.). It is colored purple or violet by warm sulphuric acid, violet blue, becoming blue, yellowish, and colorless by Frohde's reagent. It yields salts readily and these are somewhat soluble in water.

The remaining alkaloids occur only in very minute amounts, and are merely objects of curiosity in materia medica. They are:

Codamine ($C_{20}H_{25}NO_4$), *Cryptopine*($C_{21}H_{23}NO_5$), *Gnoscopine* ($C_{22}H_{23}NO_7$), *Hydrocotarnine* ($C_{12}H_{15}NO_3$), *Lanthropine* ($C_{23}H_{25}NO_4$), *Laudanine* ($C_{20}H_{25}NO_4$), *Landanosine* ($C_{21}H_{27}NO_4$), *Meconodine* ($C_{21}H_{23}NO_4$), *Oxynarcotine* ($C_{22}H_{23}NO_8$), *Protopine* ($C_{20}H_{19}NO_5$), *Pseudo-morphine* ($C_{34}H_{36}N_2O_6$ "Phormine" or "Oxydimorphine"), *Rhoeadine* ($C_{21}H_{21}NO_6$), *Tritopine* ($C_{42}H_{54}N_2O_7$), and *Xanthaline* ($C_{37}H_{36}N_2O_9$).

Next to the alkaloids, the most important constituent of opium is about four per cent. of meconic acid ($C_7H_4O_7$), occurring free and in the alkaloidal salts. It can be extracted by the addition of lime, as calcium meconate. It occurs in colorless scales or prismatic crystals, soluble in alcohol and in hot water. It is colored deep red by ferric salts, the color not being destroyed by hydrochloric acid or by chloride of mercury or gold. It is tribasic and is decomposed, by boiling, into *comenic* and *pyrocomenic acids*.

A variable amount of lactic acid occurs in opium. *Meconin* and *Meconoisin* are neutral principles. The former ("opianyl") is in colorless, odorless, shining, bitter prismatic crystals, melting in the air at 110° C. (230° F.) and is soluble in alcohol and ether, slightly in water. It gives a green color when evaporated with sulphuric acid, with the addition of a little water. The latter has a somewhat higher melting point and yields a red, changing to a purple color, on similar treatment with sulphuric acid.

Among the less important constituents of opium neither starch nor tannin occurs. There is a varying amount of resin, a caoutchouc-like substance, gum, pectin, fixed oil, wax, glucose, coloring matter, and a volatile odorous principle.

Action and Uses.—A consideration of the actions of the more important constituents must precede those of opium. Those of morphine, codeine, and narcotine have already been considered under these titles. Of the minor constituents, the odorous principle of opium is often objectionable to the senses, and is removed in the *Opium Deodoratum* or *Deodorized Opium* (*Opium Denarcotisatum*, United States Pharmacopœia, 1880) by repeatedly washing with ether, and adding to the dried residue enough sugar of milk to restore the product to its original weight. This treatment is supposed to remove also the narcotine, and probably most of the thebaine, the latter result greatly affecting its physiological action.

Thebaine.—This alkaloid is to be regarded as the principal constituent antagonistic to morphine, and hence to the general action of opium. It is a power-

fully poisonous irritant of the spinal centers, producing convulsions. Therapeutical uses for it have not been developed.

Narceine acts very similarly to morphine, but is much weaker; its employment is vaguely stated to be free from the disagreeable after-effects of the latter drug, while others regard it as practically inert. Probably much of that used has been contaminated with morphine, yet the use of its numerous salts with organic and inorganic acids, has fully demonstrated that it does possess activity. Its dose is about the same as that of codeine 0.025–0.05 gram (gr. $\frac{1}{3}$ to gr. $\frac{3}{4}$). None of the other alkaloids is known to be of importance in medicine.

Meconic acid, though of no importance physiologically, has been considerably employed in compounding salts of alkaloids, under the impression that these, being the natural forms of occurrence in opium, were more diffusible and active than other salts. In this view, it was long official in the British Pharmacopœia, but the idea has now been abandoned and the substance is little used.

Opium.—From the foregoing it would appear that the action of opium should be that of morphine, except for the slight modification due to the presence of its thebaine. In the main, this is true, yet practice demonstrates differences which cannot thus, nor in any positive way, be accounted for. Doubtless the difference is partly due to the substitution of primary effects, when used in one form, for secondary effects when used in the other. In opium, as in most nervines, such primary and secondary effects are more or less antagonistic, as specially exemplified in its effects upon intestinal excretion, where a dose, relatively very small or very large, in consideration of the condition of the patient, is liable to increase peristalsis and discharge, while the characteristic effect of a moderate dose is to constipate. That opium should be less promptly hypnotic, producing more of a preliminary excitation of the spinal and lower cerebral centers, commonly with irritable pulse, can be readily charged to the action of its thebaine. It is difficult, however, thus to explain its greater intestinal astringency or constipating effect or its peculiar diaphoretic properties.

From a therapeutical standpoint opium can be used for all the purposes for which morphine is employed, though the dose should be relatively somewhat larger; that is, a dose of opium should contain more morphine than would be employed as a salt for the same purpose. Even with this proviso opium is not to be selected in preference to morphine for ordinary somnifacient purposes, since its action cannot be so accurately estimated, nor is it so prompt. On the other hand, there are cases in which it is to be preferred, even for such uses, since its after-effects are not so disagreeable or lasting as those of morphine. For checking intestinal discharges, opium is greatly to be preferred, though its continued use is not so constipating as that of morphine; often, in fact, it tends to looseness of the bowels. When it is necessary to maintain for some time an equable analgesic effect, as in relieving abdominal pain in peritonitis, for instance, opium is usually to be preferred, though it is sometimes desirable first to get the patient under its influence by the use of morphine. Subject to the above modifications, the specific actions and uses of opium should be sought under *Morphine.*

Special Uses and Doses of the Preparations.—(It is to be remembered that the doses of opium and its preparations are subject to the same enormous special variations as are those of morphine.) Of opium itself there is but one official preparation, namely, the *Opii Pulvis* or powdered opium, from which all the other preparations are made. This discrimination is of practical importance, since powdered opium must contain between thirteen and fifteen per cent. of morphine, about a half more than the lowest allowable (and usual) content in opium. It is specified that powdered opium of too high a percentage may be reduced to the proper strength by mixing in due proportion with that of a lower grade, or with some inert substance. Whenever the dose of opium is stated, it is powdered opium, which is to be understood. For ordinary purposes, this is one grain (0.06). The substance is often given without change, much oftener in the form of the pills (*Pilulæ Opii*), each containing the above-mentioned amount, with a little soap, or in the deodorized form, mentioned at the beginning of our paragraph on Actions and Uses, its strength and dose being equal to those of powdered opium. Crude, undried opium is occasionally given in pill form when slow solution is desired, as in cases of relaxed intestine, diarrhea of phthisis, and chronic dysentery. Old and hard pills are sometimes written for (and many apothecaries keep them on hand for the purpose), in the hope that they will pass the stomach undissolved and exert a local continuous influence upon the intestine. This result is, however, not exactly within control, and may be better attained by coating pills with keratin. More often still, when the effect of solid opium is desired, the extract (*Extractum Opii*) is given, its morphine strength being eighteen per cent., and the dose from half as large to as large as that of powdered opium. The above-named are favorite forms for the administration of opium when it is desired to produce a constipating effect, to restrain intestinal peristalsis and relieve the pain dependent thereon, to relieve irritation dependent upon extreme purgation and irritant poisoning, and to stay nearly all forms of abdominal inflammation. In these cases the grain of opium is often combined with three or four grains of lead acetate. In this connection, the external employment of the "lead and opium" wash must not be forgotten. Its effect in relieving pain and averting or reducing inflammation in and underneath the skin are sometimes magical. It is made by dissolving 120 grains of lead acetate in about ten ounces of water, adding one-half a fluidounce of tincture of opium, and water enough to make sixteen fluidounces. It should be shaken well before using.

The simple liquid preparations are the tincture (*Tinctura Opii*), or laudanum, the deodorized tincture (*Tinctura Opii Deodorata*), the vinegar (*Acetum Opii*), and the wine (*Vinum Opii*), all containing ten per cent. of powdered opium and between 1.3 per cent. and 1.5 per cent. of morphine, and exhibiting no important difference in physiological action, the selection being based chiefly on the basis of odor and flavor, and the ordinary dose of each being ten minims. Laudanum contains its opium in a mixture of equal volumes of alcohol and water. The deodorized tincture bears the same relation to laudanum that deodorized opium does to powdered opium. It is made from powdered opium, the deodorizing process being part of its manufacture. The vinegar contains three per cent. of nutmeg and twenty per cent. of sugar in dilute acetic acid. The wine is made with a mixture of white wine and fifteen per cent. of alcohol, and contains one per cent. each of cloves and cassia cinnamon. The action and uses of laudanum may be taken as the type of those of this group. It is used in cases similar to those in which opium is itself employed, but where a more prompt effect is desired. It is a favorite preparation for relieving the convulsions of puerperal eclampsia, as much as a fluiddrachm being often given and repeated once or twice if necessary. In some forms of hemorrhage connected with pregnancy or delivery, large doses are also commonly employed. Laudanum constitutes a favorite addition to poultices, for relieving superficial pain, and it is frequently rubbed in with liniment or applied with lime liniment to relieve pain when not deeply seated. In spite of the fact that absorption of morphine by the skin is slight, such treatment is of undoubted value. Laudanum is very

commonly applied on pledgets of cotton to aching teeth or ears, though the latter treatment is not always to be recommended.

There are several mixed preparations of opium which are of great importance, paregoric (*Tinctura Opii Camphorata*) being perhaps the most so. This preparation contains only 0.4 per cent. of opium, with the same amount each of benzoic acid, camphor, and oil of anise together with four per cent. of glycerin in diluted alcohol. It has no alkaloidal standard. Paregoric constitutes a most excellent combination of a carminative with an analgesic, and is of the greatest value in relieving abdominal pains which present such indications. It is pre-eminently the form of opium for administration to children; but it is to be borne in mind that its continued administration, through the inattention rather than the direction of the physician, has frequently been the means of leading to the formation of an opium habit. The dose of paregoric is fl. ℥i.–iv. (4.0–16.0).

The brown mixture or compound mixture of liquorice (*Mistura Glycerrhizæ Composita*) contains twelve per cent. of the camphorated tincture of opium with six per cent. of wine of antimony, three per cent. each of the extract of liquorice and the spirit of nitrous ether, five per cent. of syrup, and ten per cent. of mucilage of acacia. The dose is about fl. ℥ss. (16.0). This preparation is in its nature somewhat similar to the Dover's powder, being a much used expectorant and diaphoretic, with distinct diuretic properties also.

Dover's powder (*Pulvis Ipecacuanhæ et Opii*) contains ten per cent. each of powdered ipecac and powdered opium in sugar of milk, the dose being gr. x. (0.6), and the corresponding liquid, often spoken of as liquid Dover's powder (*Tinctura Ipecacuanhæ et Opii*), consists of ten parts of the fluid extract of ipecac in 100 parts of the deodorized tincture of opium (corresponding to ten per cent. of opium), the whole reduced by evaporation to 100 parts; the dose is ten minims. The last-mentioned two preparations constitute a remarkably useful combination of a diaphoretic with an analgesic and somnifacient action. In this diaphoresis both elements play their own peculiar part. An approaching "cold" can frequently be averted by a full dose of either, with a few hours' rest. An irritable cough, preventing rest, is relieved by the hypnotic effect, while the condition itself is benefited by the diaphoresis. The troches of liquorice and opium (Trochisci Glycyrrhizæ et Opii) each contain 0.15 gram (about gr. ij.) of extract of liquorice, 0.005 gram (gr. $\frac{7}{100}$) of powdered opium, with sugar, acacia, and a little oil of anise to flavor. They are very useful in allaying throat irritation and mildly promote expectoration. By adding a little ipecac or tartar emetic the effect of Dover's powder may be simulated in mild degree.

Opium Poisoning.—Poisoning by opium is practically the effect of its morphine. Depending upon the age and condition of the patient, the form and strength of the preparation, the method of introduction and similar circumstances, the symptoms may manifest themselves almost at once, or after the lapse of an hour or more. Three stages are commonly recognized, although the first is often nearly or quite absent. When present, the latter is characterized by excitability, both physical and mental, active imagination and talkativeness being prominent symptoms. This stage is ordinarily very brief, and is calculated to mislead the novice as to the nature of the case.

The second stage is one of progressive drowsiness and bodily languor. At first, the condition resembles deep sleep, from which the patient can be roused to an intelligent consciousness. Soon, however, it becomes one of stupor, from which it is extremely difficult, then impossible to awaken him. The physical symptoms are a greatly contracted pupil, pale face with purple lips, cold perspiration, violent itching, usually with a rash of variable character, pulse full and strong at first, becoming gradually weak. The most conspicuous, and also the most dangerous symptom is progressive respiratory failure, as to both rate and depth, becoming, in fatal cases, complete paralysis. Ordinarily, there is retention of urine.

The third stage is that of collapse, from complete narcosis, although there may be spasmodic twitchings, chiefly referable to respiratory failure. In fatal cases, death almost always occurs in from ten to twenty hours.

It is almost impossible to specify any dose as toxic, since few poisons vary so greatly in their effects, with the conditions of the case. However, one grain of morphine, or a corresponding amount of opium, is to be regarded as dangerous for an adult. In young children, the amount, although fixed in accordance with the age rule, will be relatively more active. An enormous tolerance is often established through the habitual use of this poison, although all such persons suffer from chronic poisoning, which is as certainly fatal as the consumption of a large poisonous dose.

Treatment.—Removal of the remaining poison by mechanical means or by an emetic should never be neglected, even when there is a probability that complete absorption has taken place, because of re-excretion into the stomach. The lavage tube is best for this purpose, especially in the late stages. Stimulating emetics, if any, should be employed, although apomorphine is often of great value. Continued washing of the stomach should be maintained, since excretion of the poison from the circulation into the stomach is to be expected. This washing may well be performed with a one-tenth per cent. solution of potassium permanganate, which may perform a most valuable service in oxidizing the poison. The principal element in the physiological treatment is to get and keep the patient awake and active, employing electricity, whipping and cold douches to the head to awaken him, and continuous walking to keep him awake, no matter how piteously he may appeal against the treatment. The body and extremities must be kept warm. Great care must be taken to maintain the respiration, using electricity, oxygen inhalation or artificial respiration, as the case may demand. The bladder should be kept empty. Physiological antidotes are chiefly useful by promoting wakefulness, as caffeine and strychnine, by promoting elimination, as caffeine and pilocarpine, and by aiding respiration, as atropine. The latter, however, must be given with great caution. Henry H. Rusby.

von Oppolzer, Johann.—Born in the little town of Gratzen, in Bohemia, in 1808. His parents died while he was still quite young, and he was left almost without means for his support. Under these circumstances he was obliged to give lessons, at a very low rate of remuneration, during his course of studies at the Gymnasium and also during his university career at Prague. His eagerness to learn, however, and his industriousness—not to mention the agreeable personality which he possessed—attracted the attention of his instructors, and particularly of Krombholz, the Professor of the Medical Clinic, who promptly made him one of his clinical assistants at the Allgemeines Krankenhaus. In 1835 he received the degree of Doctor of Medicine; but up to 1839 he took no steps to acquire the right to practice, preferring instead to hold on, during the intervening period of four years, to his position as an assistant in the Medical Clinic. Then, in 1839, he settled in Prague as a practicing physician, and very rapidly won for himself a large *clientèle* of patients and the honor of being considered one of the celebrated physicians of that ancient city. Soon afterward, upon the promotion of Kromholtz to the regular professorship in the University of Vienna, Oppolzer was given the clinical

chair and was at the same time made a First Physician in the great hospital (Allgemeines Krankenhaus) that forms an important part of the university equipment. In 1848 he accepted a call to be a clinical teacher at the Jakobs-Hospital in Leipzig, and two years later he was asked to return to the Allgemeines Krankenhaus in Vienna and to his former chair in the university. He accepted the invitation, and during the following twenty-one years he continued to give clinical instruction, and to treat the patients entrusted to his care, in the most admirable manner. He died on April 16, 1871, from an attack of typhoid fever.

Oppolzer made very few contributions to medical literature. His son-in-law, Count Stoffela, who was also for many years his assistant, published (1866–1870) a portion of his lectures on special pathology and therapeutics. This volume contains only diseases of the heart and blood-vessels, and diseases of the respiratory organs. In 1872 he published a second volume, or, rather, a mere fasciculus, containing only diseases of the mouth. Oppolzer was made a noble in 1869. A. H. B.

Opsicoetus.—A synonym for a genus of bugs, *Reduvius*. *R. personatus* is the "masked bedbug hunter," which gives a very painful bite when handled. See *Insects, poisonous*. A. S. P.

Opsonic Therapy.—See *Vaccine Therapy*.

Opsonins.—Opsonins have been demonstrated in the study of phagocytosis. The pioneer Metchnikoff recognized some factor besides the vital activity of the phagocyte and concluded that an agent in the blood or other body fluids acted as a stimulant to the phagocyte enabling it to ingest the cell, microparasite, or other foreign substance. Denys and Leclef decided that something in the blood combined with the foreign cell in such a manner as to render it attractive to the phagocyte. This conception was extended by Neufeld and Rimpau who more clearly defined these substances in normal and immune serum and styled them bacteriotropins. Closely following came the investigations of Wright and Douglas who independently identified these bacteriotropic agents and proposed for them the name opsonins (from ὀψωνῶ, I prepare as food for).

It is now pretty generally admitted, in keeping with the conclusions of Hektoen and others, that opsonins are independent antibodies, in this particular ranking like lysins, agglutinins, and antitoxins. They appear in the blood serum and in lesser degree in certain other body fluids. Those of particular importance are the opsonins specific for certain pathogenic bacteria, and it is customary to class them as *normal opsonins*, ordinarily present in blood serum of healthy individuals, and as *immune opsonins* which are provoked specifically in response to infection by a certain bacterial species, or by artificial inoculation with these living or dead bacteria or their products. Under such circumstances the presence of opsonin can be demonstrated by mixing an emulsion of the bacteria, leucocytes washed free of serum, and the serum to be tested. Such a mixture is examined as a stained microscopic preparation after an interval of incubation and the bacteria will be found engulfed by the leucocytes. As a control, a mixture of the same washed leucocytes and bacterial emulsion minus the serum will show little or no phagocytosis.

Wright and his followers considered the opsonins of paramount importance in immunity against a number of pathogenic bacterial species, and by measurement of the opsonic power of the blood they believed useful information could be obtained in the diagnosis, prognosis, and treatment of such infections. Wright's revival of the practice of bacterial inoculation now popularized as vaccine therapy (see *Vaccine Therapy*) was closely associated with the theory of opsonins and the estimation of the opsonic index. A more conservative view minimizes the rôle of the opsonins, considering them as but one of a number of known and unknown factors in the complex phenomena of immunity.

Opsonic Index.—As a measure of the opsonic power of the blood Wright and Douglas have proposed their opsonic index. Essentially this consists in comparing the phagocytic power of normal blood with the blood of an infected or inoculated person. In the early days of vaccine therapy much importance was attached to the opsonic index as carried out by Wright's technique. It was held to afford a trustworthy guide to the nature of certain bacterial infections, and to the response elicited by the indicated bacterial inoculations. One could scarcely be expected to practise vaccine therapy without it. Theoretically this still holds good, but in practice it is now uncommon to employ the opsonic index both because satisfactory therapeutic results are obtainable without it, and because errors in its prosecution or interpretation have been demonstrated so often as to impair its usefulness.

Albert P. Ohlmacher.

Optometry—from ὀπτ-, root of ὄψομαι, fut. of ὁράω, to see, and μέτρον, measure—signified in its older use, the measurement of the range of vision. With the attainment of broader and more accurate knowledge of the physiology and pathology of vision, quantitative methods have been applied to the investigation of visual functions, and we now recognize, as parts of one general subject, the measurement (1) of the acuteness of the visual perception of form (eidoptometry), (2) of the perception of light (photoptometry) (3) of the perception of colors (chromatoptometry), (4) of the extent and limitations of the visual field (perioptometry), (5) of the accommodative and refractive states of the eye (dioptometry), and (6) of the position and movements of the eyeballs (ophthalmostatometry and ophthalmotropometry).

Eidoptometry—from εἶδος, form—deals with the measurement of the acuteness of the visual perception of form. Assuming an adequate illumination and a sharply defined retinal image, the physiological limit of the acuteness of vision is determined by the fineness of the mosaic formed by the cones of the retina at the fovea centralis. Let *dd* (Fig. 4207, *B*) represent the mosaic of retinal cones at the macula, and *a*, *b*, and *c* the images of three vertical bars of a grating for which the eye is accurately accommodated. When the grating is removed to such a distance from the eye that the image of each bar does not much exceed the diameter of one of the retinal cones the several images appear more or less distorted or beaded, according as they happen to fall upon one or another, or perhaps upon two, of the cones lying nearest to their tracks. With the bars and interspaces of the grating each of a width of 0.4167 millimeter, the appearance shown at *A* begins to be manifest when the grating is removed to a distance of 1.1 to 1.2 meters. This corresponds to a width of about 0.005 millimeter in the retinal image for each bar of the grating, and to a visual angle of about 1.2′; it also indicates a very close approximation of the width of the image to the diameter of the

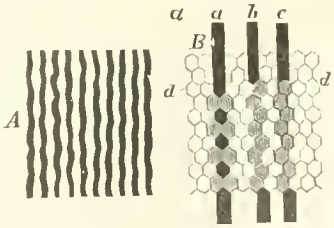


Fig. 4207.—Diagram Illustrating the Physiological Limit of the Acuteness of Vision.

retinal cones at the macula (0.0045 to 0.0054 millimeter). Observations on the smallest angular distance at which two fixed stars of lesser magnitude (Hooke) or the bars of a grating (Helmholtz) can be positively distinguished by the naked eye, point also to an angle of about 1′, as the normal limit of distinct retinal perception.

The first serious attempt to apply a system of exact measurement to the clinical determination of the acuteness of vision was made by E. Jaeger. Jaeger's *Strichscale* consists of a series of lines diminishing in length and in width from No. I, with a width of 0.4597 Vienna inch, to No. 80, with a width of 0.0037 inch; the measure of the acuteness of visual perception is the narrowest line which can be positively distinguished at the distance at which the observation is made. Thus a normally acute eye sees No. 5 at 100 feet; No. 30 at 20 feet; No. 80 at 1 foot, etc. Unfortunately, the ratio of gradation adopted by Jaeger is such that the numbers do not indicate the relation of individual measurements to the normal. Moreover, the determination turns entirely on the unchecked statement of the person examined, that he sees the lines down to a certain place in the scale. The results of numerous and characteristically careful measurements made by Jaeger with this scale point to a visual angle of about 1′ as the limit of distinct recognition of the individual lines by a normal eye.

Snellen was the first to work out a system of measurement adequate to the needs of the ophthalmic practitioner. Assuming a visual angle of 1′ as the average limit of distinct vision in the normal eye, Snellen constructed, upon this basis, a number of capital letters of sizes corresponding to seventeen different distances, ranging from 200 Paris feet (No. CC) to 1 foot (No. I). Each square letter, viewed from its appropriate distance, subtends a visual angle of 5′, and each letter is made up of lines subtending each an angle of 1′. The ultimate elements from which the several square letters are constructed are small squares, each subtending an angle of 1′; and twenty-five of these smaller squares are equal in area to the larger square in which the letter is inscribed. Only such letters are used as can be drawn approximately within the compass of a square, and even of these scarcely any two are of absolutely equal legibility; still, the difference is not so great as to impair the practical usefulness of the method, and the recognition of only a part of the letters in any line affords the means of making a finer discrimination than if only the more easily recognizable letters of the alphabet were used. Furthermore, certain of the letters often appear under characteristically modified forms when viewed by an astigmatic eye; D sometimes looking like B, O like the numeral 8 or like S, H like N, V like W, etc. The test of perfect recognition of form is the correct naming of all the letters at the distance corresponding to the number. Representing the greatest distance at which all the letters in any given line are recognized by d, and the greatest distance at which the same letters are seen by a normally acute eye by D, the measure of the acuteness of vision in any particular case is expressed in the fractional form $\frac{d}{D}$. The adoption of this simple and very convenient system was immediate and general; it remains the only method suited to the daily requirements of the practitioner.

The system of Snellen admits of but little further development; simple geometrical figures and representations of familiar objects of characteristic outlines are of use in examining children or illiterate persons. The substitution of a scale based on distances taken in meters instead of in Paris feet was made by Snellen in 1875. The simpler form of letters known to printers and sign painters by the inappropriate name of "Gothic" has been tried instead of the "block-letter" used by Snellen, and a regular ratio of gradation in geometrical progression has been employed in the place of his somewhat arbitrarily selected series of numbers* (see Plate XLIX). A notation expressed in tenths of the normal, and therefore capable of being expressed in decimal form, has also been somewhat extensively used.

For testing the perception of form at short distances, printed texts are in general use; such texts were first published by Jaeger in a great number of different languages and in various kinds of type. Jaeger's smallest type (No. 1, = "gem" or "brilliant"), read fluently at a distance of one foot, is a pretty severe test of normally acute vision conjoined with good power of accommodation for the reading distance. Jaeger's numbers have no definite significance, beyond the fact that the higher numbers indicate the larger sizes of letters; still it is more convenient to employ even an arbitrary standard than to use the somewhat uncertain nomenclature of the type-founders.

Photoptometry—from $\phi\tilde{\omega}s$, light—is comparatively little employed in the ordinary routine of ophthalmic practice, yet it is not without positive value in the diagnosis of impaired function of the retina. Two principal types of photoptometers have been used, each of which has its special applications.

A rapidly rotating disc, upon which a smaller or larger sector (Masson) or a row of short lines arranged along a radius (Donders) is depicted in black upon a white ground or in white upon a black ground, presents the appearance of a shaded surface or of a number of concentric shaded rings diminishing in intensity toward the periphery of the disc. Whenever the width of the black line is less than $\frac{1}{117}$ of the circumference of an imaginary circle drawn through it, the shaded ring is ordinarily so faint as to be no longer perceived by a normal eye in average daylight within doors (Helmholtz). The acuteness of light perception, in any particular case, is indicated by the number of the concentric rings seen when the disc is rapidly rotated.

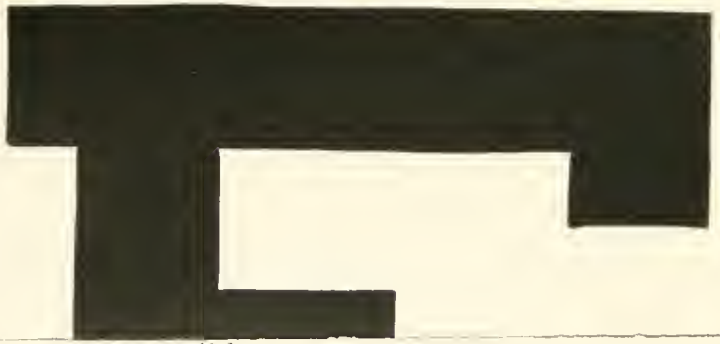
The photoptometer of Förster is a closed box one foot long, eight inches wide, and six inches high; at one end are two openings for the eyes, and a window, about two inches square, covered with translucent white paper. Behind this paper diaphragm is a small lantern, enclosing a candle of standard illuminating power. The quantity of light which enters the box is determined by the area of the paper diaphragm, and this is regulated by means of two notched plates of metal sliding over each other so as always to leave a square opening whose area may be read off from a graduated scale. At the opposite end of the box is placed the test object, a card showing alternate black and white stripes of from one to two centimeters in width. The measure of the acuteness of the perception of light (L) is the quotient of h, the smallest area of the window required for the recognition of the stripes by a normal eye, divided by H, the smallest area which suffices for the recognition of the same stripes by the eye under examination. According to Förster's observations, made with an instrument of the construction just described, h = 2 square millimeters, giving the value, $L = \frac{2}{H} = \frac{1}{\frac{1}{2}H}$.

* The card of test-letters shown in Plate XLIX is constructed on the basis of a constant ratio of gradation, $\sqrt[3]{2} = 1.26$; the Arabic and Roman numerals denote, respectively, the distances in meters and in feet at which the letters should be distinguished by a normal eye. For convenience, the foot has been taken as equal to one-third meter, which is a little more than the Paris foot. In the arrangement here reproduced only a single letter is given for each number of the scale. The construction of the individual letters is slightly altered from that adopted by Snellen, with a view to somewhat more uniform legibility of the different letters.

TEST-LETTERS IN GEOMETRICAL PROGRESSION

Based on the common ratio: $\sqrt[3]{2.} = 1.25992$

J. GREEN *inv.*— 1867, 1872, 1876, 1887, 1903



40.3
CXXI.

32.
XCVI.

25.4
LXXVI.

20.
LX.

16.
XLVIII.

12.7
XXXVIII.

10.
XXX.

8.
XXIV.

6.35
XIX.

5.
XV.

4.
XII.

TEST-LETTERS IN GEOMETRICAL PROGRESSION

Based on the common ratio: $\sqrt[3]{2}$. = 1.25992

J. GREEN Jnr.— 1867, 1872, 1876, 1887, 1903

64.
CXCII.

50.8
CLII.

40.3
CXXI.

32.
XCVI.

25.4
LXXVI.

20.
LX.

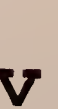
16.
XLVIII.

12.7
XXXVIII.

10.
XXX.

8.
XXIV.

6.35
XIX.



5.
XV.

4.
XII.

Chromatoptometry—from χρῶμα, color—as applied to the diagnosis of defective color perception, has been discussed under the title *Color Perception.*

Perioptometry—from περί, around—is properly the measurement of the limits of the visual field in its several dimensions; it includes also the detection and measurement of defects in the field of vision (scotomata), wherever they may be situated. The simplest method of testing the central portions of the field, up to a distance of about forty-five degrees from the point of fixation, is by means of a blackboard or a large sheet either of dark or of white paper, upon which a central point of fixation is marked by a small cross, +. The patient is placed at a measured distance from the

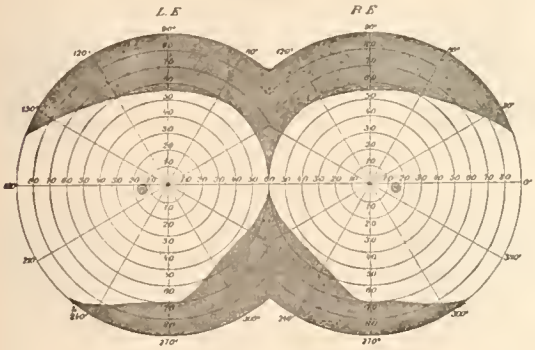


Fig. 4208.—Perimeter Chart.

board (usually one foot), and is directed to look with one eye (the other being covered) at the central cross. A bit of chalk or crayon, fixed to the end of a short wand of the same color as the board or paper, is then moved from the periphery toward the center of the field, until it reaches a point at which it is seen by the patient. The observation is repeated for other ocular meridians in succession, until the boundaries of the field have been determined at a number of points sufficient to admit of drawing a continuous outline through them.

For mapping the periphery of the field, when of nearly normal extent, a plane surface is insufficient, and for all distances greater than forty-five degrees from the point of fixation the distortion of the peripheral portions of the chart becomes excessive. For the projection of the entire field, with all its parts in due proportion, we require a hemispherical background instead of a plane surface; to this end we make use of the *perimeter*, which is merely one-half of a broad blackened hoop, upon the inside of which the angular distance of any point of the fundus, lying in the meridian corresponding to the direction of the hoop, may be noted. By turning the hoop about a central pivot as an axis, it is brought into the necessary position for the observation of the extent of the field in different meridians; each point, as determined, is transferred to a blank chart printed in concentric circles (Fig. 4208).

One of the latest forms of perimeter is that of Skeel (Fig. 4209), the mechanism of which is described as follows (Meyrowitz's catalogue): "The test object is carried on the thin extremity of a circular sliding wedge which is fitted to the large arc and rotates with it. The posterior side of this wedge bears against a rod, which extends through the axis of the arc and transmits its motion to a vertical arm, carrying at its lower end a pencil. This vertical arm is connected to the axis of the large arc by means of a bevel gear, the rotation of the arc causing it to rotate on its own axis. It is also capable of motion toward and from that axis. This latter motion is transmitted to it by the sliding of the circular wedge along the arc. When the test object is at zero or the center of the visual field, the pencil occupies a position directly over the center of the chart. When the test object is moved away from the center of the field it transmits to the pencil a similar motion over the chart, where the latter occupies at all times a position corresponding with that of the test object. When the test object has reached a position which the examiner wishes to record he depresses a lever (shown at the back of the instrument below the chart), and a small dash is marked upon the chart. A line drawn through these dashes outlines the field thus recorded. It is not necessary for the examiner to look at the chart until the operation of taking the field is finished. The meridian of the arc is indicated by the divisions on the chart and the corresponding graduations on the back of the large dial, which also conceals the hand of the observer from the eye of the patient. The chin-rest is reversible for right and left, and adjustable for height."

For the direct mapping of the visual field in its entire extent the perimeter of Scherk has been devised; it consists of a hollow hemisphere, of one foot radius, blackened on the inside. The eye to be examined is placed at the center of the sphere, and the limits of the field are marked with chalk in the

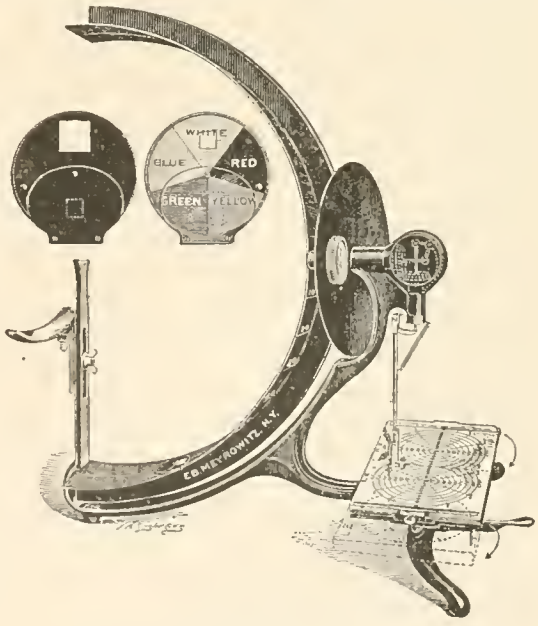


Fig. 4209.—Skeel's Self-recording Perimeter.

same manner as when the blackboard is used. For greater convenience the hemisphere is made in separable halves, and the mapping is done for one-half of the field at a time.

For practical utility the arrangement in use at the Utrecht clinic is to be commended; it consists of a blackboard, about three feet square, to the center of which is pivoted a removable half-hoop of one foot radius; the blackboard serves for the direct mapping of limitations of the field within the limits of forty-five degrees from the point of fixation, and the arc is used for peripheral measurements. The divisions of the arc between zero and forty-five degrees are projected upon the board in circles whose radii are equal to the tangents of the respective angles. The half-hoop of the perimeter is usually made of brass, and is rather heavy; the points are determined by moving a bit of chalk or a small square of white cardboard along the blackened arc.

Instead of the small square of cardboard a small electric lamp, the intensity of which may be regulated

at will by means of a rheostat or by varying the internal resistance of the battery, may be used in determining the limits of the visual field in cases of cataract or other obscuration of the media; a candle may be used for the same purpose.

For testing the limits of the field for color perception, small pieces of colored cardboard, usually one centimeter square, are used instead of the bit of chalk or square of white card. A small convex mirror of very short radius of curvature, such as the bulb of a thermometer, may also be used to reflect white or colored light from a lamp placed a little above and behind the patient's head.

The perception of form in the peripheral regions of the retina is tested by means of two small black squares on a white ground, with an interspace equal to one of the squares (Fig. 4210). These squares, of sizes corresponding to the thickness of the limbs of Snellen's test letters (Nos. XXI to CI), are moved along the arc of the perimeter toward the center of the field, until the white interval is seen between the two black squares.

Fig. 4210. Squares for Testing Form Perception.

Dioptometry.—from διά, through—has to do with the eye considered as an optical instrument, with especial reference to the detection and measurement of the different anomalies of refraction and accommodation. The detection, measurement, and correction of the several anomalies of refraction and accommodation are treated in this Handbook under the titles, *Accommodation and Refraction, Astigmatism, Hypermetropia, Myopia, Ophthalmometer,* and *Presbyopia.*

Ophthalmostatometry—from ὀφθαλμός, eye, and στα-, root of ἵστημι, to stand—is the measurement of the position of the eyes. The most important measurements are those which have to do with the two eyes in respect of their mutual distance and the relative direction of the visual axes.

The distance between the two eyes may be roughly measured by looking the patient in the face and letting him direct his gaze alternately upon the two eyes of the observer, who in turn reads off the position of the fixing eye with his fixed eye upon a graduated rule held in the hand or mounted like a spectacle frame. The right or left corneal margins, or the right or left margins of the pupils, may be taken as fixed points whose mutual distance is an approximate measure of the true interocular distance. An inaccuracy of this, as of other objective methods of measuring the interocular distance, arises from the fact that the visual axis does not exactly coincide with the geometrical axis of the eye, but, as a rule, cuts the cornea a little to the inner (nasal) side of its vertex. The angle which the visual axis makes with the axis of the cornea (angle α of Donders) averages about five degrees in the emmetropic eye; it is somewhat greater in hypermetropic and less in myopic eyes, and in very high grades of myopia it may even be negative, so that the visual axis may cut the cornea at, or a little to the outer (temporal) side of, its vertex. Objective measurements of the interocular distance are, therefore, ordinarily a little too large, though sufficiently accurate for most practical purposes.

If we place a diaphragm with a central perforation of about one millimeter in diameter, in each of the two clips of a trial spectacle frame, and adjust the distance of each from the median line of the nose so that a distant vertical line shall be seen bisecting the small circular field as defined by the margins of the perforation, the distance between the centers of the two perforations will be the true measure of the distance of the two (parallel) visual axes from each other.

To measure any deviation of the optic axes from parallelism, when the patient fixes his gaze upon a distant object, a lighted candle may be held about a foot in front of the deviated eye and moved in different directions until its image, as seen reflected on the cornea, occupies a position central to the pupil when viewed from a station just behind the light. The angle at which the light must be held to one side of a line drawn from the observed eye to the (distant) point fixed by the other eye is the measure of the angular displacement of the deviated eye; it may be conveniently measured upon the arc of a perimeter, the eye whose deviation is to be measured being at the center of curvature of the arc (Landolt).

Ophthalmotropometry—from ὀφθαλμός, eye, and τροπή, turning—is the measurement of the movements of the eyeballs. Most important, from a clinical standpoint, is the estimation of the interrelation of the recti interni and recti externi muscles.

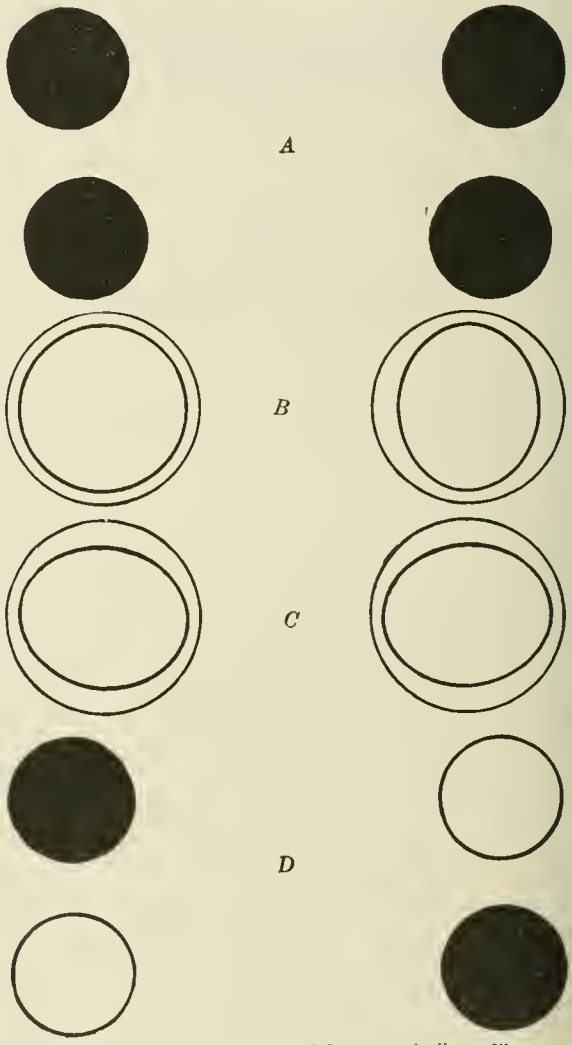


Fig. 4211.—Diagrams to be Viewed Stereoscopically to Illustrate Binocular Vision.

In insufficiency of the recti interni, not amounting to strabismus divergens, the phenomenon of double vision (see *Diplopia*) does not ordinarily manifest itself so long as it is possible to maintain the fusion of the two retinal images through the forced exercise of the convergence; if, however, we displace one of the retinal images upward or downward, by means of a weak prism, any insufficiency of the interni immediately reveals itself by a crossing of the images, which then assume an oblique direction, one to the

other, instead of the vertical direction proper to the action of the prism. The measure of the insufficiency is the prism, with edge turned horizontally outward, which is required to convert the oblique into a vertical diplopia. This test, which may be applied both at a long range and at shorter distances, reveals the state of the convergence as related to the degree of accommodation which is brought into play at the particular distance.

The "glass-rod" test of Maddox (see vol. iii., p. 615), especially in its later form as developed by its inventor, is even more convenient in use, and is of wider applicability than the vertical prism. By rotating the disc of fluted glass in front of one of the eyes, the resultant bright streak may be given any desired direction, from the vertical to the horizontal, thereby revealing a deviation of the visual axes from parallelism in any direction. The measure of the deviation is the prism, or sum of two prisms before the two eyes, which brings the streak through the flame.

Insufficiency of the recti externi, or preponderance of the recti interni, is tested, *mutatis mutandis*, in the same manner as insufficiency of the interni.

Binocular vision, conditioned on the simultaneous perception and comparison of the two retinal images of the object upon which the two eyes are directed, is most easily tested by means of the stereoscope. Rejecting all representations of objects in which solid forms are suggested by perspective, as is almost always the case with photographs of objects in nature, we make use of diagrams of the simplest possible construction; a few examples of these are shown in Fig. 4211. Viewed in the stereoscope A is seen as two discs, the one vertically above the other, but lying in two different planes at different distances from the observer; the more distant of the two discs appearing also to be the larger. Inverting the slide in the stereoscope, the relative distances and sizes of the discs appear reversed. B shows a circle and an ellipse, which may be considered as two different perspective views of another, larger ellipse; when the two images are combined in the stereoscope a horizontally elongated ellipse is seen rotated about its vertical diameter as an axis; inverting the slide, the ellipse is seen rotated in the opposite direction. In C the ellipse is seen to tip backward or forward, according as the slide is placed in the stereoscope in the position shown in the plate, or inverted. D shows a combination of a ring with a white center and a black disc of the same diameter; the effect is that of a mirror or of a shining surface polished with plumbago.

JOHN GREEN.
W. M. CARHART.

Orbit, Diseases and Injuries of the.—Orbital disease or injury is of much importance, not only with reference to the preservation of sight, but also on account of the close connection of the orbit with the cranial cavity, and these affections often present difficult and serious problems in diagnosis and prognosis.

There are two symptoms of orbital disease or injury which occur so constantly as to be essentially pathognomonic. These are (1) exophthalmus and (2) impaired mobility of the eyeball, the latter usually associated with diplopia, unless vision is lost in the affected eye. In addition most affections of the orbit are accompanied by decrease or loss of vision, pain in the orbit, either constant or evolved on ocular movement, frontal headache, tenderness on pressure, swelling and redness of the eyelids and chemosis of the conjunctiva.

The disease of the orbit most frequently met with is

ORBITAL CELLULITIS.—This is generally not difficult to recognize. It is usually an acute disease, and often of a violent inflammatory character. Pain, which is a prominent symptom, is in proportion to the degree of swelling and consequent pressure, and, when this is excessive, it is very intense. It is referred to the ball and orbit and to the parts of the face to which the ramifications of the ophthalmic branch of the fifth nerve are distributed, and is always increased by the slightest backward pressure of the globe. The conjunctiva is congested and soon becomes chemosed, and the lids are swollen and edematous and have an erysipelatous appearance.

The most striking symptom is the exophthalmus, which is decided, even in slight cases and in the early stages. The diplopia resulting from displacement of the eyeball is sometimes among the first symptoms, and may even occur before the exophthalmus attracts attention. In severe cases, particularly if an abscess is formed, the protrusion of the ball may be so great that the lids can no longer cover the cornea. The movements of the eye are, of course, restricted and painful, or it may be completely fixed in its unnatural position.

More or less constitutional disturbance is to be expected, and the formation of pus is usually announced by well-marked rigors. Suppuration is the rule, but a few cases end in resolution, a result said to be much more frequent in children than in adults. This form of the disease is sometimes called edematous cellulitis. When an abscess is evacuated spontaneously, the pus escapes through the skin of the lids, near the superior or inferior orbital margin, or sometimes behind the lids, through the palpebro-ocular fold of the conjunctiva. In the latter case the disease is sometimes mistaken for purulent conjunctivitis. In rare cases orbital cellulitis assumes a chronic form, and ends by the escape of pus only after the lapse of months or years. There may be little or no pain, and no decided symptom except the exophthalmus. There is likely to be periostitis or caries in such cases.

Etiology.—Idiopathic cellulitis is so rare that most authorities deny its occurrence, and maintain that cases described as such have been due to the extension of inflammation from a focus which had escaped the attention of the observer. Primary cellulitis in healthy adults must be considered, to say the least, a very unusual affection, but its occasional occurrence in delicate children is generally admitted. Perhaps the most frequent causes are direct injuries of the orbital tissue and extension of local inflammation from neighboring parts. Operations upon the appendages of the eye, or even upon the ball itself, are sometimes followed by this complication. The most frequent cause of orbital abscess is empyema of the accessory cavities of the nose with caries of their walls. Birch-Hirschfeldt declares that sixty per cent. approximately of cases of orbital cellulitis are caused by disease of the accessory sinuses, usually ethmoiditis. The writer has recently had a case of this character. Phlegmonous erysipelas of the face has extended to the orbital tissue in a number of cases. Finally, orbital abscess may be the result of a metastatic process in puerperal fever, phlebitis, typhus, carbuncle, etc. While thrombosis of the orbital vein necessarily occurs in orbital phlegmon, and may extend to the cavernous sinus, orbital cellulitis may have its origin in suppurative phlebitis of the ophthalmic vein. It is well known that suppuration may be communicated to the ophthalmic vein and cavernous sinus from abscesses of the lids, operations about the face, the extraction of teeth, and especially from facial erysipelas. Cases of orbital cellulitis may follow diphtheria, and orbital cellulitis is present in all cases in which blindness results from facial erysipelas.

Diagnosis.—The conditions with which orbital cellulitis is most likely to be confounded are periostitis of the orbital walls and new growths in the cavity. In periostitis the progress of the disease is usually less rapid, and the pain, though perhaps less severe, is an

earlier symptom and may even be the first. Except in cases in which only the deeper parts of the orbit are affected, a tender spot can frequently be detected by passing the finger as far back as possible and pressing against the wall. While in cellulitis the eye is usually protruded directly forward, and its motions are limited equally in all directions, it is likely to be given a special direction by the more localized swelling of periostitis. These two lesions may, however, sometimes appear together, the inflammation extending from the periosteum to the orbital cushion. The acute course of cellulitis will usually distinguish it from orbital growths. The eye is rarely protruded directly forward by a tumor, and the latter may often be felt with the finger. The diagnosis is, however, sometimes extremely difficult, and may prove a stumbling-block to the most skilful and careful observer.

Prognosis.—Though a large proportion of cases of orbital cellulitis recover without serious injury to the eye, the disease is a dangerous one and places not only sight but sometimes life in peril. The most frequent causes of loss of sight are injury to the optic nerve from pressure and stretching, and interference with the circulation in the central vessels of the retina. The tense chemosis may cause the cornea to slough, or panophthalmitis may result from interference with the circulation of the choroid or from direct extension of the inflammation to that membrane. The movements of the ball are sometimes permanently impeded by cicatricial contractions or atrophy of the external muscles, or their paralysis from injury to the nerves. Life is threatened by direct extension of inflammation to the meninges, through the sphenoidal fissure or optic foramen, by flow of pus into the intracranial cavity, or by thrombosis of the ophthalmic vein. Fatal pyemia may result without extension of thrombosis beyond the orbit, or the thrombosis may extend to the brain sinuses. The latter condition may be diagnosticated positively if exophthalmus occurs suddenly in the other eye. Exophthalmus frequently results from venous obstruction only, with little or no inflammation of the orbital tissue, and is a constant and important symptom of phlebitis of the cavernous sinus.

Treatment will necessarily vary with the violence of the local inflammation and the general condition of the patient, and should be along the lines of general surgery. In its incipiency cold applications tend to limit swelling and exudation. In traumatic cases, and others occurring in persons in fair health, leeches may be applied to the temple in the early stages of the affection before suppuration has commenced. Even this kind of depletion, however, is to be condemned in the large proportion of cases in which the inflammation of the orbital tissue is a complication of some exhausting disease. Hot stupes will promote resolution while there is hope of that termination; but warm fomentations or poultices should be applied when it is desirable to encourage suppuration. Most cases will require the liberal exhibition of anodynes. When suppuration is evident, there is no question about the propriety and urgency of free incision, and when it is doubtful it is often prudent to make an exploratory puncture. When great swelling inflicts intense pain and threatens the integrity of the eyeball and optic nerve, deep and free incisions should be made without waiting for indications of suppuration, and with a view to relieving the tension of the parts. A narrow, straight bistoury or a long Graefe cataract knife is entered near the upper or lower margin of the orbit, and its point kept near the roof or floor, while it is passed toward the apex of the orbit. It is well to keep the wound open by a tent of carbolized or borated lint. Curetting of the inner wall of the orbit and drainage through the nose may be necessary when the accessory sinuses are involved. In many cases treatment of the disease of the accessory sinuses, whether ethmoiditis or involvement of the frontal or maxillary sinus is absolutely necessary for cure of the resultant orbital cellulitis. The writer found treatment of an ethmoiditis to prevent recurrence of an orbital cellulitis which recently resisted cure by surgery applied directly to the orbit, and in this case the eye was saved from permanent injury to vision after repeated relapses had threatened the integrity of the eyeball.

Tenonitis.—The capsule of Tenon is a fibrous envelope of the ball, derived from the dural sheath of the optic nerve, and lined by a serous membrane which, according to some authorities, is continuous with the arachnoid. The eyeball moves in this envelope like the head of a bone in its articular capsule. The recti muscles pass through this capsule at the equator of the ball, where it is intimately connected with their sheaths, and in the neighborhood of the corneal margin it is merged in the conjunctiva and subconjunctival tissue. While it forms a barrier to the extension within the eye, of inflammatory processes when they commence in the orbital tissue, its direct connection, by means of the anterior ciliary vessels with the intraocular circulation makes this danger greater when the capsule itself is inflamed. On the other hand, it probably rarely entirely escapes participation in very acute and intense intraocular inflammation, and is the cause of the protrusion of the ball in panophthalmitis. In enucleation in such cases the extensive and firm adhesions of the capsule and the muscles and connective tissue about the ball often considerably complicate the operation. Tenonitis is said to occur occasionally after facial erysipelas or as a rheumatic affection, but is usually the result of extension of inflammation from the ball, or of direct injury. It has sometimes followed operations, especially those upon the external muscles.

The *symptoms* are conjunctival and subconjunctival congestion, sometimes with chemosis, moderate exophthalmus, restriction of the movements of the ball, and pain, greatly increased by pressing the eye backward. The lids are less affected than in cellulitis, and if pus forms it escapes on the surface of the ball.

Treatment will, of course, depend upon the cause and the intensity of the inflammation. Rheumatic cases require hot stupes, cotton compresses, anodyne applications, and the appropriate internal medication. In the early stages of traumatic tenonitis leeching at the temple, the local application of ice, and calomel internally may be needed.

Periostitis of the orbital walls is sometimes difficult to distinguish from cellulitis, and indeed the two conditions may exist together, or phlegmonous inflammation of the orbital connective tissue may originate in periostitis. Aside from disease of the accessory sinuses periostitis is perhaps the most frequent cause or complication of orbital cellulitis, and few cases of periostitis of the orbit or environment occur without considerable orbital cellulitis at some stage of the disease. The usual seat of periostitis of the orbit is near the margin, where it can be detected by pressure with the finger. The exophthalmus is not directly forward as in uncomplicated cellulitis, and the movements of the ball are limited more in the direction of the seat of the disease than in other directions. When the disease is at the apex, paralysis of some of the muscles of the ball is likely to ensue from involvement of the nerves at their entrance into the orbit. Periostitis usually, though not invariably, ends in suppuration. Sometimes there are more or less permanent localized thickening of the periosteum and consolidation of the neighboring tissue, which closely simulate a tumor.

Prognosis.—A large proportion of cases end favorably. The bone may become involved in the disease. In a few cases death has resulted from direct extension of inflammation from the periosteum to the meninges of the brain, or from the escape of pus into the intracranial cavity. The danger is, of course, much greater when the deeper parts of the orbit are affected. In

the chronic form the progress of the disease is very slow, sometimes extending over months or even years.

The *cause* may be traumatic or rheumatic, or the disease may be due to an extension of inflammation from one of the neighboring cavities, but it is most frequently syphilitic. The local *treatment* is the same as in cellulitis, and when suppuration is suspected or when excessive swelling endangers the eye or brain, early and free incision should not be neglected. Iodides and tonics are generally needed.

Caries and necrosis of the orbital walls are usually the result of periostitis when not due to disease of the accessory sinuses. The seat of the disease is, fortunately, most frequently near the margin of the orbit, where the danger of injury to the eye or of extension to the brain is much less than when the deeper parts of the orbital cavity are involved. The adherent cicatrix of the skin, however, which invariably forms, is likely to cause serious deformity of the lids by its excessive contraction. This cannot be prevented, but must be remedied by operation, as best it may, after the affection of the bone has run its course. Abscesses should be promptly evacuated and a free opening maintained. When they discharge spontaneously the resulting sinuses will frequently need to be enlarged. The cavity should be frequently syringed with antiseptic solutions. The danger of reckless probing should be borne in mind, and no forcible attempts to remove sequestra should be made. Acute cases, which are often mistaken for erysipelas of the lids and face, may need local treatment. Iodide of potassium is always in order, and should be given in large doses if syphilis is suspected. Many patients require a long course of treatment by quinine and iron and cod-liver oil, and careful attention to diet and hygiene.

Hemorrhage in the orbit is extremely rare from other than traumatic causes. It has occasionally occurred in scorbutic subjects, in sudden suppression of the menses, and from violent coughing or muscular straining. Permanent hematomata have been formed by repeated hemorrhages.

When hemorrhage occurs in the orbit after serious injuries of the head, it is an almost certain symptom of fracture of the walls of the cavity; though intracranial hemorrhage may find its way into the orbit without fracture. In a few cases of injuries bleeding has resulted from rupture of vessels within the orbit. The symptoms are exophthalmus and ecchymosis of the lids and conjunctiva. The ophthalmoscopic appearances are those resulting from sudden pressure.

Treatment.—Iced-water or pounded ice should be applied while there is probability of further hemorrhage, and afterward absorption may be hastened by a compressive bandage.

Emphysema of the orbit is still more rare than hemorrhage. The symptoms are exophthalmus and the characteristic crepitation on pressure upon the puffy lids. The *causes* are rupture of the lacrymal sac, or communication between the orbit and the frontal sinuses, ethmoidal cells, or nasal cavity. This communication with neighboring air spaces is generally traumatic, but may be the result of ulceration. No *treatment* is likely to be of much use. The patient should be cautioned against blowing his nose and encouraged to wait for the rent to close.

Pulsating Exophthalmus.—This comprehensive term, based on convenience rather than on scientific accuracy, is now quite generally used to include a large class of cases which are dependent upon different pathological conditions, and which it is always difficult and generally impossible to distinguish positively during life.

Symptoms.—There is protrusion of the eyeball, and pulsation is evident to the touch and sight. Above the eye, and beneath the upper and inner margin of the orbit, is a rather firm, elastic tumor, also pulsating. The patient complains of a puffing or whirring noise in the head, and an aneurysmal bruit is heard, on auscultation, over the eye and temple, and sometimes over the whole side of the head. In some cases this sound has been audible at a distance of several feet from the patient. There are usually distention and pulsation of the supraorbital vein, and sometimes of the infraorbital also. When the carotid is compressed in the neck the pulse and bruit cease, the tumor becomes soft, and the eye can be pushed back into the orbit. The hollow between the ball and the orbital arch is obliterated. The conjunctiva is congested, and in many cases a tumor is formed by intense chemosis of its lower fold, which projects beyond the lid. There may be no decided ophthalmoscopic changes, but the retinal vessels are usually congested, and the disc is sometimes found swollen as a result of pressure upon the optic nerve in the orbit. Pain may be slight or severe.

Vision is not generally much affected in recent cases, but the eye has often been destroyed by long-continued and excessive pressure. The symptoms usually appear suddenly, after direct injury to the orbit or a severe blow upon the head in traumatic cases; or during violent effort, as in childbirth, in cases of spontaneous origin. They have not been noticed, however, in a number of traumatic cases until some weeks or months after the injury.

In several spontaneous cases the patients have been roused from sleep by a loud sound like the report of a pistol.

Progress and Termination.—The deformity and inconvenience are so great, and the danger to the eye and to life is so decided, that few cases have been allowed to pursue a natural course, uninterrupted by more or less active treatment. As a rule, the character of the affection is chronic, and some cases have undergone little or no change in the course of years. In others the eye has been destroyed by sloughing of the cornea and general ophthalmia. The causes of death include erysipelas, complications of brain and heart, and hemorrhage.

Pathology.—The typical symptoms of pulsating exophthalmus are protrusion of the eyeball, pulsation, and aneurysmal bruit, and all cases presenting these symptoms were formerly classed as orbital aneurysm. Pulsating exophthalmus may be produced by true arteriovenous or anastomotic aneurysm of the orbit; by aneurysm of the carotid artery, or of the ophthalmic at its origin; by aneurysmal varix between the carotid and the cavernous sinus; by thrombosis of the ophthalmic vein or cavernous sinus; by dilatation of the sinus; or by obstruction of the return of venous blood by growths at the bottom of the orbit or behind it. The protrusion of the ball is the result of venous engorgement; while the pulsation and bruit are communicated from the carotid, or are produced by the rush of blood into dilated vessels confined in a bony cavity and with obstructed outlets, or are symptoms of an aneurysmal varix of the orbit due to a communication between the carotid artery and the cavernous sinus. Marked pulsation and bruit have most frequently been produced by aneurysmal varix of the orbital veins, or by rupture of diseased carotid arteries in the cavernous sinus. In a number of cases the diagnosis of arteriovenous communication in the cavernous sinus has been made, with more or less confidence, during life.

Vascular malignant growths of the orbit may produce the symptoms of pulsating exophthalmus, and in such cases the carotid artery has been tied for the cure of orbital aneurysm. The bruit in these cases may be very decided, but is not likely to be so loud; the tumor shows more tendency to extend toward the temporal side of the orbit, and is less reducible after compression of the common carotid than in cases of pulsating exophthalmus dependent upon the causes we have been considering. Of course, multiple

tumors and other indications of malignant disease should be carefully looked for.

Treatment.—The long continuance of some cases without material change, and the recovery of a few without interference, or with only hygienic care and medical treatment discourage resort to serious surgical procedure when there is no immediate danger or decided suffering or deformity, though these conditions may, perhaps, be considered exceptional.

The exhibition of veratrum viride, digitalis, or extract of ergot, application of cold, direct pressure on the swelling, and compression of the carotid artery may effect a cure.

Ligature of the common carotid has proved by far the most efficient means of treatment, and a number of brilliant successes have been reported. It must be remembered, however, that it is not without its chances of failure and its dangers of a fatal issue.

Vascular Protrusion, without Pulsation.—As has already been stated, in thrombus of the cavernous sinus, though more or less exophthalmus is almost invariable, pulsation and bruit may be absent; and this is, perhaps, the rule. *Cavernous tumors* of the orbit have been met with in a few cases.

Simple angioma (telangiectasis) sometimes extends into the orbit from the skin of the lids, forming a soft, slightly compressible tumor. The best treatment is extirpation or electrolysis. Frequent repetition of the operation is usually necessary.

Encephalocele.—Though encephalocele, or meningocele, of the orbit is extremely rare, it is important to bear in mind the possibility of its occurrence. It may be extremely difficult to distinguish such a tumor from a vascular swelling, particularly as, if of considerable size, it would be likely to pulsate; and, if situated behind the ball, it would cause exophthalmus. Its congenital character should excite strong suspicion; it would be increased in size by forced expiration and much diminished by pressure. If the contained fluid, obtained by acupuncture, is found to be not coagulable, it is probably cerebrospinal. Other congenital defects would be likely to occur in connection with it.

Tumors of the Orbit.—Tumors of the orbit may be classed as cystic and solid. Senn's definition of a tumor as a localized proliferation of embryonic tissue produced independently of microbic infection would exclude cysts as well as all inflammatory swellings, and yet the old broad classification is useful although modern pathology condemns it. As stated by Ball this pathological distinction is important in that while many or all of the clinical symptoms of a true tumor may be caused by inflammatory swellings and cysts, no well-authenticated case of a neoplasm, with the possible exception of lymphomata as cited by Weeks, has been observed to disappear under strictly medicinal measures. The most prominent *symptom*, and one that, in greater or less degree, is necessarily constant when the tumor is situated behind the ball, is exophthalmus, which will vary in extent and direction with the size, position, and character of the tumor. If the latter is situated outside the muscular pyramid, it will cause the ball to protrude in a direction opposite to its own position; if within the pyramid it will press the eye more directly forward, and will participate more in its movements. Diplopia is a frequent and sometimes an early symptom. The motion of the ball is not necessarily affected by a small tumor, but is limited by a large one; and, if this is outside of the muscles, the limitation will be chiefly in the direction of its site. Complete immobility of the eye suggests malignant growths, as their well-known tendency is to involve and include the neighboring structures. Paralysis of the orbital muscles often causes squint, ptosis, etc., and compression or stretching of the optic nerve may produce blindness in an otherwise sound eye; or, the nerve may be involved in a morbid growth. Injury to the ciliary nerves may be shown by dilatation of the pupil, or may result in sloughing of the cornea from neuroparalytic keratitis. Finally, the eye may be destroyed by ophthalmitis resulting from interference with its nervous and vascular supply. Pain is a very variable symptom, being sometimes severe and sometimes absent. It is in some cases referred to the bottom of the orbit, in some appears as frontal or ciliary neuralgia, and in others as general headache. The ophthalmoscopic appearances are sometimes negative, but often show some signs of pressure upon the optic nerve, such as venous congestion and arterial contraction, retinal hemorrhage, choked disc, or optic atrophy.

Diagnosis between tumors of the orbit and periostitis or phlegmon, vascular protrusion and disease of the neighboring cavities often presents serious difficulties. The mode of onset of the disease, whether sudden or slow, and whether accompanied or not by acute inflammatory symptoms, is an important consideration, but will not always be a safe guide in case of chronic periostitis or chronic abscess. Vascular protrusion may generally be distinguished by the fact that the ball can be pressed back, by the effect of compression of the common carotid, by the dilatation of vessels beyond the margin of the orbit, and by the existence, in some cases, of pulsation and bruit. It must be remembered that pulsation and bruit have led to mistakes in cases of highly vascular malignant growths. Careful inquiry should be made as to predisposition to syphilis or malignant disease. Valuable information is obtained by careful exploration with the finger pressed well back behind the ball. Osseous growths and solid tumors attached to the walls of the orbit, if not too deep in the cavity, can usually be distinguished in this way with a considerable degree of certainty, though periostitis will sometimes simulate the latter closely. An effort should be made to decide, by palpation, whether the tumor is hard, elastic, or fluctuating, whether fixed or movable, and whether situated outside of or within the muscular pyramid. Enlargements of the lacrymal gland, on account of their position, can generally be recognized with comparative ease. It may sometimes be necessary to determine the character of the contents of a supposed cyst by puncture. The nasal cavities and the vault of the pharynx should be explored with the mirror.

Cystic Tumors.—The most common true retention cysts found in this locality are the *sebaceous*. They probably arise from the skin, though their connection with this point of origin may not always be traceable. Cysts of the lacrymal gland are rare. They are due to retention of the tears from obstruction of the ducts. The swelling enlarges with increased secretion of tears and its character is not usually difficult to recognize.

Serous cysts have been attributed to disease of the bursa in the trochlea of the superior oblique muscle, or of those sometimes found on the levator and superior rectus; and most serous orbital cysts arise in this way. Congenital *dermoid cysts* are found more frequently in the orbit than elsewhere. Their usual seat is near the external angular process of the frontal bone. Their walls are of a cutaneous structure, and contain sebaceous matter and sometimes hair. Teeth have also been found in them. Serous cysts may form voluminous tumors, which enlarge the orbit by excessive pressure, and extend through foramina into the cranial cavity. A rare form of cyst is congenital orbital cyst with anophthalmus or microphthalmus. In a few cases there has been entire absence of the eye, but generally there has been a rudimentary ball. In the latter case the tumor appears beneath the lower lid. The lower lid is bulged forward by an incom-

pressible but tensely fluctuating cyst, the bluish color of which is evident through the thin and distended skin. The pathology of these cysts is obscure, but it is generally believed that they are formed of embryonic elements intended for the development of an eye. *Hæmatoma* of the orbit has already been referred to in discussing hemorrhage. *Echinococci* and *cysticerci* have been found in the orbit.

Solid Tumors.—As almost every form of tissue is represented in the orbital cavity, almost all kinds of tumors are possible there. In addition to the vascular and cystic tumors referred to above, the following forms of more solid growths have been described: lipoma, fibroma, enchondroma, carcinoma, osteoma, neuroma, and sarcoma. Epithelioma may extend into the orbit from the skin of the lids. Enchondroma and carcinoma are very rare, and fibroma and neuroma not much less so. Lipoma is frequently referred to in a general way, but only a few cases have been recorded. Osteoma is, comparatively speaking, not very uncommon. The larger proportion of solid tumors met with in the orbit belong to some of the numerous forms of sarcoma. When we perceive in any part of the orbit a solid tumor with a nodulated surface, which does not fluctuate or pulsate, is not compressible or stone-hard, is not in probable connection with the brain, and does not arise from the lids, the ball, the lacrymal gland, the optic nerve, or the neighboring cavities, we may decide on the diagnosis that we have to do with a sarcoma of the orbit.

Some of the most extensive growths that attack the orbital tissue originate in the eyeball. By far the most common intraocular tumors are retinal glioma and choroidal sarcoma, and these, when they have once passed the fibrous envelope of the ball, extend rapidly in the orbit. The former generally ends fatally by direct extension to the brain, or by metastasis to that or some other organ. Orbital sarcomata sometimes grow to an enormous size and make terrible ravages upon neighboring parts.

Tumors of the lacrymal gland are treated of in the article on *Lacrymal Diseases* in Vol. V.

Tumors of the optic nerve have been reported and have consisted of glioma, myxoma, sarcoma, endothelioma, and carcinoma. The following symptoms are diagnostic: progressive protrusion of the eyeball, parallel to the axis of the orbit, or a little outward; preservation of the mobility of the eye; preservation of a layer of connective tissue between the eye and the tumor, and the integrity of the center of rotation; soft consistence of the tumor; absence of pain; absence of subjective luminous sensations, and rapid abolition of vision. Valuable assistance in diagnosis can be obtained by palpation—pressing the finger deep into the orbit behind the ball.

Osteomata may grow immediately from the diploë of the bone, or originate in inflammatory exudations from the periosteum. In the former case they are likely to extend at the same time into the orbit and into one of the neighboring cavities. They vary in size from a mere nodule to a mass filling the whole orbit, and may be of cancellous structure or of ivory-like density. The latter is much the more common form. They have, in a few cases, occurred in both orbits at the same time. The etiology of orbital osteoma is very obscure. Syphilis, which might naturally be thought a frequent cause, is an extremely rare and even doubtful one. Bony tumors of the orbit are of slow growth, and are injurious only by their mechanical effects, which, however, are sometimes serious enough. All tumors in the orbit are dangerous to the integrity of the eyeball, and therefore should be removed as early in their formation as diagnosis is possible. Malignant tumors particularly require most prompt removal if at all, as later an operative procedure seems to hasten a fatal issue not only from the probability of recurrence *in situ* but from rapid metastasis elsewhere.

In the *removal of orbital tumors* antiseptic precautions should be carefully carried out. If there is useful vision, or even a sound eye, the eyeball should be preserved whenever possible, unless its retention renders impracticable the thorough removal of tissues involved in malignant disease. It will usually be possible to retain the ball when the growth is outside the intramuscular space and sometimes even when it is within it. To avoid the deformity of the resulting cicatrix, it is usually better, where practicable, to operate through the conjunctiva, and this will, of course, be necessary in the case of tumors within the muscular space. To gain room, the external canthus may be freely incised, the upper lid may be dissected back, or the external wall of the orbit may be temporarily resected, and replaced after the removal of the tumor, by the method devised by Krönlein. In removing tumors situated well forward or attached to the orbital walls, or of large size, it may be necessary to make the incision through the skin of the lid. The handle of the knife will often be found of more use than its edge in freeing the growth from its attachments, and much of the operation can most conveniently be performed with a strong pair of blunt-pointed scissors, curved on the flat. Extensive malignant disease sometimes necessitates the removal of all the contents of the orbit, and the application of the chloride of zinc paste to its bared walls. Though such cases are extremely discouraging, in a few that were apparently desperate the operation has succeeded at least in securing some years of comfort to the patient. It may be necessary to resort to the actual cautery to check hemorrhage, though this can usually be accomplished by hot water and compression. When extension of the disease to neighboring cavities renders its complete removal impracticable, the operation should never be undertaken. Exostoses may be removed with comparative safety when situated on the floor or on the inner wall of the orbit, but the attempt is rarely justifiable when the deeper parts of the roof are involved. It has occasionally been found possible to cut these bony tumors with the pliers or to wrench them from their bases with the forceps, but usually the chisel and mallet will be found more efficient. The use of the dental engine has been suggested and may be applicable to some cases. The attachment of the base to the orbital wall is less firm than the structure of the tumor, and in operating this should be made the point of attack. The difficulties of the operation are greatly increased when the growth originates in the diploë and extends on both sides of the bone. Knapp describes a method of shelling out such tumors within their periosteal envelope, by cutting, with the chisel, the orbital wall encasing them and removing them entire. He thinks the operation may be performed with success even though the exostosis project into the cranial cavity.

Injuries of the Orbit.—These derive their greatest interest and importance from the fact that only a thin plate of bone separates this cavity from the brain. Punctured wounds of the roof of the orbit may very easily penetrate the intracranial cavity. Such injuries were formerly sometimes inflicted by the sword, while in more modern times the umbrella-stick has figured most prominently as the offending instrument. These, of course, are very fatal wounds.

Great caution should be used in the treatment and prognosis of such cases, as the surgeon is liable to be misled by the innocent appearance of the external wound and the absence of immediate symptoms of an alarming character.

The result of a *gunshot wound* of the orbit will depend upon the direction that the ball takes. In a

large proportion of cases the brain is injured and death ensues; but a ball passing obliquely through the temporal region may destroy one eye only, and cases are reported in which sight was entirely destroyed, without other injury, by balls crashing through both orbits behind the eyes.

Fractures of the base of the cranium frequently extend into the walls of the orbit, generally the roof. Blindness may result immediately from rupture of the optic nerve, or from hemorrhage in its sheath, or it may be subsequently induced by neuritis. Intracranial hemorrhage and hemorrhage and emphysema of the orbit, as results of fracture of the orbital walls, have already been referred to.

It is important to remember that *foreign bodies*, even of considerable size, may easily escape detection in the orbit. Shot from fowling-pieces and chips of iron driven with force by the hammer or lathe sometimes pass through the ball and lodge in the orbit. Shot may become encysted and cause no irritation, and even larger and rough substances may give little indication of their presence.

x-ray examination may be made useful in detecting the presence of a foreign body and in determining its location. The giant Haab magnet is also most necessary in some cases both for diagnosis and removal of foreign bodies lodged either behind the eyeball or within it.

Dislocation of the eyeball may be caused by a foreign body thrust into the orbit behind it. It has frequently been produced by the "gouging" thumbs of brutal fighters. The ball lies upon the malar bone and the orbicularis muscle contracts behind it, retaining it beyond the lids. The optic nerve is, of course, violently stretched, but is not usually permanently injured if the dislocation is soon reduced.

In the *treatment* of injuries of the orbit it is important to bear in mind the character of its anatomical relations, and the serious mischief that may easily be inflicted by probing. It is better to treat many trivial cases with unnecessary caution than to underestimate the danger of one that may have a serious or even fatal termination. Complete rest, cold applications, and sometimes leeching will be required in the early stages, and if pus forms subsequently it should be allowed prompt and free escape. If incisions are necessary for the removal of foreign bodies, they should be made through the conjunctiva rather than through the lids, to avoid the danger of ectropium or other deformity that might follow the contraction of cicatrices. Where foreign bodies are lodged behind the eyeball or within it, the eyeball must usually be sacrificed if the injury is at all extensive. In reducing dislocation of the eyeball, the upper lid should be stretched and drawn forward, while the ball is gently pressed back. It may be necessary to divide the external commissure. A compress bandage will be required to retain the eye in position for a few days.

William Merle Carhart.

Orfila, Mathieu Joseph Bonaventure.—Born at Mahon, in the island of Minorca, Spain, on April 24, 1787. He studied medicine at the universities of Valencia and Barcelona; and the latter institution, discovering that he gave promise of future usefulness as a teacher in the domain of medicine, and with the expectation that it might thus later secure his services as a professor, made him a grant to enable him to follow his studies at Madrid and Paris. The breaking out of war in 1807 between France and Spain at the very time when Orfila was carrying on his studies in Paris, threatened destruction to his prospects. At this juncture, however, the chemist, L. N. Vauquelin, claimed him as his pupil, guaranteed his conduct, and saved him from being expelled from Paris. Four years later he graduated, and immediately began giving, privately, lectures on chemistry in the French capital. In 1819 he was elected Professor of Medical Jurisprudence, and in 1823 he succeeded Vauquelin as Professor of Chemistry in the Paris Faculty of Medicine. In 1830 he was chosen Dean of that Faculty, a high medical honor in France. He died in Paris on March 12, 1853.

Of his published writings the following deserve to receive special mention: "Traité des Poisons, on Toxicologie générale," 1813; "Leçons de médecine légale," 1823; "Traité des exhumations juridiques," 1830; and "Recherches sur l'empoisonnement par l'acide arsénieux," 1841. Orfila's fame, says the Encyclopædia Britannica, rests mainly on the first-named work, published when he was only in his twenty-seventh year. It is a vast mine of experimental observation on the symptoms of poisoning of all kinds, on the appearances which poisons leave in the dead body, on their physiological action, and on the means of detecting them. A. H. B.

Organotherapy.—*Synonyms:* Histotherapy—from ἱστός, tissue; cytotherapy—from κύτος, cell.

History.—The oldest medical manuscript in existence, the "Papyrus Ebers," mentions the use of animal extracts in medicine. Among the writers of antiquity Homer, Democritus (450 B.C.), Aretæus, Dioscorides, Galen (600 A.D.), among writers of the Middle Ages, Guido de Chauliac (1300 A.D.), John Hunter, Burton (in his "Anatomy of Melancholy") all speak of the treatment of disease with various animal products. It is interesting to note some of the bizarre preparations that were recommended, *e.g.* (Dr. William Salomon, "New London Dispensatory," 1677), human heart, *cor hominis*, in powder for epilepsy, human skull and human brain, *tinctura cranii*, *essentia cranii hominis*, *spiritus cerebri humani*, for a variety of disorders, chiefly "debility"; the brain of the hare for tremors, the lung of the fox for dyspnea, the testicles of the stag as an aphrodisiac.

Brown-Séquard, in 1869, advanced the hypothesis of the "internal secretion" of the glands and tissues; he held that all the cells of the body manufacture specific soluble products which, entering the blood, exercise "an important if not necessary" influence on other cells. Insufficiency of this function in certain organs, he argued, produces certain definite disorders that can best be remedied by supplying the deficient secretion. The extravagant and sensational claims advanced by over-enthusiastic disciples of this "method" have done much to discredit organotherapy. Of recent years, however, many clinical and experimental data have accumulated to show that certain organs actually do manufacture internal secretions, and that these products profoundly influence metabolism. The postulates of Brown-Séquard were in part, therefore, correct and his method was not altogether irrational.

It is manifestly a precarious and an unscientific procedure to introduce substances of unknown properties into a sick organism without first determining their effect on the healthy body. Before organotherapy could be raised above the level of crude empiricism and could attain the dignity of a rational system of treatment, the power of organ extracts to influence physiological processes had to be studied. This problem was approached in two ways, viz., on the one hand, different animal preparations were administered to normal animals or human subjects and the effects determined; on the other hand, different organs (chiefly ductless glands) were removed and the perversions of function that followed established. The knowledge, moreover, obtained from operative ablation of organs was in many instances supplemented by clinical observations on human sub-

jects in whom spontaneous degeneration or atrophy of these organs had occurred. In this way a fund of knowledge was acquired that based organotherapy on a rational foundation, and furnished concise indications for the administration of definite organ preparations in definite diseased states. Organotherapy was finally rendered still more exact by the discovery and isolation of "active principles" that possessed all the specific properties of the organs from which they were derived; these, it was shown, could be advantageously administered in the place of the crude extracts, of indefinite and uncertain composition, that were formerly employed.

These "active principles" are called *Hormones*. They are limited in number. Nearly all of them are inhibitory in their effect, act as "brakes," while a few are augmentory, acting as "whips." Among the latter the most important are secretin and adrenin, products of the small intestine and of the adrenal glands respectively. Aside from these there have been recognized a gastric hormone, a hormone of the liver, pancreas, kidney, testis, ovary and corpus luteum, thyroid, and pituitary body. Their activity corresponds to the two kinds of nerve fibers and it has been recognized that the nervous system is not the only factor controlling function; very important effects are produced by chemical stimuli (hormones) alone; it is possible that the nervous system is itself controlled by chemical agencies.

I. The Ductless Glands.

1. Thyroid Gland.—The administration of thyroid gland in large doses accelerates proteid and fat metabolism, causes increased elimination of nitrogen, phosphorus, and chlorine, and leads to an increased absorption of oxygen. Clinically, polyuria, polyphagia, polydypsia, sweating, tachycardia, palpitation, tremor, emaciation, fever, and occasionally glycosuria are observed. This syndrome is called *thyroidism*, and has so many cardinal features in common with exophthalmic goiter (Basedow's, Graves' disease) that this affection is held by many to be due to excessive activity of the thyroid gland, *scil.*, *hyperthyroidism*.

Removal of the thyroid gland is followed in a few days or often after a longer time (as late as nine months) by anemia and oligemia (*cachexia thyreopriva*, if the normal gland is removed, *cachexia strumipriva* or *operative myxedema* if the diseased gland is removed); there is often an initial rise of temperature usually followed by a descent to subnormal; the growth of the bones is retarded in young animals, and various trophic disturbances develop; the rate of respiration increases; a variety of nervous phenomena are observed that may be either irritative or depressive in character, viz., at first fibrillary twitchings of the muscles followed later by tetany and contractures, or again paresis and diminished sensibility. Other symptoms are palpitation, tachycardia, vomiting, loss of mental vigor, irritability followed by languor and lassitude, apathy, and finally idiocy.

A similar syndrome is presented in myxedema and cretinism (infantile or fetal myxedema); myxedema is undoubtedly due to arrest or insufficiency of thyroid function, scil., *athyroidism*. We witness the same arrest of development of bones and external soft parts, the impairment of psychic and of nearly all somatic functions. The infantile type is maintained throughout, the physiognomy is typical, there are characteristic disturbances of the organs of sense and of the intellect, the skin is bloated, the sweat glands are depressed, the heat regulation is disturbed. There are general muscular quiescence, apathy, and idiotism. Exact metabolic studies have so far not been made. In one case the oxygen absorption was found subnormal and the nitrogen excretion reduced. It is probable that metabolism becomes retarded after ablation or atrophy of the thyroid gland.

The function of the thyroid is either nutritive or antitoxic, *i.e.* it either supplies something to the blood that is necessary to normal life or it removes something that is harmful. The most plausible theory advanced to explain hyperthyroidism and athyroidism is the following: The blood normally contains certain bodies that can inhibit metabolism; the origin of these bodies is obscure; the thyroid secretion possesses the power of neutralizing these substances and rendering them inert. Normally metabolism is regulated in this way. Hyperthyroidism causes complete neutralization of these inhibitory substances followed by acceleration of metabolism; athyroidism, on the other hand, by permitting the accumulation of excessive quantities of the inhibitory bodies, favors retardation of metabolism.

The active principle of the thyroid gland is thyroidin (iodothyrin), a proteid body containing over nine per cent. of iodine. Removal of the iodine renders this substance inert. Iodothyrin administered to healthy animals produces the same effects as fresh thyroid gland or thyroid extracts. When administered immediately after ablation of the thyroid it is capable of arresting the convulsions that frequently follow this operation. The action of iodothyrin is cumulative, but only of short duration. In order to do good it must be administered continuously. When iodothyrin is given to dethyroidized animals all the iodine appears in the urine in a short time and is wasted. In animals with a thyroid the bulk of the iodine is retained. The thyroid, therefore, seems to be concerned in arresting and preserving the valuable iodine that is ingested with the food and that is intended to play some physiological rôle.

It appears, from experimental investigation, that the iodine body of the thyroid is an indispensable regulator of oxidation, and is also needed to preserve the normal function of the brain and nervous system and possibly of other organs. The "colloid substance" of the thyroid that was long believed to be the active ingredient of the gland has been shown to contain an organic iodine compound, probably iodothyrin.

Various *preparations of thyroid glands* are in use in medicine. Bircher in 1889 implanted a piece of thyroid gland under the skin. Later different extracts were prepared with glycerin alone, or with glycerin and carbolic acid or thymol. These extracts were administered hypodermically. The French favor fluid extracts made with carbolized physiological salt solution sterilized under pressure with carbonic acid gas and pressed through clay candle filters; this extract, too, is used for hypodermic injections. Vermehren precipitates the glycerin extract of thyroid with alcohol, gathers the sediment, desiccates it, and administers it in pill form (Vermehren's thyreoidinum). Many clinicians give the fresh gland raw by mouth; some boil the gland to make it more palatable, and claim equally good results as from the raw organ.

Still others give clysmata of thyroid gland. The most popular preparations nowadays are compressed thyroid tablets made from the desiccated gland. These are less disagreeable to the patient, and if prepared by a reliable house enable the physician accurately to determine the dose. True, very little is known of the amount of active principle which they contain, but the same objection applies to all the other preparations. As it is essential to individualize in thyroid medication, it is at all events of advantage to know that the qualitative and quantitative composition of the tablets is approximately uniform. For the many methods in use for preparing dry thyroid extracts and tables we refer to text-books of pharmacology.

The *dose* to be administered naturally depends on the preparation employed. Many subjects manifest an idiosyncrasy for thyroid products, so that it is always well to begin with very small doses and carefully to

watch for symptoms of thyroidism (see above). Dried thyroid powders frequently contain ptomaïns and peptonized proteids that are toxic; they may consequently give rise to additional untoward symptoms. The best guide is the pulse. Quickening of the heart beat and palpitation should lead us to stop the administration of the drug until the heart action becomes normal. Gastric disturbances or rapid loss of flesh should also put us on our guard. Occasionally a change of preparation or a different mode of administration will enable the patient to tolerate the drug, but it is usually best either to stop its exhibition, or at least materially to diminish the dose.

The fresh gland furnishes about twenty-seven per cent. of dry powder, so that each unit of powder corresponds to about four times its equivalent in fresh gland. Manufacturers of thyroid tablets always indicate the amount of thyroid powder contained in each tablet. Beginning with a fraction of a tablet a day the dose may be gradually increased to seven or eight tablets in the twenty-four hours. Of the raw gland one-eighth to two may be given in the course of a day. The common dose of the desiccated powder is from one to five grains three times a day.

Therapeutics.—Thyroid preparations are employed most successfully in all those diseases which are due to insufficiency of thyroid function, viz., infantile myxedema *cretinism*), operative myxedema (*cachexia strumipriva*), and adult (*sporadic*) *myxedema*. Thyroid treatment in these states is a true substitution therapy.

In all forms of myxedema thyroid medication as a rule produces amelioration of all the symptoms; in a minority of the cases only the main symptoms are relieved, while the minor and probably secondary menifestations persist. In adult myxedema, for example, the swelling may recede while the anemia persists. In cretinism the results are particularly brilliant. The skin becomes soft and moist, the bloating disappears, the physiognomy changes, healthy growth of the bony structures and of the soft tissues is stimulated, normal development of the teeth sets in, and the mental condition improves.

The younger the subject the better apparently the result, although all ages seem to react favorably. A case is on record, for instance, of a woman of seventy-two years who had been a sufferer from myxedema for twenty-six years, and who was completely cured in three months. Some authors maintain that the older the disease the more rapidly does it yield to thyroid therapy. The sex of the patient is without influence. Each individual seems to react differently.

In a very small proportion of cases thyroid treatment is without result, and one or two cases are on record in which the disease was aggravated. The unsuccessful cases constitute not quite two per cent. of all the cases reported in the literature. As it is not excluded that in some of these instances the thyroid preparation employed was worthless, this is a remarkably good showing, and one that warrants the use of thyroid, with the precautions outlined above, in all cases of myxedematous disease.

Thyroid preparations have also been employed in a large number of other diseases; the indications for the exhibition of thyroid being based either on our knowledge of its physiological effect or, in many instances, on pure speculation. In some diseased states the results obtained have been sufficiently favorable to warrant recording.

As trophic disturbances of the skin are common in sporadic and operative myxedema, thyroid preparations have been used in the treatment of many *skin diseases*. The best results have been obtained in psoriasis. The sphere of usefulness in this disease is, however, limited, and thyroid should be employed as a last resort, only after all other standard remedies and measures have failed. In lupus, cutaneous tuberculosis, leprosy, keloid, alopecia, eczema vulgaris, acne rosacea, ichthyosis, thyroid has also been tried with varying effect. The results are often negative and uncertain throughout. Scleroderma does not yield to thyroid therapy. It is probable that thyroid gland acts favorably in some cutaneous affections by stimulating the circulation of the skin. Improved vascular supply leads to improved nutrition, increased activity of the cutaneous glands, and increased vitality of the epidermal layer, all tendencies that must act beneficially in correcting the trophic perversions that form the basis of many skin lesions. Thyroid preparations, either in the form of the dry powder or as an ointment, have also been applied locally to *serpiginous ulcers*, *suppurating buboes*, syphilitic and soft *chancres*. Good results are claimed for this method.

Loss of weight is a common result of thyroid medication. This observation has led to the employment of thyroid gland for the reduction of *obesity*. A loss of fat undoubtedly can be brought about in the majority of cases. Patients with anemic obesity are more suitable for thyroid therapy than patients with plethoric obesity. In the latter the results are as a rule indifferent; in the former oxidation is increased, as shown by the increased amount of oxygen that is absorbed and the greater amount of carbon dioxide that is eliminated. Together with the fat some proteid is, however, always lost in these cases, so that from this point of view alone thyroid medication is to be condemned in the treatment of obesity. As obesity, moreover, is frequently complicated by various cardiac disorders, gout, diabetes, and kidney lesions (all conditions in which thyroid preparations may do harm), this therapy is dangerous also on these grounds. It must further be remembered that as soon as the administration of thyroid gland is discontinued the fat returns; consequently the drug must be taken continuously. This leads to the indiscriminate use of thyroid preparations by the laity, a procedure that is manifestly dangerous. Finally, the exhibition of thyroid is totally unnecessary in obesity, for correct dietetic treatment produces results that are equally favorable, more constant, more permanent, and not at all dangerous. In carefully selected cases which are rigorously supervised by the physician small doses of thyroid, together with rational dietary regulations, produce satisfactory results and may be permitted.

In *insanity* the results of thyroid therapy are not constant; some cases are strikingly benefited, others are not affected at all. It is probable that in many sufferers from melancholia, recurrent mania, delusional insanity, and the insanities of adolescence, the climacterium, and the puerperium there is at the same time some derangement of thyroid function, and that these cases precisely, and possibly these cases alone, derive benefit from the use of thyroid preparations. The insanities of myxedema, needless to say, often improve under thyroid medication. The largest statistics on the subject show that of 1,032 such cases 16.8 per cent. recovered, 24 per cent. were improved, and 59.2 per cent. remained unimproved. The results, therefore, in this particular form of mental derangement are fairly good.

Because infantile myxedema and *rachitis* are both characterized by disturbances of the bony development thyroid medication has been employed in the latter disease. The relation between the two diseases is, however, purely superficial and their pathogenesis radically different, so that we need not be surprised to learn that thyroid therapy has led to absolutely negative results in rickets.

There is a superficial resemblance between *acromegaly* and myxedema, and in some cases of acromegaly the thyroid has been found degenerated or atrophied. Some experiments are also on record that seem to show that the pituitary body hypertrophies after removal of the thyroid. These observations have led to the employment of thyroid in acromegaly. The results

of this treatment are not satisfactory. A few isolated cases are on record, however, in which thyroid medication seemed to do good after all other measures, including the exhibition of pituitary extract, had failed. The method deserves further trial.

Simple goiter often yields to thyroid treatment. Some statisticians report improvement in two-thirds of the cases. Young persons, it is claimed, are more benefited than older subjects. It is necessary to continue the administration of the remedy for a long time, as otherwise the goiter is liable to return. The swelling rarely if ever disappears completely. The treatment must be considered symptomatic and in no case curative. The treatment is useless in goiter that has undergone secondary degeneration (colloid, cystic). The simple parenchymatous form is the most suitable for treatment with the thyroid gland. Of 60 cases of the latter kind 14 were cured, 29 improved, and 19 not benefited. One author reports improvement in all of a series of 79 cases, another one improvement in 92 per cent. of a large series of cases.

The treatment of *Basedow's Disease* (exophthalmic goiter) with thyroid preparations seems altogether paradoxical, for, as we have seen, the cardinal symptoms of this disease are actually produced by the administration of thyroid. To expect a cure would be to avow faith in the homeopathic "law" of similars. Nevertheless the remedy has been extensively employed in this disease either empirically or from ignorance of the physiologic action of the thyroid extract, and finally on the basis of various hypotheses that are not worth recording. The consensus of opinions, as was to be expected, is that thyroid has a tendency to do harm in this disease. In many instances no effect was noticed when small doses were given. A few cases of improvement are also reported, chiefly by American and French authors, but the case reports (which have been carefully studied by the author) do not show that the amelioration of symptoms could in any way be attributed to the action of the thyroid preparations given. In exophthalmic goiter, therefore, the use of thyroid should be discouraged as useless.

A more rational method of treating Basedow's disease has recently been tried, apparently with good results. It consists in injecting the serum of dogs whose thyroid has been removed. This method is at least based on sound physiologic reasoning. It warrants further trial, for of the nine cases treated all improved.

Thyroid preparations have at one time or another been tried in nearly every known disease. Benefits have been claimed in tetany, the various disorders of lactation (galactagogue action), certain middle-ear disorders, muscular and osseous dystrophies, hemorrhages in uterine diseases, cancer of the breast, and syphilis. Very little value, however, attaches to isolated case reports, for in the majority of them grave sources of error are not excluded, and no conservative judgment in regard to the therapeutic value of the thyroid preparations administered can be rendered.

2. The Suprarenal Glands.—The adrenals consist of two physiologically different structures, the medulla and the cortex. The medulla belongs to the group of chromaphil (staining with chromium) tissues that are found distributed over many regions of the sympathetic; of the function of this chromaphil tissue we know something, of the function of the cortex we know nothing. Cortex and medulla are derived from two altogether different tissues in the lower vertebrates; higher in the scale they become united. In so far as the cortex is derived from the germinal epithelium the idea has been advanced that, by means of a hormone, it influences the development of the regenerative organs. Injection of suprarenal extract produces a very marked rise of blood pressure. This is primarily due to vasoconstrictor action, for suprarenal extract exercises its chief effect on the peripheral circulatory apparatus. This is made manifest after section of the medulla or the cord (even complete removal of the cord), section of the vagi, of peripheral nerves, or paralysis of the nervous end apparatus with atropine, for all these operations do not hinder the rise in blood pressure after injection of suprarenal extract. Direct application, moreover, to mucous surfaces causes rapid contraction of the blood-vessels of the part. It is not established whether suprarenal extract acts directly on the muscle cells of the arterial muscularis or on the ganglion apparatus of the vessel walls. Suprarenal extract also acts directly on the heart, causing retardation and strengthening of the heart beat, and in this way, too, a rise in blood pressure. It seems that the extract directly stimulates the heart muscle and at the same time irritates the vagus center. The former action strengthens the heart beat, the latter retards it. If the medulla is destroyed or the vagus severed, the heart beat is greatly accelerated after the exhibition of suprarenal extract, more so than after simple section of the vagi. Applied to the excised heart of a frog suprarenal extract also causes quicker and more forcible contractions. The *direct* effect of the extract on the heart muscle is accelerating, in other words, excitory, as in the case of the arterial muscularis.

Other effects that follow the injection of suprarenal extract are: (1) The excretion of dextrose (suprarenal glycosuria); (2) local pigmentation around the point of injection; (3) destruction of red blood corpuscles and deposit of hemosiderin in the spleen and lymph glands; (4) excretion of pigments related to bile pigments.

Removal of the suprarenal glands, a very difficult operation, is invariably followed by the death of the animal. If one gland alone is removed or if accessory adrenals are left behind, compensatory hypertrophy of the remaining organ occurs and the animal may survive for months or even years.

The statements made by different authors in regard to the effect of removal of the adrenals on general nutrition are contradictory. The same applies to the effect on the temperature; some report a rise, some no change, some subnormal temperatures. The effect on the nervous system is marked. All authors agree that degenerative changes in the brain, cord, and sympathetic plexuses follow removal of the adrenals. The statements in regard to the clinical nervous phenomena observed are not uniform. There is always great muscular asthenia. The digestion is always impaired; there are increased peristalsis and diarrhea. The blood pressure always falls. No uniform changes in the pulse rate or the respiration have been noted. Occasionally, when the animals survived for a period of several months, abnormal pigmentation of mucous and cutaneous surfaces has been noted. The most marked changes occur in the chemical composition of the blood. (The statements in regard to changes in the hemoglobin content and the number of red blood corpuscles are absolutely contradictory.) The blood of an animal whose adrenals have been removed becomes very poisonous and acts like curare on healthy animals. It accelerates the death of other animals whose adrenals have been removed, whereas the injection of normal blood into such animals improves their condition. It appears that after removal of the adrenals certain substances accumulate in the blood that paralyze the motor endings of the nerves and may be the muscles themselves. We are justified in assuming, therefore, that one of the functions of the suprarenals is to disintoxicate the blood. There is much experimental evidence to show that the toxic principle which the adrenals normally arrest or neutralize is a fatigue product of muscle and nerve activity.

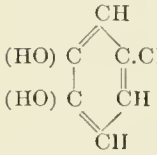
Our knowledge of the *function* of the surparenal glands is supplemented by clinical studies in Addison's disease. Here we find in the majority of cases spontaneous degeneration of the adrenals (usually tuberculous) and a symptom complex which corresponds in many features with some of the symptoms that

follow *removal* of the adrenals, viz., asthenia, cardiac weakness. In other features Addison's disease resembles the syndrome following *injection* of adrenal extract (pigmentation, glycosuria).

This observation makes it probable that the function of the suprarenals is twofold, viz., that on the one hand they supply a substance that stimulates the sympathetic ganglia and striped and unstriped muscle fiber; on the other hand, that they arrest or disintoxicate certain poisonous principles which are the product of nervous and muscular activity. The latter fatigue products, we must imagine, when present in excess produce asthenia, blood impoverishment, and occasionally pigmentation and glycosuria. Only on this duplex basis can we explain how insufficiency of suprarenal function or absence of the glands can produce the whole syndrome of Addison's disease.

The *"active principle"* of the suprarenal glands has recently been isolated; it is called adrenalin. Older impure preparations are sphygmogenin (a syrupous liquid), suprarenin, and epinephrin (both albuminoid bodies). It is best to employ the term "adrenin" as all the other terms have a commercial, trade-mark flavor. Other substances (lecithin, jecorin, pyrocatechin, neurin, etc.) that have been isolated from adrenal extracts, do not possess the specific properties of the fresh glands. With the discovery of adrenalin and its manufacture on a large scale all the other preparations have been superseded with the exception possibly of the desiccated and powdered gland itself.

The constitutional formula of adrenin is



$(HO)C{<}\begin{matrix}CH\\ \|\\ CH\end{matrix}{>}C.CH(OH)CH_2.NHCH_3$,

the empiric formula $C_9H_{13}NO_3$. Upon oxidation of adrenin the substance adrenalin is formed (methyl-aminoacetyl-pyrocatechin) and this has been prepared synthetically by Friedmann, Dakin, Stolz; its reduction product is identical with adrenin with one exception, viz., that it is optically inactive, whereas natural adrenin is levorotary ($^{\alpha}D = 43°$). The physiological action of synthetic (racemic) adrenin is only about one-half as strong upon the blood pressure as that of the natural product; if this racemic form is divided into its two optically active components it will be found that the dextrorotary component possesses only one-twelfth to one-fifteenth the power to raise blood pressure of the natural product, whereas the levorotary component is identical with it in its blood-pressure raising effect.

Dose and Administration.—In one case of Addison's disease a piece of fresh gland was implanted under the skin of the patient. No effects were observed and death occurred in three days. The dry powdered extract is given by mouth in capsules or in compressed tablets, in doses varying from twenty to forty grains a day. The gastric juice does not destroy the action of suprarenal preparations. It must be remembered, however, that the drug when given by mouth exercises little effect on the blood pressure. Nevertheless it should be given with care to individuals suffering from arterial degeneration.

For hypodermic use, for intravenous injection, and for administration by mouth, it is usually dispensed as the hydrochlorate in the form of a white crystalline powder. Applied locally it is a most powerful remedy. One part to ten thousand blanches the conjunctiva in from thirty to sixty seconds; 0.000008 of a grain, injected intravenously, causes a rise of blood pressure that is equal to the effect of 0.005 gm. of the dry powdered extract; 0.0000014 gm. per kilogram of body weight exercises a distinct physiological effect. It is the most powerful hemostatic and astringent known, and the strongest stimulant of the heart. The preparation is non-irritating and non-cumulative. It is generally employed in the strength of 1 to 1,000 for hypodermic and local as well as for internal use. Hypodermically a few drops (two to ten) usually suffice to bring about the desired immediate effect (see below). By the mouth, from five to ten drops should be given every fifteen to thirty minutes for two or three times, and then every three hours, as needed. In combination with cocain or eucain it forms a valuable local anesthetic or for spinal anesthesia; one of the most useful solutions being the following:

β-eucaine	0.2 gram
1 per cent. adrenalin chloride solution	♏x
Sodium chloride	0.8 gram
Distilled water	100 c.c. (Barker)

This mixture represents a 1 to 200,000 adrenalin solution.

Therapeutics.—In *Addison's disease* suprarenal preparations have been extensively employed. The results are not altogether unfavorable. In many instances improvement seemed to be maintained as long as the drug was exhibited. In one case the patient improved for two years under adrenal treatment. As soon as the remedy is stopped in these cases relapses are liable to occur; they are often sudden and severe, and may even terminate fatally. In the majority of cases the remedy is altogether without effect. In a few cases the patient's condition seemed to grow worse. No case of a complete cure is on record.

A number of statistics on the treatment of Addison's disease with suprarenal preparations have been published, but they are essentially without value because the stage of the disease, the time during which the cases were under observation, the quality of the suprarenal preparation are not included in the tabulation. In many instances the diagnosis is not even positive. One series, the most accurate one, includes 48 cases. Of these 6 were greatly improved, 22 slightly improved, 16 were not affected, and 2 grew worse. The results obtained so far are withal sufficiently encouraging to stimulate further trial.

Suprarenal preparations are the most rapid *cardiac tonic* which we possess. In sudden heart failure due to shock or hemorrhage, narcotics, anesthetics, asphyxia, phosphorus and chloral poisoning, hypodermic injections of adrenalin are very effective. The action of adrenalin is very transitory, however, so that in chronic heart lesions it cannot take the place of nitroglycerin, digitalis, or strychnine, but should merely be employed as an adjuvant to these remedies. In certain forms of neurasthenia as well as in some types of migraine with lowered blood pressure, adrenalin is often effective as a palliative. In the condition known as vagotonicity, its use both for diagnostic and therapeutic purposes is almost specific.

As rapid and powerful *vasoconstrictors* suprarenal preparations have a large sphere of usefulness. They can be given by mouth for the arrest of *internal hemorrhages* of all kinds (hemoptysis, hemophilia, etc.), and can be applied locally as *hemostatics* to all bleeding surfaces. In the treatment of epistaxis adrenalin is particularly useful. In *inflammation of the conjunctiva* depletion of the engorged vessels with relief of pain and redness is rapidly brought about by the instillation of a few drops of adrenalin solution into the eye. In *glaucoma, episcleritis, vascular keratitis,* and *kerato-conjunctivitis* suprarenal gland is a valuable adjuvant to other treatment. In *operations on the nose* or other mucous surfaces the application of a spray of adrenal extract or of adrenalin will produce rapid ischemia of the parts and consequently render surgical interference practically bloodless. Whenever it is desired to apply cocaine to intensely inflamed surfaces suprarenal extract may be first applied with profit, as it relieves the congestion of the tissues and in this way renders the action of cocaine

more powerful. For the details of the employment of suprarenal preparations in ophthalmology, in intratympanic surgery, and in nose and throat work we refer to special articles on these subjects.

Suprarenal gland has been used in the treatment of *diabetes*, this use being based on the view that certain forms of disturbed carbohydrate metabolism are due to "lack of vasomotor tension," and upon more or less uncertain effects of an inhibitory type that the adrenal secretion is believed to exercise upon the pancreas and the thyroid as well as upon the glycogen storing power of the liver. These researches are still *sub judice*. The results of this treatment have been quite unsatisfactory. In view of the fact that fluctuations always occur in the condition of diabetic subjects, the reports in regard to temporary amelioration, following the use of suprarenal extract, must be judged with caution. The discovery of suprarenal glycosuria has also led to the employment of adrenalin in diabetes, but the results obtained are altogether negative so far. In a few cases the dextrose excretion was even increased for a short time.

In *asthma* with vasomotor ataxia occurring in neurotic subjects the drug apparently has a certain application, and beneficial results from its administration are reported.

In the *asthenia* of certain nervous diseases, both functional and organic, the drug may do good as a muscle tonic. It is said to cause the feeling of profound fatigue so frequently complained of by neurasthenics to disappear. It also acts on the uterine muscles, and has been successfully employed to stimulate uterine contractions and to arrest uterine bleeding.

Other conditions in which suprarenal preparations are reported to have exercised favorable effects are acute maniacal excitement with low blood pressure, cyclic albuminuria, and the pain of cancer of the breast and the esophagus. Following the withdrawal of pleuritic and ascitic fluid the injection into the pleuritic or peritonitic cavity of forty to fifty drops of adrenalin chloride solution 1:1,000 retards or inhibits the reaccumulation of the fluid.

3. Thymus Gland.—*Removal of the thymus* in animals in which it persists during life is not followed by any characteristic perversions of function. In man the gland spontaneously decreases in size from the second year, and is almost totally obliterated in adult life. The organ is therefore not essential to life, nor apparently of physiological importance in adult man. Of its function we know little. It is probable that thymus furnishes an internal secretion that exercises an effect upon the organism later assumed by the generative organs and that it fills this need before the latter are developed; in support of this view the fact must be recalled that in castrated individuals the thymus maintains its function and fails to become obliterated. The internal secretion of the thymus cannot, however, be identical with the internal secretion of the reproductive organs for, after castration, and despite the persistence of the thymus, secondary sex characteristics fail to develop.

Injection of thymus extract produces the fall of blood pressure produced by all tissue extracts, acceleration of the pulse rate, restlessness, dyspnea, and in large doses collapse and death.

No *active principle* has been isolated. The gland contains iodine in smaller quantity than the thyroid. Dogs who are fed on thymus excrete a peculiar purin body, and the theory has consequently been advanced that the thymus is concerned in the metabolism of nuclein and the genesis from nuclein of uric acid and its chemical congeners.

The *dose* of thymus is much larger than the safe dose of thyroid. From ten grains to several ounces of the fresh gland have been given per day. Of the dry extract the common dose is from twenty-five to sixty grains (1.6–4.0) a day. No thymus preparation is used hypodermically.

Therapeutics.—Thymus is particularly useful in *simple goiter*. In this disease it acts very much like thyroid, only not so energetically. The statistics in regard to the efficacy of thymus treatment of simple goiter vary greatly. In many of the successful cases reported other treatment was given at the same time; and some of the cases were not kept under observation for a sufficiently long time to justify final conclusions in regard to a cure. The consensus of opinions is, however, very favorable. A critical review of the whole literature of the subject seems to show that about one-half the cases of simple goiter are much benefited by thymus. In several instances thymus brought improvement after thyroid had failed.

In *exophthalmic goiter* the reports are very much at variance. A few authors report aggravation of all the symptoms; others report altogether negative and indifferent results; a few report improvement. One author studied twenty cases of Basedow's disease treated with thymus, and contrasted with them twenty cases treated by various other means. The balance in regard to the retardation of the pulse rate, the decrease of the thyroid swelling and of the exophthalmus inclined toward treatment without thymus. The statistics as a whole are better than for thyroid treatment, but not as good as for other standard methods of treating exophthalmic goiter.

4. Pituitary Gland.—*Removal of the pituitary body* constitutes an operative inroad of such magnitude that only very few statements in regard to the effects of ablation of this organ are recorded in the literature. All the symptoms described, moreover, are ambiguous, and may be ascribed to shock or to injury of neighboring vital parts. From this source, then, we gain no reliable information. Spontaneous degeneration consisting in hypertrophy of the connective-tissue portions, cystic degeneration, sclerosis, atrophy, and tumor formation on the other hand is almost invariably followed by the syndrome of acromegaly. One case of hypertrophy of the pituitary body is on record in which acromegaly was absent, and a few cases of acromegaly are reported in which the gland was not found diseased. The connection between disease of the organ and acromegaly is nevertheless sufficiently apparent to warrant the employment of pituitary preparations in the treatment of this disease. In two cases of adiposis dolorosa the pituitary is also reported enlarged. Gigantism is probably due to hyperfunction of the gland. Frölich's disease (degeneratio adiposogenitalis) with fat accumulation and disturbances of the genital development is found in pituitary tumor without acromegaly, and is probably the result of hypofunction of the pituitary gland.

Injection of the infundibular portion of the organ produces a rise of blood pressure. Injection of the hypophyseal portion does not produce such a rise, but merely retardation of the pulse beat that persists to a certain extent, even after division of the vagi. A substance has also been isolated from the gland that causes contraction of arterioles and augmentation of the heart beat.

The *function* of the gland is not understood Some authorities claim that it regulates the intracranial blood pressure, and is also concerned in the regulation of general metabolism. It is finally believed to exercise some effect on the growth and development of the bony structures and the cutaneous tissues of the body.

No *active principle* has been isolated. Extracts from the posterior lobes containing only nervous tissue are the most active. This is surprising as the anterior portion has glandular structure and contains many epithelial cell groups. A colloid substance in the infundibular portion probably exercises the chief circulatory effect. The extract of the anterior lobes retards blood coagulation, while the extract

from the posterior portion accelerates it. In hemaphiliacs posterior lobe extract increases the coagulability of the blood, whereas anterior lobe extract retards it.

Therapeutics.—Pituitary gland is used in *acromegaly*. The most rational treatment is partial extirpation of the diseased gland. A pituitary antiserum has been suggested. The extract of pituitary gland seems to exercise no effect on the course of the disease, but does seem to be efficient in relieving some of the most distressing symptoms, as, for example, the headache, the neuralgic pains in the limbs, the general lethargy, and the loss of memory. In a series of thirteen cases seven showed relief of symptoms, five showed no improvement, and one case grew worse. Some authors claim to have seen marked benefits accrue from the combined use of pituitary gland and thyroid, particularly in regard to the relief of headache; but it is difficult to determine how much of this good effect must be attributed to the thyroid (see above) and how much to the pituitary gland. It is best in the present state of our knowledge to give sufferers from acromegaly the benefit of the combined use of thyroid and pituitary, in connection, of course, with other established measures for the relief of symptoms.

In *shock* pituitary gland is valuable, possibly more so than adrenin, for it keeps the blood pressure raised longer than the latter preparation.

It is most commonly used as a stimulant to uterine contractions in *delayed labor* and in *postpartum hemorrhages*.

As an excitant of intestinal peristalsis when the latter is sluggish, hence in the treatment of atonic forms of constipation, pituitary gland extracts have a distinct field.

It may also be employed as a diuretic provided the suppression of the urine is due to functional rather than advanced organic causes.

II. The Blood-forming Organs.

The rôle which the spleen, the lymph glands, and the bone marrow play in blood formation has suggested their employment in various diseases of the blood. Extracts made from the three organs are used rather indiscriminately, either singly or in combination. Very few clinicians in administering these preparations apparently have clear conceptions in regard to the physiologic function in blood formation which these different organs perform. A summary of our present knowledge in regard to the hematopoietic function of the spleen, the lymph glands, and the bone marrow reads as follows: The spleen and lymph glands are not really glands, nor do they apparently set free any substances of physiological utility. They contain no epithelial secreting cells and belong to the hemolymph series of organs.

The *spleen* plays only an insignificant part in blood formation. It is not at all concerned in the formation of red blood corpuscles (in man!) nor in the formation of granular mononuclear and polynuclear leucocytes, nor of eosinophile leucocytes. It appears to manufacture a small proportion of the lymphocytes. Its chief rôle is to arrest the fragments of red and white corpuscles that are carried to it in the blood of the splenic artery (spodogenic tumor of the spleen in infections).

The *lymph glands* manufacture only lymphocytes and have no other function in hematopoiesis. The lymph glands are closely related to the spleen; both contain lymphoid tissue.

The *bone marrow* forms the granular mononuclear and polynuclear leucocytes, and in all probability the red blood cells. It is not related to the spleen and lymph glands and consists largely of myeloid tissue.

There are then two types of leucocyte-forming tissue—the lymphoid (spleen, lymph glands) and the myeloid (bone marrow). Metaplastic vicarious transformation of lymphoid to myeloid tissue may, however, occur. In myelogenous leukemia, for example, large quantities of myeloid tissue are found in the lymph glands and the spleen. Under these conditions, therefore, the spleen may be said to play an important part in blood formation.

1. The Spleen.—*Extirpation of the spleen* is invariably followed by vicarious hypertrophy of numerous lymph glands, and in many instances by enlargement of the thyroid. A colossal lymphocytosis develops very soon, but no increase is witnessed in the number of mononuclear and polynuclear granular leucocytes. If the animal survives for a year or longer, marked eosinophile leucocytosis develops.

The injection of splenic extracts produces a fall of blood pressure followed by a continuous rise and often by elevation of temperature. Splenic juice is irritating and may produce abscesses when injected hypodermically, and inflammation of the upper digestive tract when given by the mouth. "Enrythrol" is a salt-water extract of spleen that is given in the dose of one or two teaspoonfuls a day, and is said to be non-irritating and not disagreeable to the taste.

Therapeutics.—On physiological grounds splenic extract should be administered only to increase the lymphocytes. The spleen, however, contains much nuclein, and it is well known that this substance produces a marked general leucocytosis. From this point of view spleen may be used to produce general leucocytosis, but it seems much more simple and expedient to employ pure nuclein for this purpose.

It is very difficult to render conservative judgment in regard to the efficacy of splenic extracts in diseases of the blood. Innumerable reports have been published, but very few of them are free from ambiguity.

The most careful and exact observers report very little benefit. In the majority of cases other preparations were used together with the organ extract, so that no positive conclusions in regard to the latter can be reached. How splenic extract should produce an increase of red blood corpuscles, as some writers claim, or how, *e.g.* red bone marrow should cause a marked lymphocytosis, as others relate, it is difficult to understand on the basis of the physiological considerations we have outlined above.

In *leukemia*, in which disease we have a relative decrease of lymphocytes, and also often a decrease of polynuclear neutrophiles, splenic extract might be expected to act beneficially. Physiologically, the supplying of spleen would raise the number of lymphocytes; chemically, the presence of nuclein would raise the number of granular leucocytes. What effect, however, splenic extract would have on the development of the myelocytes that are so colossally increased in this disease, what effect finally on the primary process, it is hard to foresee. Some good results have been claimed from this therapy, notably in regard to the increase of polynuclears (nuclein!) and the improvement in the subjective sensations of the patient. It does not appear from the case reports that the course of the disease is appreciably modified.

In *other blood diseases* no valid reports of good results are on record. In *typhoid fever* and in *tuberculosis* splenic extract has been given, apparently with some benefit. We are inclined to attribute this to the nuclein leucocytosis.

As the spleen is occasionally found enlarged in operative and sporadic *myxedema*, splenic extract has been employed in this condition. It seems to improve the general condition of the patient and to ameliorate the distressing mental symptoms. Combined with thyroid it seems also to enhance the efficacy of the latter. In this disease spleen has been given in the form of the dry desiccated organ (400 to 600 grains a week) and as fresh gland (twenty grains per dose three times daily in capsules).

A few cases of *exophthalmic goiter* and of *paludism* (malarial cachexia) are on record in which great benefits were claimed from splenic medication.

2. Lymph Glands.—*Total extirpation of all the lymph glands* is manifestly impossible. In many clinical cases, however, the lymph glands are found extensively degenerated or involved in tumor formation. In all such cases the number of lymphocytes is greatly reduced.

What has been said in regard to the physiological function of the spleen applies with equal force to lymph glands; they, too, may possibly increase the lymphocytes, and they, too, contain much nuclein and consequently can produce leucocytosis. Theoretically, therefore, lymph gland extract is indicated wherever splenic extract is indicated in blood diseases. As a matter of fact, lymph-gland preparations have not been extensively used. All the case reports describe the administration of lymph-gland extract in combination either with spleen or with bone marrow.

3. Bone Marrow.—*Removal of all the bone marrow* is of course impossible. Comparative counts of corpuscles in the afferent and efferent blood-vessels of the marrow have yielded essentially negative results. In clinical cases in which the bone marrow was largely displaced by other tissues (malignant tumor formation), the number of polynuclear leucocytes was found greatly decreased. In the bone marrow are found preliminary forms of red blood corpuscles, and after great loss of blood the yellow marrow of certain bones is converted into red marrow, showing that a process of regeneration is stimulated here. It seems, therefore, that bone marrow should be employed to stimulate the formation of red blood corpuscles and of leucocytes other than lymphocytes. In addition it contains iron in organic combination, and many clinicians recommend its use on these grounds. They argue that the iron in the form found in bone marrow is more readily assimilable than iron in other combinations or metallic iron.

These claims are probably exaggerated, and are not based on experimental or clinical evidence of value. In fact, the majority of clinicians obtain equally good and equally bad results with the standard inorganic preparations of iron.

Bone marrow is either given raw in doses of several ounces a day or in the form of glycerin extracts. As the marrow of young animals is more active in blood formation than the marrow of adult animals, it seems advantageous to employ the former alone. The anterior extremities of the ribs are crushed so as to expose the cancellous tissue. The fragments of bone are then extracted with glycerin for a number of days, the extract is filtered off and given in teaspoonful doses from three to six times a day.

What good effects have been claimed from bone marrow can hardly be attributed to any ingredient that might be utilized to build up corpuscles, or, as we have seen, to the iron which it contains. We must hypothetically assume the presence of some body in bone marrow that is capable of stimulating blood formation.

In *leucocythemia* (leukemia) the employment of bone marrow is altogether irrational, because in this disease we have already hypertrophy and overactivity of the bone marrow.

In *progressive pernicious anemia* some good results are claimed. No case is on record, however, in which bone marrow was given alone. The best that can be said, therefore, is that as an adjuvant to other remedies it may be tried. It certainly cannot replace arsenic.

In *chlorosis* and in secondary *anemias* the results have been more favorable than in the primary anemias. Here again it may be used in combination with iron, but cannot replace the latter.

In *pseudoleukemia* (Hodgkin's disease) the best results have been recorded. The exhibition of bone marrow is a more rational procedure in this disease than in all the other diseases of the blood, for here the spleen and the lymph glands are extensively diseased and the bone marrow, we must suppose, vicariously assumes the greater portion of the hematopoietic function. Anything that can stimulate the bone marrow to increased blood formation is indicated. It is not impossible that bone marrow does this (see above). The best results are reported from the combined use of bone marrow, thyroid, and arsenic.

III. The Generative Organs.

The use of orchitic and of ovarian extracts is of historical interest. Brown-Séquard, when an old man, performed his first experiments with "*suc testiculaire*" on himself, and claimed to experience "a return of vital energy and rejuvenescence with renewed and efficient peristalsis and control over the bladder and sphincter." His conclusion was that the testicles secrete into the blood a substance that profoundly influences nervous and possibly muscular metabolism and increases mental vigor. There can be no doubt that the ridiculous claims of charlatanistic advocates of this particular application of the "Brown-Séquard method" have done much to bring organotherapy into disrepute. Nevertheless, the use of testicular and ovarian extracts, if we carefully weigh all the clinical evidence, cannot be absolutely condemned as useless. Favorable symptomatic results at least, that are not due to suggestion, are obtained without question in certain conditions. Neither the testicles nor the ovaries are properly glands, however, they both contain certain cells of a glandular type and probably furnish an internal secretion.

1. The Testicles.—*Removal of the testicles* in children exercises a very marked effect on growth and development. The voice remains treble, the subjects usually grow obese, show lack of mental vigor, and manifest psychic perversions of various kinds (eunuchs). The *injection of testicular extract* into normal subjects produces indifferent results. Nevertheless experimental evidence is all in favor of the postulate that the secondary sexual characteristics of the male are due to the internal secretion of the testis. The ablation of the testicles produces, however, an infantile, not a feminine, type of development. Ligature of the spermatic cord produces the same effect as castration; but ligature of the vas deferens does not produce this result. The internal secretion is furnished not by the proper spermatogenic structure of the testicle but by the interstitial tissues the cells of which have glandular structure; the internal secretion, therefore, is blood borne. Bone growth is stimulated by castration, the presence of the testicle presumably exercising an inhibitory influence on excessive osseous development. The growth and the functional integrity of the prostate are also dependent upon the presence of a hormone manufactured by the testes.

Several so-called active principles have been manufactured from testicles. The best known is spermin. There are two different kinds of spermin. The one can be converted into its polymer piperazin (dispermin), the other cannot. Poehl discovered the latter, and claims the most startling effects from its exhibition. His statements are borne out by many Russian and some French authors, but the reports are not convincing. The majority of conservative French and German authorities failed to witness any physiological effects from Poehl's spermin and report negative results from its administration in all the morbid conditions for which it is recommended. Brown-Séquard states that spermin is not the active principle of testicular extract. Charcot's crystals which are found in testicle juice are phosphate of spermin.

Testicular extract is best made from the testicles

of young animals by maceration of the glands, extraction with normal physiological salt solution, to which may be added a little carbolic acid, thymol, or glycerin. The extract is sterilized according to d'Arsonval, under pressure with CO_2 and filtered through a clay candle filter. No uniform data in regard to the concentration of this extract nor the exact dosage are given by the different authors who have written on the subject. The best results are claimed from hypodermic injection, and Brown-Séquard states that testicular extract is inactive when given by mouth.

The most interesting results are claimed in the treatment of *locomotor ataxia*. The destructive sclerotic lesions of the spinal cord that form the anatomic basis of tabes cannot of course in any way be influenced by the injection of testicular fluid. A cure is, therefore, *a priori* out of the question. It appears, however, that many of the symptomatic manifestations of the disease can be ameliorated by orchitic medication, so that the remedy may be tried. The statistics published are altogether contradictory. Brown-Séquard and d'Arsonval have published the most comprehensive tabulation of results. Three hundred and forty-two cases were treated. All improved, and some, they claim, were "cured" (!). Other French authors report eighty-five and ninety per cent. of successful cases. German clinicians, on the other hand, claim essentially negative results throughout.

In neurasthenia, hysteria, hypochondriasis, melancholia, and kindred *pyschoses* transitory improvement is reported by many writers, but the element of suggestion can hardly be excluded in cases of this character.

In general *debility* from wasting disease and in *senility* a certain tonic effect is conceded by nearly all authorities. It appears, therefore, that the chief therapeutic sphere, and probably the only sphere of testicular extract is to act as a tonic to the cerebrospinal centers. This power, it seems, is also inherent in many other organs, though possibly not to such a marked degree as in the testicles. Whether the latter produce a specific internal secretion that is distributed to other organs, or whether all organs secrete such a tonic principle, cannot be determined.

For the arrest of *surface hemorrhage* minced testicle, locally applied, has been found to be of value.

2. The Ovaries.—*Removal of the ovaries* before the age of puberty prevents the appearance of the characteristic phenomena of puberty. The pelvis does not enlarge, menstruation fails to appear, the mammæ and the genital organs atrophy, and occasionally certain male attributes develop. One has reason to assume that masculine characteristics are latent in all female animals and that their development is inhibited by the presence of the ovaries; removal of the ovaries removes this check. In adults, aside from the cessation of menstruation (a few cases are recorded in which periodic uterine bleeding persisted even after removal of the ovaries) and atrophy of the genital organs, a variety of distressing nervous phenomena and in many patients obesity are apt to develop. In cows removal of the ovaries causes the milk to become richer in fat.

The *administration of ovarian extract* to healthy animals has been known to cause death from hemorrhage into the spinal cord. Males are claimed to be more susceptible to this influence than females.

No *active principle* has been isolated. The *corpus luteum* furnishes an important portion of the internal secretion of the ovary; it resembles in its structure a glandular organ without a duct, the luteal cells probably being derived from the follicular cells. The hormone of the corpus luteum stimulates increased nutrition of the uterus during early gestation and helps in the fixation of the embryo; it also stimulates the growth of the mammæ after ovulation and impregnation, but exercises no effect on the secretion of milk. To what extent the ovary as a whole or the corpus luteum specifically determine the estrous cycle remains doubtful.

Ovary is administered as dry powdered gland in *doses* of from one to five grains. The powder is conveniently dispensed in compressed tablets. Glycerin extracts have also been recommended for hypodermic use.

Therapeutics.—Ovarian extract is a useful remedy for all the symptoms following double *oöphorectomy*. The nervous and vasomotor disturbances (insomnia, headache, psychoses, flatulence, lumbar pains, etc.), of the climacterium and of certain uterine disorders also often yield to ovarian medication. The drug is not, however, reliable in all cases, and it is impossible to predict in any given case whether or not ovary will do good. Ovarian transplantation after oophorectomy in animals almost invariably prevents these disagreeable after-effects. Grafting of an ovary in a human being is a difficult undertaking but is worth attempting.

Senile debility in old women seems to be counteracted by the use of ovary. Of sixty-four old women treated in one of the Paris hospitals all, we are told, were greatly benefited and rejuvenated.

In *hysteria* good results are also related. In a young child hysterical contractures disappeared after a few doses; "*mais que n'obtient-on pas dans l'hystérie!*"

In *chlorosis* ovary is of greater benefit than spleen, lymph glands, or bone marrow. It is believed by leading authorities that the ovaries secrete a substance that stimulates blood formation, and that in chlorosis this function is insufficient. On these grounds they supply ovary and claim very favorable results. In amenorrhea and in the psychoses of the menopause ovarian extract is especially useful. It should never be given to pregnant women.

Ovarian extract has finally been given with success as an aphrodisiac.

IV. The Nervous System.

Brain cortex, cord, and nerve tissue have been employed either singly or in combination in many nervous or mental disorders. The most common preparation used is a sterile glycerin extract that is injected hypodermically.

All nervous tissues contain cholin and neurin, two bodies that are highly toxic. They are probably catabolic products of brain and nerve activity, for in nervous diseases in which nerve metabolism is increased the cerebrospinal fluid contains abnormally large quantities of cholin. It is probably due to the action of the latter substance that the injection of nervous extracts often produces a rise of temperature, leucocytosis, increased absorption of oxygen, and increased excretion of nitrogen. In addition to this toxic action nervous tissue, and particularly brain cortex, seems to exercise a distinct tonic effect, *i.e.* in healthy subjects a feeling of exaltation and of increased energy. There is no record of any influence having been exerted on the pulse and respiration.

Therapeutics.—The best results, it is claimed, are obtained in *neurasthenia*, but suggestion cannot be excluded. In *epilepsy* and in a case of *bulbar palsy* one authority reports excellent effects. In *mental diseases* the psychopathic disorders seem to remain unaffected, whereas the physical condition of the patients improved greatly under this treatment. Of eleven cases of *tabes* treated with nervous extracts seven are reported benefited.

As against many favorable reports we find an equal or even greater number of absolutely negative results. Nerve-tissue extracts probably possess tonic properties for the nervous system and merit employment in this sense. Many other remedies that we possess are, however, equally efficacious, so that

nerve extracts are by no means an indispensable adjuvant to our therapeutic armamentarium. Charlatans in and out of the profession have utilized these preparations extensively to impose on a credulous laity, so that their employment has fallen into considerable disrepute among conservative physicians.

V. The Secreting Glands.

Aside from their external secretion some of the glands of the body seem to furnish an "internal secretion" that plays an important part in intracellular digestion. In the case of the pancreas and the stomach and intestine this may be practically considered established; in the case of the liver, the kidneys, the mammæ, and the salivary glands it is highly probable.

1. The Pancreas.—Complete extirpation of the pancreas is invariably followed by the complete syndrome of diabetes mellitus. If a small portion of the gland is left behind, or if a piece of the extirpated pancreas is subsequently grafted under the skin, diabetes does not develop. Ligation of the pancreatic duct does not cause diabetes. There are numerous theories in regard to the rôle of the pancreas in carbohydrate metabolism; they cannot all be discussed in this place. The preponderance of experimental evidence points to the secretion by the pancreas of a glycolytic, *i.e.* dextrose-destroying ferment. If this secretion becomes insufficient or is arrested, the blood sugar is not destroyed, consequently it accumulates. This leads to hyperglycemia and glycosuria. Diabetes may also be due to other causes. Degeneration of the pancreas in man may and may not produce diabetes. From very recent investigations it appears that in nearly all cases of diabetes certain cell groups in the pancreas (the "islands of Langerhans") are found degenerated. These cells are not connected with the efferent ducts of the gland, but pour their secretion into the lymph spaces. It is probable that they furnish the specific internal secretion. Ligation of the pancreatic duct causes atrophy of the cells furnishing the external secretion, whereas the islands of Langerhans remain intact for a long time. The writer is at present engaged in studying the effects of pancreas prepared in this way, *i.e.* of "isolated" islands of Langerhans in carbohydrate metabolism, both *in vitro* and *in vivo*. It is expected that these researches will throw light on the nature of the internal pancreatic secretion, and will advance the organotherapy of diabetes. For the present this method of treatment, although so clearly indicated on theoretical grounds, has furnished essentially negative results. This may be due to the fact that all pancreatic extracts contain digestive ferments and certain nucleoproteids that are toxic and produce local necrosis when injected hypodermically; thromboses, pyrexia, tachycardia, increased diuresis, and increased N excretion when administered intravenously. The administration by mouth is negative in diabetes. It is probable that the trypsin contained in pancreas extracts destroys the "internal secretion" as it destroys the fat-splitting enzyme that we *know* to be present. An extract of pancreas containing no digestive ferments, prepared as suggested above, may act more favorably.

The administration of pancreas by mouth is practised for the relief of *steatorrhea* and other *intestinal disorders* that are due to perversion or absence of the external secretion of the gland. This treatment is not, however, organotherapy proper, and will therefore be discussed under other headings.

2. The Kidneys.—Complete anuria may persist for many days without causing the development of uremic symptoms (*e.g.* hysterical anuria). If a double nephrectomy is performed in a dog and kidney extract is injected intravenously, the life of the animal will be prolonged beyond that of a nephrectomized control animal that is not treated with renal extract. The onset of uremic symptoms can be delayed in this way. From these observations the conclusion has been drawn that the kidneys furnish an internal secretion that is disintoxicating for certain urinary bodies, and that prevents the occurrence of uremia. It has also been shown that the toxicity of the blood of uremic animals is greatly reduced by its passage through healthy kidneys. Uremia is not, therefore, considered to be due to the retention of urinary bodies alone, but also to insufficiency of the internal disintoxicating secretion of the kidneys. In harmony with this theory kidney extract has been employed in the treatment of a considerable number of uremic cases, apparently with good results. Kidney therapy is too modern, and case reports are too scanty to warrant extended analysis. The subject, however, seems capable of fruitful development.

There has also been manufactured a *nephrotoxic* or *nephrolytic serum* by the injection of kidney tissue into animals. This serum is said to produce edema on account of a lymphagogue substance it incorporates. Its utility in nephritis is nil.

3. The Liver.—Liver extract contains many substances with active physiologic and toxic properties, and no less than ten well-characterized ferments besides. It is difficult therefore to understand how those who employ liver extract for the sake of an hypothetical internal secretion of the hepatic cells can exclude the action of all these bodies. It has been claimed that the virtues of cod-liver oil are due to the presence in this product of an internal secretion. A few good results are reported from the use of hepatic extract (prepared according to d'Arsonval's method) in *diabetes*. The preparation is said to stimulate the liver cells to increased activity in the sense that it enables them to store more glycogen. A great reduction in the sugar excretion has been reported by reliable clinicians. Some authors have also used liver extract symptomatically for "*hepatic insufficiency*" following alcoholic cirrhosis, and report improvement of many of the subjective symptoms.

4. Mammary Gland.—Mammary gland extracts are believed to exercise an influence on the female generative organs. Desiccated sheep's mamma has been given by mouth in twenty-grain doses for *uterine hemorrhage*. It is said to cause contraction of the uterine muscles and to arrest bleeding. Good results are also claimed from this therapy in the leucorrhea and irregular bleeding of subinvolution, and in benign tumors of the uterus it is said to relieve many of the reflex symptoms, to control the leucorrhea and bleeding, and to improve the general health of the patient.

5. Intestine.—From the intestinal mucosa there has been isolated a hormone, *secretin*, that is not destroyed by boiling with dilute hydrochloric acid that is capable of stimulating the flow of pancreatic juice, and to a slighter extent, of the bile, the saliva, the gastric juice. It is derived from *prosecretin* that is manufactured by the epithelial cells of the upper small intestine and that is activated, scilicet converted into secretin, by the acid of the gastric juice when it enters the duodenum. Secretin acts upon the pancreas through the blood stream, not through nerve connections. In this instance, therefore, the "internal" secretion of the duodenum stimulates the "external" secretion of the pancreas. A similar gastric hormone, gastric secretin, is formed in the pyloric mucosa. Secretin is not a specific substance, as far as we know, the purest preparations containing cholin and a blood pressure lowering principle that may be operative in producing the

remote effect on other digestive glands. Therapeutically its efficacy remains doubtful and, of course, difficult accurately to determine. There is some experimental evidence to show that the intestinal wall neutralizes many of the toxic products that are gathered in the bowel lumen. Insufficiency of this function would lead to autochtonous intestinal intoxication. It has also been shown that the injection of sterile feces does not produce death so rapidly in animals which have been treated with intestinal extract as in animals which have not. The disintoxicating action of the cells of the intestinal wall is believed to be carried out with the aid of a soluble internal secretion which they produce. It does not seem improbable that the violent systemic disturbances of intestinal strangulation, volvulus, and invagination are in part due to insufficiency of this function and the resulting self-intoxication. The same applies to certain anemias, psychoses, etc., which may be attributed to autointoxication from the bowel.

Extract of intestine has, in fact, been employed with some success in *chlorosis*, and in several cases of stercoremic poisoning following *strangulation* of intestinal hernias. We are told that in a few of the latter cases the general condition of the patients improved so much under this treatment that operative interference was rendered more safe. This field of organotherapy also merits further cultivation.

6. Parotid Gland.—The parotid gland and the ovaries appear to stand in some sympathetic relation to one another. Parotid extract has been used with success by eminent clinicians in Germany and Scotland for the relief of certain symptoms due to ovarian disorders, notably the pain and reflex manifestations of ovaritis in cases in which the glands were enlarged and prolapsed.

VI. Miscellaneous Tissues.

Nearly every tissue of the body has at some time been made to yield an extract. No exhaustive experimental or clinical data relating to their employment are, however, recorded excepting in the case of muscle tissue, lung tissue, and heart. We will therefore discuss these three alone.

1. Muscle Tissue.—Muscle extracts contain abundant quantities of potassium salts and consequently are toxic when given hypodermically. In addition, muscle juice has a distinct thermogenic action and can produce salivation. Reliable investigators claim that small quantities of muscle extract prepared in the cold and sterilized under CO_2 pressure act as distinct muscle tonics.

Muscle extract has been employed apparently with some success in all primary myopathies in which there was no injury to the anterior horns or the peripheral nerves. A leading French neurologist recommends its use in all "*dystrophies musculaires progressives*" with lesions of the fibrillæ of the muscle and connective tissue.

2. Lung Tissue.—Pulmonary extract has been successfully employed in the treatment of pulmonary arthropathies. It is believed that destructive lesions of the lungs, in addition to interfering with the respiratory interchange of gases, inhibit the formation of an internal secretion of the pulmonary cells, and that the lack of this secretion in the blood leads to the development of the osteoarthritic lesions of lung disease. Very good results are reported from pulmonary therapy in a case of Marie's disease (*ostéoarthropathie hypertrophiante pneumonique*). The arthritic process was arrested, the dynamometric pressure rose from 9 kilograms to 19.5 kilograms, and the general health of the patient was markedly improved after the twenty-ninth injection. In pleuropulmonary suppuration with osteoarthritis pulmonary extract is also said to act beneficially, and recently "pulmozyme," a pulmonary preparation, has been advised for the treatment of lesions of the lungs themselves. Case reports are scanty and results not uniform, so that judgment cannot as yet be rendered on this therapy.

3. Heart.—Heart extract was extensively used a few years ago in the treatment of a large variety of disorders. The effects claimed from the injection of this preparation were, among others, an increase in the pulse rate, a rise of arterial pressure, increased diuresis, and a general tonic effect. The extract used by the chief advocate of cardiotherapy unfortunately contained appreciable quantities of alcohol, so that we need not be surprised to learn that it exercised the above effects. The literature on cardiotherapy is large and many cures are reported. A careful analysis of the case reports, however, reveals the method to be utterly devoid of value and the claims of its advocates to be unfounded. Cardiotherapy is mentioned only to be condemned. Alfred C. Croftan.

Oribasius.—The first medical author of any importance who appeared after Galen. He came from Pergamon, Greece, and flourished during the fourth century. By reason of his high personal character and his skill in the treatment of disease, he acquired, at an early period of his career, great popularity among the citizens of Constantinople, the metropolis of the empire of the Orient. He was an especial favorite of the Emperor Julian; but, after the latter's death (June 26, 363), a great change took place in the manner in which Oribasius was treated at Court. His property was confiscated, he was deprived of his titles and all emoluments, and was sent into exile among barbarians. Here, again, he rendered such helpful services to the people that they worshipped him as a god. Eventually he was recalled to Constantinople, and in due time (about the year 400) he appears to have regained all the consideration and material prosperity which he had enjoyed during the reign of Julian. Notwithstanding all the interruptions which he must have experienced, Oribasius managed to write a number of treatises. Some of these have been lost, but of those which have come down to our time the following deserve to be mentioned: "Oribasii sardiani collectorum medicinalium libri xvii., qui ex magno septuaginta librorum volumine ad nostram aetatem soli pervenerunt," etc., Paris, 1555; "Oribasii synopseos ad Eustathium filium libri ix., quibus tota medicina in compendium redacta continetur," Venice, 1554. In his style of writing Oribasius was very concise and clear, much more so than was his predecessor, Galen. A. H. B.

Oriental Sore.—See *Leishmaniasis*.

Ornithodoros.—A genus of mites in which no eyes are present; lateral borders of body straight; integument mammillated. There are a dozen species, some of which not only attack man but spread various parasites such as spirochetes and Filaria. See *Arachnida*. A. S. P.

Ornithine.—α-, ϵ-diaminovalerianic acid, is a noncrystalline, water soluble body which may be formed by treating arginine with barium hydroxide. It was first obtained from the ornithuric acid prepared from hen's urine after benzoic acid feeding. Ornithine is split into carbon dioxide and putrescine in cystinuries, and also during ordinary putrefaction. F. P. U.

Oroya.—Carrion's fever, a malignant type of verruga peruviana which is without doubt carried by insects, probably by Phlebotomus flies. A. S. P.

Oroya Fever.—*Synonym:* Carrions's disease. The disease caused by an invasion of *Bartonella bacilliformis*, Strong, 1913. It is characterized by a long incubation period, moderate irregular fever, rapidly developed and intense anemia of pernicious type, and high mortality.

This disease has not yet been observed elsewhere than in Peru where it prevails on the western slopes of the Andes at altitudes of 3,000 to 9,000 feet. It is seen chiefly in certain narrow valleys and has to some extent a seasonal prevalence from January to April, diminishing, but not disappearing, with the close of the warm, rainy season. A severe outbreak of what was probably the disease now recognized as Oroya fever occurred in 1870 among the laborers engaged in building the railway from Lima to Oroya. From that time until recently the disease has been more or less confused with other diseases by many observers and writers, some of whom believed that it was a pre-eruptive febrile stage of verruga peruviana. In 1885 Daniel Carrion, a medical student at Lima, who shared this belief, inoculated himself in both arms with blood taken from a verruga tumor. After an incubation period of twenty-one days he developed the symptoms of Oroya fever, which ran a course of eighteen days and terminated fatally without any signs of verruga having developed. The prevalence of paratyphoid fevers, malaria and verruga within the endemic area of Oroya fever, and the fact that any two of these diseases may coexist in the same patient, served to prevent the differentiation of Oroya fever as a disease *sui generis* in the absence of any knowledge of an infecting parasite. In 1901–02 Barton observed in the blood and organs of Oroya fever patients minute rod-like organisms which he believed at first to be bacilli, but which were quite probably the parasite identified by R. P. Strong and the Harvard research expedition in 1913 as the one responsible for Oroya fever. This parasite is believed to be a protozoon and has been named by them *Bartonella bacilliformis*. They have found it in both rounded and rod-shaped forms in the red blood cells and in endothelial cells, and have been able to make some deductions concerning its intracorporeal life cycle.* Nothing has yet been discovered concerning the mode of infection, nor concerning any insect carrier or host. Townsend has suggested that a species of *Phlebotomus* which is abundant in the endemic region may be the transmitting agent.

Symptoms.—After an incubation of about twenty days a mild, irregular fever sets in, the temperature ranging between 100° and 102° F. in most cases, occasionally higher, and running an irregular remittent course. Malaise, pains and weakness in the limbs and slight rigors are observed, the rigors increasing in severity as the disease advances. A severe anemia develops rapidly, the red cells being often reduced to 1,000,000, or even lower, and hemorrhages from mucous membranes sometimes occur. The skin and mucous membranes become pale, and murmurs are heard over the heart and great vessels. Edema of the lower extremities or of the joints may be observed. The urine is scanty and sometimes albuminous, the tongue coated, the bowels irregular. Prostration increases, with restlessness, and often delirium. The temperature at the end may be subnormal and death occur from exhaustion. Cases may terminate fatally in from ten to thirty days from the onset of symptoms. The mortality is stated to be from thirty to seventy-five per cent. In those cases that recover, improvement sets in after a febrile course of twenty-five to thirty days. The spleen is demonstrably enlarged in many cases. There is no eruption.

Gross Pathology.—The most striking feature observed at necropsy is the evidence of an advanced anemia. Ecchymoses may be found in the mucosa of nose, mouth, intestines and conjunctiva; and in some cases in the epicardium, pleura, and fatty tissue. The lungs are sometimes edematous at the bases and moderate pleural effusion may be present. The spleen is enlarged and infarctions are common. The liver, too, may be enlarged and show a fatty degeneration of the central type. The mesenteric lymph nodes are usually swollen. Ulcerations are sometimes found in the large intestine. The bone marrow is softened and appears mottled.

Histopathology.—Strong and his colleagues of the Harvard expedition have found that the most characteristic and constant histological change is in the lymph nodes, spleen, and intestinal mucosa. In sections of these tissues stained by Giemsa's method, large swollen endothelial cells are found, sometimes free in the lumen of the blood-vessels, sometimes attached to their walls. These cells are distended with rounded and rod-shaped elements containing chromatin, from which it is apparent that a multiplicative phase of *Bartonella bacilliformis* takes place within these cells. The choking of the vessels by these cells is probably the cause of the degenerative changes seen in lymph nodes, spleen and liver, and of the ulcerations sometimes found in the intestinal mucosa, these latter lesions being brought about in much the same way that intestinal ulcerations are produced in leishmaniasis and in pernicious malaria. The round bodies in these distended endothelial cells break up into a large number of minute elongated elements each containing a chromatin granule at one end. These are identical in appearance with the rods found within the red blood cells. Strong thinks that these minute chromatin-bearing rods have the character of microgametes rather than merozoites. Within the red blood cells in fresh blood they exhibit motion. Strong regards *B. bacilliformis* as a protozoon which probably belongs to the same group as *Lympho-hematocytozoon parvum*, Meyer, 1913.

The liver, spleen and bone marrow all show evidence of an active phagocytosis of red corpuscles by endothelial leucocytes.

Diagnosis depends upon the recognition of the parasite in the blood. In severe cases with heavy infection this presents no special difficulty. In mild infections the parasites are scarce and a prolonged search is often necessary to detect them. The disease is to be suspected in any case of fever with sudden onset and a very rapidly developed anemia occurring within the endemic area.

The *prognosis* is always grave. Cases which begin to show improvement in the fourth week will probably recover.

No effective *treatment* is known. The arsenic substitution compounds, atoxyl, salvarsan, etc., have been employed in a few cases without definite success.

J. F. Leys.

Orphol.—See *Naphthol Bismuth.*

Orris Root.—(*Rhizoma Iridis*, Ph. G.; *Iris de Florence*, Codex Med.) The rhizomes of three or more species of *Iris* are cultivated for the production of this article in the south of Europe, especially in the vicinity of Florence. They, and a few other species also, are familiar garden flowers both there and in this country. The three following are recognized as the sources of "Orris:" *I. florentina* L., with very sweet-scented, white, or pale slaty-blue flowers; *I. germanica* L., with dark, violet flowers; and *I. pallida* Lam., with flowers light blue, very large, and fragrant. They all resemble each other in respect to the more important particulars. The former is a native of the southern and eastern Black Sea regions, the others of Europe; all have been cultivated for a long time.

The rhizomes are gathered in the latter part of summer, trimmed and peeled, and then dried in the sun, and afterward separated into grades, according to size, symmetry, and appearance. The opera-

* *Jour. A. M. A.*, lxi., 1713; lxiv., 806, 965.

tion of curing is a delicate one, great care and much experience being required to produce the best results. The pieces are more or less long and flattened, with rounded surfaces and ends, often curved or twisted in drying, of a nearly white color, a hard but brittle texture, and a yellowish fracture. Pieces with the branches attached are called "hands;" the detached branches, "fingers." The scars where the roots have been cut away may be seen on the lower surface. Taste bitterish, aromatic and sharp. Odor, for which it is valued, mild and pleasant, recalling that of violets. Orris which has been kept for one or two years is more fragrant than that just dried. This product has been for centuries used as a perfume, and in the preparation of cosmetics, and less generally as a medicine, and is mentioned by most of the classical writers upon medicine. It yields, upon distillation, about 0.1 per cent. of a so-called volatile oil, "*orris camphor*," a buttery-looking substance. This consists chiefly of *myristic acid*, with a trace of *irone*, a liquid with a violet-like odor. *Iridin* is a glucoside, occurring in acicular crystals, in very small amount. There is a specific amaroid, giving the bitter taste. Orris contains also a little resin and fixed oil, and a very little tannin. Starch is abundant.

Action and Use.—Internally given, orris, like our Blue Flag (*Iris versicolor* L.), is a cathartic and occasional emetic, but it is almost never employed in this way. It is a common ingredient of tooth powders, as well as of sachet powders (violet), and is otherwise used as a perfume. The oil is also used in tooth washes. Large, fine pieces are now and then given to teething children to chew upon. Henry H. Rusby.

Orthoform—Methyl-para-amido-meta-oxybenzoic ester ($C_6H_3.OH.NH_2.COOCH_3$)—is a white powder without odor or taste, and permanent in the air. It is soluble in alcohol, ether, chloroform, and some of the oils, but very slightly soluble in glycerin or water. It is precipitated, but not rendered inert, by formaldehyde and mercury bichloride (Luxenburger), produces a brown color with bismuth subnitrate, and decomposes silver nitrate and potassium permanganate. It is not affected by zinc oxide, iodoform, salicylic acid, carbolic acid, lysol, aluminum acetate, or iodine, and may be safely combined in prescription with most of the ordinary antiseptics and dusting powders. It is said to remove most of the odor of an equal amount of iodoform.

Acting on the sensory end organs, orthoform produces a local anesthesia, which, owing to the insolubility of the drug, is mild and long continued. This slow action, together with a distinctly antiseptic power, makes it a valuable dusting powder for raw surfaces. It is therefore applied to burns, fissures, painful ulcers, ulcerating hemorrhoids, etc. The anesthetic effect from a ten-per-cent. powder or ointment lasts for from two to forty-eight hours (Kindler). As the drug has no penetrating power, it is of little use on unbroken skin or mucous membrane. Blondel used a few drops of a saturated solution in forty-per-cent. alcohol for fissured nipples. In zoster or herpes with ruptured vesicles much relief is obtained. It has also been used in cases of pruritus vulvæ. In painful cancer and ulcer of the stomach it has been administered in dose of 0.5 (gr. viiss.) several times a day with relief from the pain and without any systemic effect. Suspended in water it has been thrown into the bladder for painful cystitis. In dentistry, its slow anesthesia fits it for allaying the ache of an exposed nerve.

A peculiar vesicular dermatitis, resembling that from poison ivy and very resistant to treatment, has been noticed after the use of orthoform.

W. A. Bastedo.
R. J. E. Scott.

Orthorrhapha.—A suborder of dipterous insects including those without lunula or ptilinum. The larva has a distinct head; pupa obtectate; imago escapes by a T-shaped opening. This group contains the mosquitos, midges, sand-flies, horseflies, gad-flies, robber-flies, etc. See *Insects, parasitic.*

A. S. P.

Orthotylus.—A genus of capsid bugs. *O. flavoparsus* bites man. A. S. P.

Osazone is the name applied to the crystalline compound formed from a combination between phenylhydrazin and some of the sugars. The osazones afford a means of identification of these sugars since the former differ in crystalline form, solubility, and melting-point. F. P. U.

Osiander, Frederic Benjamin.—Born at Zell, in Wuerttemberg, Germany, on Feb. 7, 1759. He studied medicine at Tübingen, and received the degree of Doctor of Medicine from that university in 1779. He settled at Kirchheim, not far from Stuttgart, the capital, and devoted himself mainly to the practice of obstetrics. In 1792 he was called by the University of Goettingen to occupy the Chair of Obstetrics and to take charge of the Obstetrical Clinique. For a period of thirty years Osiander held these positions, and acquired great celebrity as an obstetrician. He died at Goettingen on March 23, 1822, leaving unfinished a large treatise on obstetrics.

Osiander was a most industrious writer. From the long list of his published writings, we venture to make the following three or four selections: "Lehrbuch der Hebammenkunst," Goettingen, 1796; "Grundriss der Entbindungskunst, zum Leitfaden bei seinen Vorlesungen," Goettingen, 1802; "Ueber die Castration des Haushahns, oder das Kapaunenmachen bei den Griechen und Roemern," in Beckmann's Beitraegen zur Geschichte der Erfindungen, 1804; and "Heilung der Mutterkrebsen und krankhafter Auswüchsen aus der Gebärmutter durch den Schnitt," in Reichanzeiger, 1803. A. H. B.

Osmic Acid.—In medical parlance the title *osmic acid* is given to the body *osmic tetroxide*, OsO_4. True osmic acid (H_2OsO_4) is not known in the free state. Osmic tetroxide is a volatile crystalline substance, softening at a moderate heat like wax, and melting at a lower temperature than does that body. It dissolves slowly but completely in water, forming a colorless solution, which, however, on exposure to light, rapidly darkens, even to blackness, by decomposition of the tetroxide with formation of the tetrahydroxide, $Os(OH)_4$. Osmic tetroxide is a powerful oxidizer, and, to living tissues, is excessively irritant. Its odor is powerful and disagreeable, and its vapor intolerably pungent and poisonous, with a peculiar faculty for exciting irritation of the conjunctiva. In the event of the inhalation of fumes of osmic tetroxide, hydrogen sulphide ("sulphureted hydrogen") has been recommended as a chemical antidote, to be taken by inhalation; but since in this case the remedy is itself a powerful poison, the greatest care would be required in its employment.

Osmic tetroxide is of peculiar service to the histologist, being employed as a hardening and also as a staining agent. Its power of staining fatty tissues black renders it particularly valuable in studying fatty degenerations. As a medicine it has been used, by hypodermatic injection, for the relief of peripheral neuralgias. The results have been quite variable, but a certain amount of efficacy for the remedy seems to have been demonstrated. A one-

per-cent. aqueous solution of the tetroxide is used, and the same should be made only in small quantities when wanted, and kept in the dark. Of such a solution, quantities from ℥iij. to ℥xv. (0.2–1.0) have been injected at a dose. The injections are made as near as possible to the painful spot. The operation is often severely painful, is occasionally followed by temporary swelling and thickening of the tissues at the site of the puncture, and, practised over an efferent nerve, has in one instance been followed also by paralysis. No constitutional effects have followed these injections.

EDWARD CURTIS.
R. J. E. SCOTT.

Osmosis.—If two gases are brought into contact they soon mix in such a manner that a homogeneous mixture results. This mutual interpenetration is called dialysis or *diffusion* and it is due to the movements of the gases in the confining space. Also when two liquids, miscible without chemical interaction, are placed in contact a similar interpenetration occurs until a homogeneous mixture of the two fluids is obtained.

The term *osmosis* is applied to diffusion taking place between two liquids separated by a membrane. One of the simplest examples is that in which a solution of a substance is separated from the pure solvent by a membrane permeable for the solvent but impermeable for the dissolved substance. In such a membrane called a "semi-permeable" membrane water may pass readily but certain substances, as, for example, cane sugar, are incapable of so doing. Semi-permeable membranes may be in the form of colloidal precipitates, such as the tannate of gelatin and ferrocyanide of copper the latter of which is nearly impermeable for cane sugar. Such a membrane may be formed by dropping a concentrated copper solution upon a dilute solution of potassium ferrocyanide. This results in the drop of copper sulphate being surrounded by a membrane of copper ferrocyanide, which is impervious to copper sulphate and potassium ferrocyanide although water is allowed to pass. In order to give this membrane rigidity it may be formed upon a rigid porous wall as in a small porous earthenware vessel. The membrane deposited upon the porous vessel is impervious to cane sugar. If a cane-sugar solution fill the vessel and the latter be placed in pure water no sugar leaves the cell but water passes in. If the cell is closed with a cap adjusted to a manometer the force with which the enclosed solution attracts water, or the *osmotic pressure*, may be determined as soon as equilibrium has been established. The osmotic pressure of a dilute solution rises slowly with the temperature, but at constant temperature is proportional to the concentration. All substances in true solution are capable of exerting osmotic pressure. In the body the membranes that are concerned in osmotic processes are only approximately semi-permeable, hence the dissolved substance as well as water may pass the membrane. This results in the passage of two streams, that of water in one direction and that of the dissolved substance in the other. This continues until there is an equal quantity of the dissolved substance on either side of the membrane.

FRANK P. UNDERHILL.

Ospedaletti, Italy, a town of 1,000 inhabitants, with nearly a mile of frontage toward the sea, is situated midway between Bordighera and San Remo, eighty-seven and a half miles from Genoa. It is a quiet Riviera resort, lying under the spurs of the Ligurian Alps, well sheltered from the winds and with a southern exposure. "There is no doubt," says Dr. Wendt, in an article upon this resort in the first edition of this HANDBOOK, "that little Ospedaletti is more effectually protected from winds than almost any other resort on this coast. Moreover, it gets the sun early and keeps it late. There is less blinding calcareous dust there than, for example, at Hyères, Cannes, or Nice. . . . . Ospedaletti spreads out for something like a mile along the head of a small crescentic bay. The eastern headland of this bay is formed by Cape Nero, and the western extremity, much farther from the village than the former, by Cape Sant Ampeglio. Thickly planted olive hills surround the place, relieved in the plain by orange and lemon trees, and the usual array of graceful palms. Successive girdles of mountains protect it from the icy north blasts, but less in a northeasterly than in a northwesterly direction. It is fully exposed only to the warm westerly marine breezes. . . . . Immediately behind this village there rises a hill of gentle slope, and a number of mountain torrents of mild proportions trace their undulating course seaward. . . . . The place is so hedged in as to constitute a veritable sun trap. . . . . For undergoing a course of absolute quiet and repose," in a sunny, well-protected situation, no more suitable place has yet come to my notice on the Riviera."

The hygienic conditions of Ospedaletti appear to be good; the town is spoken of by Linn as having a particularly clean and neat appearance. The drinking-water comes from the same mountain source as that which supplies San Remo, and is "soft, sparkling, and pure." The mean temperature of five winters is given by Linn ("The Health Resorts of Europe," by Thomas Linn, M. D., 1901) as follows: January, 49.82° F.; February, 51.62° F.; March, 53.42° F. The mean relative humidity is 62 per cent., and the number of rainy days, 32.

There are several hotels and pensions of moderate price, well kept, and very comfortable. There is also a fine casino and English church service in winter. Medical service can be had there. A short distance from the village are some hot sulphur springs. "Gouty and rheumatic elderly people," says Wendt, "should do particularly well at Ospedaletti." Linn states that this place is rapidly coming into favor as a resort, and it seems to combine very many favorable conditions for a winter health station, viz., its fine natural situation, its pleasant surroundings, its excellent protection from cold winds, the large amount of sunshine, its near proximity to San Remo and Bordighera, and the quiet and repose obtainable there. Moreover, it is said to be two degrees warmer than its neighbors, Bordighera and San Remo.

EDWARD O. OTIS.

Ossein.—The organic matrix of bone consists of ossein which is generally considered as identical with the collagen of connective tissue. F. P. U.

Osteitis.—See *Bones, Inflammations of.*

Osteoma.—OSTEOBLASTOMA.—Although abnormal bony growths are common, true osteomata are rare. Strictly speaking the term "osteoma" should be applied only to autonomous growths. The tumor should grow expansively from its own center, without transition into adjacent bone. There should not be a periosteal covering common to the osteoma and adjacent bone. The growth should be purposeless, the goal of the growth being merely the formation of bone. Those bony growths for which there is adequate explanation should not be called "osteomata." There is no sharp dividing line between the benign slow-growing osteoma and the malignant osteosarcoma while, on the other hand, the term osteoma is applied to many bony growths which are not truly tumors, but which owe their existence to definite disease of bone, cartilage, or soft tissues.

In structure osteoma resembles normal bone, but is less regular. The tumor is made of cells and inter-

cellular material. The cells arise from fibroblasts or osteoblasts. The intercellular material may be more or less fibrillated; it may be homogeneous from osseomucin; the homogeneous material will be partly or completely impregnated with lime salts. The proportion between the number of cells and the amount of intercellular material varies in different osteomata, and the same is true of the proportions between the fibrillated, the homogeneous, and the limy materials.

The bony tissue may be arranged in parallel lamellæ, often forming extremely hard bony tumors; or spongy irregular bone may be formed, or combinations of the two, the lamellated bone usually external. Haversian systems, and cavities containing marrow cells or fat may be found. Regressive changes may occur. There is probably a continual slow absorption by osteoclasts and reformation of the bony tissue as in normal bone. Regressive changes (mucoid) in the marrow also are common. Where the osteoma presses upon adjacent tissues regressive changes in the tumor occur as well as in the compressed surrounding tissue. Occasionally an osteoma may become separated from its point of attachment to the body, thereby losing its blood supply. Under these conditions it necroses. This has been described in the osteomata developing in the cavities of the nose and head.

Osteomata are usually found in connection with bones. Either long bones or flat bones may be affected. In the long bones tumors are especially apt to arise from the diaphysis near the epiphyseal line. As a rule the bony tumor is formed from a connective-tissue periosteum, after the manner of the cranial bones; less often the osteoma is formed by replacing cartilage, while osseous growths in other tissues are less common, being found occasionally in the membranes of the brain and cord, in tendon, ligament, muscle, in the mammary, parotid, adrenal, thyroid, or prostate gland, in the tracheal mucosa, pleura, or lung, and rarely in the skin. Osteoma in the corpora cavernosa is rare. As was mentioned, not all of these bony growths are to be regarded as true tumors.

Bony tissue is also found in the mixed tumors of the parotid and testicle, in osteosarcomata, osteochondromata, etc. In addition to tumors primarily composed of bone with other tissues, tumors occur in which growth of bone seems to be secondary (ossifying fibroma, ossifying chondroma). "Osteomata" at the ends of the long bones, covered with cartilage, may be examples of this mode of development.

Virchow classified osteomata according to their structure as osteoma eburneum, osteoma spongiosum, and osteoma medullosum.

Osteoma eburneum, or eburnate osteoma, or ivory exostosis is a tumor consisting altogether or for the most part of dense osseous tissue. In this form the tumor is made up of nearly parallel or concentric, branching layers of compact bone, containing possibly a few small vessels, and covered by a connective-tissue periosteum. The number of bone corpuscles is usually not great.

Osteoma spongiosum, or spongy osteoma, consists of looser, cancellous bone. In the spaces between the trabeculæ there may be marrow.

Osteoma medullosum, or medullary osteoma, has an outer shell of compact bone covering cancellous bone and a central marrow cavity, the tumor having the structure of a long bone. At times the marrow cavity composes the greater part of the tumor. The marrow in the osteomata may be either normal red or white marrow, or mucoid.

Osteomata may be single or multiple. Cortical osteomata or exostoses are bony tumors on the surface of bone; a central osteoma or enostosis is a bony tumor in the interior of bone. A continuous osteoma is directly continuous with bone; a discontinuous osteoma is separate from bone. Dental osteomata spring from the cement substance of the teeth; subungual exostosis is employed to designate an osteoma occurring beneath the nail of the great toe.

Exostosis, enostosis, hyperostosis, osteophyte are terms applied both to osteomata and to other pathological bony growths.

The *eburnate osteomata* are more frequently found on the bones of the head than elsewhere; they are usually multiple, rarely attain a greater diameter than one or two centimeters; and occur as small, flat, rounded outgrowths from the bones. The eburnate osteomata of the orbit and frontal bone and the osteomata occurring near the epiphyses of the long bones may grow to the size of a man's fist or larger. These tumors have a very rough, irregular surface; they may be very firmly or loosely attached to the bone. The multiple osteomata of the dura and arachnoid are small and very rough and spiculated. The multiple osteomata of the skin are the smallest medullated osteomata. They occur as platelets the size of a grain of sand in the cutis or subcutaneous tissue. Skin osteomata are more common in old people.

The tumor formed from cartilage, *osteoma eartilagineum*, is covered by a more or less incomplete layer of cartilage. These tumors are found on the long bones, especially on the humerus, tibia, and femur. They may be progressive and form tumors as large as a man's head. In the early stages they are usually made up of compact bone; later they may be spongy. Osteomata developing in connection with bone are homoplastic, those arising in non-bony tissue are heteroplastic. In some instances discontinuous osteomata, close to bone, may arise from displaced osteoblasts, but in many osteoid growths in soft tissues the bony growth must be regarded as the result of true metaplasia, connective-tissue cells assuming the character of osteoblasts. Osteomata starting from periosteum are apt to grow at right angles to the shaft.

Etiology.—The following etiological factors appear important: (1) Misplacement of embryonal bone cells, especially important in congenital multiple osteomata. (2) Heredity, especially in cases of multiple osteomata. Reinecke collected from the literature thirty-six cases of multiple osteomata which occurred in families. In one instance the condition was transmitted through five generations; in two instances to the fourth generation; in fifteen instances to the third generation; and in twelve instances to the second generation. It has been observed that the inheritance is more common among the male members of a family. Wm. Koch (1907) claims that the majority of osteomata are atavistic, representing reversions to bones normal in lower animals. (3) Postnatal bone-cell displacement from recurring rachitis and other developmental diseases of bone and cartilage. (4) Trauma, either of bone, with bone-cell displacement, or of soft parts, followed by metaplasia and bone formation from connective-tissue cells. (5) Metaplasia may lead to the growth of tumor-like bony structures not only after trauma, but also after other retrogressive changes with calcification have occurred in soft parts. (6) Heredity, trauma, and the other factors mentioned cannot explain why any bony growth should assume the independent or autonomous character shown by all true tumors. There is apparently a relationship between bone growth and the functioning of the parathyroid gland. From the time of Charcot and Virchow it has been observed that cachexia (tuberculous, syphilitic, etc.) and abject poverty predispose to abnormal bony growths.

Diagnosis.—An osteoma is a painless, benign, slow-growing tumor, usually small, in most cases arising from bone, appearing, as a rule, during childhood or early youth, that is, during the developmental period of bone. The tumors are seldom seen in very

young children, and rarely arise after the third decade. The growth is slow and ceases after middle life. The exostoses at the epiphyses do not enlarge after the growth of the skeleton is complete. Osteomata occur more frequently in males than in females. The tumors are sometimes symmetrical. The position, the consistence, and the features that have been mentioned will usually give the basis for a diagnosis. It is often difficult to distinguish between "dental osteoma," which arises from the cement substance and is found at the root of the tooth, and "odontoma," which arises from the dentin and may be found also on the shaft or crown of the tooth. The *x*-ray will reveal some unsuspected osteomata.

The following may be differentiated from true neoplasms:

1. Irregular bony growths forming part of an inflammatory reaction, as in osteitis deformans, osteomyelitis, and other productive inflammations of bone or periosteum.

2. Bony growths, often secondary to cartilage in cases of developmental defects, such as multiple cartilaginous exostoses (Ehrenfried, May, 1915).

3. Limited, non-progressive bone formations developing on the site of degeneration, or of necrosis with calcification. Such metaplastic bone growths are common, being seen in sclerotic arteries, the heart valves, endocardium (rarely), arteries of the lung, in necrotic and calcified fibromata and other tumors; in old scar tissue; in degeneration of the eye; in partially organized hematoma, etc. (Poscharrisky, 1905).

4. The bony spicules forming in the falx cerebri and spinal pia are not progressive growths though of unknown causation.

5. The symmetrical, chiefly tropical, nasal tumors, Goundou, or dognose, are progressive but seem definitely to have an inflammatory origin.

6. The bone in myositis ossificans, and those of the infantryman's "osteoma" of the shoulder, and the cavalryman's adductor "osteoma" are not regarded as true neoplasia.

7. Many traumatic "osteomata," after injury to bone or joint, are not independently progressive, but represent growths from traumatically displaced periosteal cells or cartilage.

For reasons unknown a progressive osteoma may on occasion arise from reactive bony growths.

Prognosis.—All osteomata are benign. This, of course, does not apply to the mixed tumors containing bone. No osteoma is dangerous except as a result of its pressure upon neighboring parts. The frontal or orbital osteomata may press upon the brain or eye; an osteoma of the pelvis may obstruct labor; an osteoma may press upon vessels or nerves, or the skin over the tumor may be injured and a chronic ulcer result. Unless treatment is indicated to relieve pressure, the tumor should not be attacked.

Treatment.—This is altogether operative. Owing to the firm attachment and dense structure of some osteomata, it is often difficult to remove them without injury to the adjacent soft parts.

Harry T. Marshall.

Osteomalacia.—*Synonyms.*—Mollities ossium; fragilitas ossium.

Definition.—A chronic disease that is characterized clinically by pain and muscular weakness and pathologically by decalcification and absorption of bones already formed, with bending or fracture and sequential deformity.

History.—Since the time of Glisson (1650), the decalcification of bone in osteomalacia has suggested a relation to rickets, but the exact connection between the two is uncertain. They differ in the ages at which they develop, in finer bone changes, and in the tendency of osteomalacia to continue for years with exacerbations and remissions.

Levacheur (1772) first pointed out the relationship between osteomalacia and pregnancy, the puerperal state and lactation; this relationship can be seen not only in the human species, but also among lower animals (cattle, sheep).

Fehling first propounded the ovarian theory of the disease.

Etiology.—While many theories have been advanced, yet the fundamental cause of osteomalacia is unknown; it belongs in that nebulous group of "metabolic" bone disturbances about which much has been written and yet but little is known. Whether or not it is due to an attenuated infection is problematic.

Distribution.—Osteomalacia is chiefly prevalent in parts of the Rhine country, South Germany, Austria, Switzerland, and Italy.

Sex.—Statistics show that osteomalacia occurs in males in but four per cent. of the cases.

Age.—Osteomalacia is most often found attacking those in the third decade of life, between the ages of twenty and thirty.

Pathology.—Hanan referred to the malady as "physiologic osteomalacia." Fehling attributed the disease to morbid activity of the ovaries. Hoennicke (1905) advanced a thyroid theory. Erdheim (1907) pointed out the relation between calcium metabolism and the parathyroid glandules and its possible bearing upon osteomalacia. In this connection the occurrence of tetany in osteomalacia adds interest.

Bones.—In osteomalacia the bones are characteristically soft, and at necropsy can be squeezed and twisted into fantastic shapes. At times the bones feel like wet paper and cut without resistance; they look and feel greasy. On section the amount of both compact and spongy bone is reduced; there are often cystic cavities (relationship with osteitis fibrosa cystica?). The specific gravity is lowered from 1.877 to 0.721.

The *joints* are not affected.

The *muscles* are atrophied and degenerated in keeping with their altered relationships consequent upon the bone deformities.

The *thyroid gland* is often enlarged and the seat of goitrous metamorphoses.

Deformities.—1. *Pelvis.*—The sacrum is pushed forward and downward with the posterior portions of the iliac bones; the acetabula are pushed upward and inward by the femoral capita; the symphysis pubis is squeezed forward like a beak (coracoid deformity). The most extreme deformity gives the pelvic cavity the shape of a clover leaf or Y. There may be a "rubber-pelvis," in which the bones are so pliant and supple that no obstruction to delivery occurs, and it was for this reason that Fehling advised the postponement of cesarean section when the pelvis is narrowed.

2. *Vertebræ.*—The normal curves are exaggerated, especially the cervical curve, so that the chin rests upon the sternum. The deformity of the vertebral column is naturally increased by pregnancy, so that the waist appears as though it were telescoped.

3. *Thorax.*—The thoracic cage is compressed in various directions, causing eventually displacements of the heart and of the lungs, resulting in dyspnea, asthmatic attacks, and palpitation. The ribs are often broken from muscular action, in breathing, or from pressure. The sternum is curved or bent.

4. *Extremities.*—The long bones are affected late in the course of the malady. Spontaneous fractures occur, with the production of callus that is usually imperfect. The weight of the trunk upon the softened bones of the lower extremity leads to coxa vara

(relationship with coxa vara juvenilis?), genu valgum, or pes planus.

5. *Cranium.*—The cranium is but rarely involved.

Symptoms.—In the beginning it is usually impossible to recognize osteomalacia, and in most cases the disease is far advanced before any suspicion of its nature arises. At times the increase of symptoms during pregnancy or the puerperal period permits of easy recognition.

Pain is the earliest symptom, and may occur in the pelvis (pregnant women), in the thorax, back, or one or more extremities. Pain is usually provoked by pressure upon certain bones, notably the pelvis and vertebræ. With the pain there is usually a feeling of weakness, often subjective and objective stiffness, with contracture or spasm of certain muscles, such as the iliopsoas or the adductors of the thigh. From various causes the gait becomes waddling and uncertain, and at times spastic.

Bones.—Upon examining the skeleton some distinct deformity may usually be found, such as lordosis, deformity of the thorax, a furrow over the lumbar vertebræ, and an alteration in the position of the hips and in the shape of the symphysis pubis.

The *muscles* may be the seat of tremor, spasm, or contracture.

The *nerves* may be the seat of paresthesia, especially the nerves of the lower extremity, due to pressure upon the emerging spinal nerves from deformity of spine and of pelvis.

The *digestion*, *blood*, and *urine* show no characteristic changes.

Metabolism.—The bones become poorer in calcium and other earthy constituents, especially phosphorus, but richer in organic matter, especially fat. The calcium leaves the body through the kidney and intestines. Renal calculi may be passed in large numbers.

Course.—In rare cases osteomalacia runs a rapid course—one year or less, but in most cases it lasts over a period of five, ten, or more years, with remissions for many months or years. While recovery is rarely spontaneous, yet it may occur at any time under treatment. Pregnancy and even menstruation usually make the symptoms worse, but following the former, improvement and even recovery have been seen.

Diagnosis.—In its early stages osteomalacia must be differentiated from "rheumatic" and other pains; later on, from lateral sclerosis, transverse myelitis, polyneuritis, tabes dorsalis, multiple myeloma, carcinoma, sarcoma, tuberculosis, osteitis deformans, senile osteoporosis, and sometimes from arthritis deformans. Multiple myeloma can probably not be positively differentiated in many cases. The diagnosis must also be made from coxa vara, genu valgum, and rupture of the pelvic articular ligaments. Osteomalacia may be strikingly simulated by hysteria. Skiagraphic examination and therapeutic tests may aid in the diagnosis.

Treatment.—The best single remedy is phosphorus, when given for several months. Of eighty cases collected by Laufer in 1900, forty recovered and thirty-six were improved. The drug stimulates new bone formation, and metabolic studies show that during its administration a distinct retention of calcium in the body takes place. Phosphorus may be administered in the form of the official pill, gr. $\frac{1}{100}$, or in larger doses in cod-liver oil. Phosphorus treatment is slower and less certain, but safer than castration.

Castration.—From sixty to seventy per cent. of patients have recovered from osteomalacia after the removal of the ovaries and many of the remainder were benefited. The improvement after operation may be remarkably prompt, the pain often disappearing within a few days. The improvement, however, may be neither uniform nor permanent and should be followed by phosphorus administration.

Indications for Castration.—1. When other methods of treatment have failed and the softening of the bones is so far advanced as to endanger life, or when the condition is such that death may occur before medicinal treatment can show marked effect.

2. In patients with pelves so narrow that pregnancy would necessitate cesarean section.

In order to diminish the osseous deformities, the skeleton should not be subjected to unnecessary mechanical strains, and in severe cases rest in bed is necessary.

The Adrenalin Treatment of Bossi (1907).— Bossi recommended the subcutaneous injections of 0.5 centimeter of 1:1,000 adrenalin solution daily or every other day. This method has been attended with success in a fair proportion of the cases, and is perhaps worth a trial when phosphorus has failed and operation seems to be contraindicated. As with phosphorus, the adrenalin treatment must be prolonged over many months before much improvement is seen.

Morris Booth Miller.

Bibliography.

1. Bossi: Ginecol. mod., Genova, 1914, vii., 121.
2. Musser-Kelly: "System of Practical Therapeutics."
3. Dock: Osler's "Modern Medicine," 1909, vi., 559.
4. von Recklinghausen: "Untersuchungen über Rachitis und Osteomalacie," Jena, 1910 (literature to 1910).
5. Schnell: "Treatment of Osteomalacia from 1898–1912" Ztschr. f. Geburtsh. u. Gynäk., Stuttg., 1913, lxxv., 139.
6. Todd: "Obstetrics in Zoological Garden." Proc. gen. meet. Zool. Soc. Lond., 1913, 855.

Osteopsathyrosis.—This term is used in a general sense to designate the condition of excessive brittleness of the bones, and is practically synonymous with *fragilitas ossium*. Such abnormal fragility may occur as the result of senile or cachectic atrophy, scurvy, atrophy of disuse, prolonged activity, pressure atrophy, neuropathic atrophy in such diseases as paralytic dementia, locomotor ataxia, anterior poliomyelitis and syringomyelia, and in syphilis, leprosy, osteomalacia, and rachitis. It occurs also in phosphorus poisoning. To these idiopathic cases the term osteopsathyrosis should be limited in its application. The condition is also known as "*Lobstein's disease.*" Such cases are rare. It is an affection of the period of development and usually ceases at thirty years of age, although some cases are reported as persisting to extreme old age. The fractures may follow the most trivial causes. They are painless, as a rule, and knit quickly. Marked deformity usually results, due to union in bad position or to distortion of the abnormally soft bones.

The known lesions in the bones seem insufficient to explain the brittleness. The cortex is thin, shafts slender, and epiphyses relatively enlarged. Veins differ as to nature and pathogenesis. Some writers believe that the periosteum does not produce a normally thick cortex; others hold that there is an overactive absorption of the cortex; others consider it secondary to changes in the venous system; Lipschutz regards the cancellous tissue as underdeveloped; while Zesos explains it as due to insufficient internal secretion. Thyroid transplantation is said to have been carried out with success in one case. Phosphorus had also been suggested. Senile osteopsathyrosis is the result of the old-age osteoporosis. The skeleton as a whole, or only certain portions, may be involved. The bones usually become fragile and are easily broken; but in other cases the bones lose their lime salts to such an extent that they may be easily bent or may be cut with a knife. Fragilitas ossium is very common among the insane, owing to poor nutrition and frequent trauma. A similar

condition may occur in the cachexia of various chronic diseases. In syphilitic infection of long standing and associated with marked cachexia, there often occurs a marked osteopsathyrosis of the long bones and also the bones of the cranium. In the great majority of syphilitics there is an increased fragility of the skeleton. In leprosy there is found in a certain class of cases a very characteristic osteopsathyrosis (leprous osteomalacia) affecting chiefly the bones of the hands and toes. The phalanges, one after another, may be affected until all the fingers and toes are destroyed, or they may be irregularly involved. ALDRED SCOTT WARTHIN.

Osteosclerosis.—The term osteosclerosis (from ὀστέον, bone, and σκλήρωσις, hardening) designates a condition in which the bone becomes abnormally dense and hard through the formation, in the various marrow and blood-vessel spaces, of new bone, which is often of an excessively high lime-salt content. Osteosclerosis is not a disease entity. It usually follows, or is associated with, chronic inflammatory processes which have been long continued but which are of relatively slight intensity. Its etiology is therefore highly varied, including traumatic, infectious, and toxic injuries to the bone and bone marrow as well as a peculiar association with hyperplasia of the bone marrow in leukemic and pseudo-leukemic states.

The following terms are used synonymously with osteosclerosis: Osteitis ossificans, endosteitis ossificans, condensing osteitis, eburnation, osteoplastic osteitis, productive osteitis.

Osteosclerosis may be either local or general and may affect either compact or cancellous bone. In any case, as seen in the gross, the essential feature is a great increase in the density of the bone which may have the appearance of ivory (eburnation). Apart from an actual increase in size of the bone (hyperostosis), which is often associated with osteosclerosis, there is an increase in weight due to the higher specific gravity of the abnormally compact bone. At the same time the bone is found to be much harder than normal, so that surgical operations involving the cutting or chiseling of such areas become very difficult. In cancellous bone the trabeculæ become thicker and much more dense, and the intervening marrow spaces are correspondingly diminished so that even cancellous bone takes on the gross appearance of bone of a rather compact character. In osteosclerosis of an advanced degree the bone becomes highly impervious to *x*-rays.

Microscopically, bone showing the condition of osteosclerosis is found to have new formed tissue, at first osteoid in character but later a densely calcified true bone, in both the marrow and vessel spaces. Thus the various internal spaces come to be filled up with dense bone. The Haversian canals, normally averaging about 0.05 millimeter in diameter, may be so constricted as to have an average diameter of but 0.01 millimeter or, in fact, may be completely obliterated, shutting off the blood supply to the part and causing necrosis of the affected area, although it is probable that this extreme degree is not often reached. In cancellous bone, the new formed osteoid or bony tissue is deposited upon the surfaces of the trabeculæ, which are widened at the expense of the marrow spaces. When the process is well advanced such cancellous bone may have the hardness and density of compact bone, but upon microscopical examination its method of growth by addition to the original trabeculæ becomes evident.

V. Volkmann (1872) differentiated a restitutive, a reactive or indurative, and an idiopathic osteosclerosis.

Restitutive osteosclerosis usually follows a rarefying osteitis, develops in the neighborhood of bone destruction from tumor growth, or obliterates the marrow cavity following fracture, amputation or osteotomy.

Reactive osteosclerosis is brought about by a large variety of chronic inflammatory processes. It is often combined with periosteitis ossificans, in which case there is simultaneous thickening and condensation of the bone.

Idiopathic osteosclerosis he considered much more rare. In this group he placed the osteitis ossificans of syphilis.

As is indicated by the classification of v. Volkmann, a consideration of the *etiology* of osteosclerosis includes a large group of pathological conditions, some of them local and capable of producing only a local sclerosis of the bone, while others are general and determine a generalized osteosclerosis. In the latter case the long bones usually show more advanced changes than the remainder of the skeleton.

Local osteosclerosis may be due to chronic inflammations of the adjacent soft parts, as in *ulcus cruris*. In that case, as also in *diffuse periosteitis*, there is usually a periosteitis ossificans as well as an osteosclerosis so that the bone is increased in size at the same time that it is increased in density. All forms of *osteitis* and *osteomyelitis* of long standing and relatively slight intensity may give rise to osteosclerosis. It is also to be met with occurring synchronously with osteoporosis in the neighborhood of *chronic tuberculosis* of the bone, *bone abscesses*, or areas of *necrosis*. In such cases osteosclerosis may serve a useful purpose in that the additional strength of the sclerosed portion may compensate for the destruction of bone in a neighboring area. A somewhat similar change takes place in the repair of *fractures*, although here the process does not necessarily produce a bone of abnormal density. After the preliminary rarefactive change in the ends of a broken bone which occurs in the early stage of healing of a fracture, there follows a sort of physiologic sclerosis which has as its result the production of bone of normal strength. In *chronic arthritis*, especially the so-called *rheumatoid arthritis*, osteosclerosis takes place in the cancellous ends of the long bones after the destruction of the articular cartilages. The spongy bone becomes dense and hard and takes a high ivory-like polish as a result of the friction in the joint. *Foreign bodies* embedded in the bone, such as bullets, may furnish chronic irritation enough to call out an osteosclerosis so that they come to be surrounded by a zone of bone of great hardness. Similar changes may take place about sequestra, acting as foreign bodies.

In *phosphorus* poisoning osteosclerosis of the jaw bone, associated with a chronic ossifying periosteitis, is one of the most common findings. The bone becomes thickened, of stony hardness and the alveolar canal may be almost obliterated. The process may be arrested with the bone in the sclerosed condition, or purulent periosteitis and necrosis may follow. An apparent tendency to bone fractures on the part of match workers has been ascribed to loss of elasticity as a result of sclerosis. In chronic *mercury* and *arsenic* poisoning, also, osteosclerosis is said to occur; and it has been experimentally induced by the administration of *strontium*. (Lehnert: Jahrb. f. Kinderheilk., lxxii., 345.)

In *syphilis*, both congenital and acquired, osteosclerosis is not uncommon. Particularly in the bones of the cranium, osteosclerosis and hyperostosis are found associated with gummatous periosteitis and osteitis so that it is rather the rule than otherwise to find very dense and hard areas side by side with areas showing the most marked bone destruction.

There remains still another group of cases showing osteosclerosis, which, while not including a large number of reported cases, is very interesting from the standpoint of etiology. Here are found the cases of generalized osteosclerosis associated with disease of the blood and blood-forming organs, particularly

leukemia. Other cases have been reported as due to *pernicious anemia* and *myelogenous pseudoleukemia*. In these cases the osteosclerosis is general throughout the skeleton but the long bones show the most marked changes. In the case reported by Schwarz (*Zeits. f. Heilk.*, Bd. xxii., 1901, p. 294) the sternum, femur, humerus, ribs, vertebræ, and cranium all showed osteosclerosis. The right femur was almost completely sclerosed in its lower half, the cortical layer reaching a thickness of one centimeter and the medullary canal being correspondingly reduced. In the upper half the trabeculæ of the spongy bone were so wide that the marrow spaces were almost obliterated. Similar changes were found in the humerus, but in the ribs and short bones the condition was less marked. The cause of the osteosclerosis in these cases and its relation to the hyperplastic and metaplastic changes in the bone marrow are not fully determined. Heuck considered the bone changes to be an accidental finding. It seems more probable, however, that there is some close association between the two, as is maintained by Baumgarten, who concludes that the osteosclerosis in these cases can have no other cause than the disease of the bone marrow.

CARL VERNON WELLER.

Otiobius.—*Ornithodoros.*—The nymph of *O. megnini* is the spinose ear tick which usually infests horses or cattle but sometimes enters the ear of man and causes great pain. It may be killed with some bland oil. Two other species which attack man occur in the United States. A. S. P.

Otis, George A.—Born in Boston, Massachusetts, on Nov. 12, 1830. After graduating from Princeton College, he began the study of medicine at the University of Pennsylvania, and received the degree of Doctor of Medicine from that institution in 1850. He subsequently frequented the hospitals and medical schools of London and Paris, and established himself as a practicing physician at Springfield, Mass., in 1854. In September, 1861, he entered the U. S. Army as Surgeon of the Twenty-seventh Massachusetts Volunteers, and rendered efficient service during the entire war. In September, 1866, he was made Surgeon and Brevet Lieutenant-Colonel in the regular service. He died in Washington, D. C., on Feb. 23, 1881.

Of Surgeon Otis's numerous contributions to medical literature, most of them in the shape of reports which he had prepared under orders from the Army Medical Department, the following deserve to receive special mention: "On the Nature and Extent of the Materials Available for a History of the War;" "A Plan for Transporting Wounded Soldiers by Railway;" "The Transport of Sick and Wounded by Pack Animals;" "Report of Surgical Cases Treated in the Army of the United States from 1867 to 1871;" and two volumes, constituting vol. ii. of Part I, and vol. ii. of Part II, of "The Medical and Surgical History of the War of the Rebellion." A. H. B.

Otitis Media.—Inflammatory disease of the middle ear or otitis media is either simple catarrhal, purulent, or adhesive. Any one of these forms may be either acute or chronic. Before entering upon a description of these conditions we must consider for a moment a condition which is in most cases primary or prodromal, namely, inflammation of the Eustachian tube or, as it is commonly known, tubal catarrh.

TUBAL CATARRH.—The Eustachian tube is lined by mucous glands and lymphoid tissue very similar to "adenoids." Consequently infection of the tube with resultant inflammatory swelling and exudate is common. There is always an associated nasopharyngeal inflammation which may clear up spontaneously. Usually where one condition persists, the other continues likewise. The patient complains of a "sense of fulness," there is a crackling sound on swallowing or a sensation of a bubble in the tube, and sometimes mild subjective noises. Hearing is very little if at all diminished. Examination shows merely a slight redness in Shrapnell's membrane and along the handle of the malleus.

Chronic tubal catarrh is not a common condition, *per se*, since it is usually associated with a chronic middle-ear catarrh. There may be marked retraction of the otherwise unchanged drum membrane. The short process and the posterior fold are strongly in evidence. Shrapnell's membrane is markedly retracted and is sometimes atrophied. Examination with the Siegle otoscope aids in the determination of these facts. Prognosis in chronic tubal catarrh is dependent upon the associated nasal and nasopharyngeal disease. If there are no adenoids, no deviation of the septum, or pathological enlargement of the tonsils, or acute inflammation of the accessory sinuses, prognosis of the tubal catarrh is favorable. Such causal conditions, when existing, must, of course, be corrected. Marked retraction of the drum usually leads to subjective noises which trouble the patient more than diminished hearing. In such cases temporary improvement can be brought about by pneumomassage of the drum. If chronic tubal catarrh with adenoid enlargement is present in children, the hearing power is markedly diminished, the child does not get on in school, and is frequently thought to be stupid.

The treatment of tubal catarrh will be described below in detail.

MYRINGITIS.—There are three forms of inflammatory diseases of the drum, myringitis acuta, myringitis subacuta, and myringitis chronica. Acute inflammation of the drum is very frequently found in children. It occurs as a primary inflammation without special cause, but in the majority of cases it precedes an acute middle-ear inflammation. Anatomically there are hyperemia and swelling of the drum membrane and formation of blebs or saccules containing exudate. Pathogenic microorganisms are seldom found in the exudate, the contents of these blebs are usually sterile. Acute myringitis is usually unilateral but may be bilateral. There occurs also an acute traumatic inflammation of the drum associated with injury to the external auditory canal or attendant upon the removal of foreign bodies.

Symptoms.—The patient complains of a sudden stinging pain in the ear, which soon recurs and finally becomes very severe. Hearing is only slightly diminished and the temperature remains normal. Otoscopic examination shows in all cases acute hyperemia, sometimes also swelling of the drum. The degree of these symptoms varies. There are cases in which the drum remains unchanged, except for a radial injection of the blood-vessels, while in others a diffuse redness appears. The handle of the malleus is either less prominent or completely invisible because of the swelling. In many cases the visible blebs are smooth and thin walled and vary in size from a hazelnut to a small pea. The contents of the blebs consist frequently of a clear, in other cases of a bloody, serum. In rare cases pus is found. When it is present the appearance of the drum membrane is yellowish. The otoscopic picture may change from a clear serum to a yellow color if there is an associated secretory middle-ear catarrh. The inner wall of the drum blister is seen in cases of acute myringitis through the epidermic layer of the drum, the tympanic wall through the substantia propia of the mucous membrane layer. In no case is there connection between the space occupied by the bleb or contents of the bleb with the tympanic

cavity. Bleb formation in acute myringitis is more frequently seen in the upper posterior quadrant than in other areas of the drum membrane.

Diagnosis of acute inflammation of the drum is made upon the otoscopic findings. One must consider acute serous middle-ear inflammation, but here there is a more severe degree of impaired hearing and greater pain as well as increased temperature. There is little difficulty in diagnosis, since simple middle-ear inflammation always begins with significant pains, and at least in the first few days with rather marked disturbances of hearing and with increased temperature. The course of acute inflammation of the drum is in most cases favorable. The symptoms disappear in a few days entirely and in about a week there is quite a complete return to normal hearing distance and normal drum picture. In other cases, on the contrary, the drum inflammation is merely the precursor of an acute simple, or at times of an acute suppurative, middle-ear inflammation. The transition of inflammation of the drum into middle-ear inflammation manifests itself apparently through the sudden decrease of hearing distance and the increase of subjective symptoms and temperature. It is worthy of mention that in those cases in which middle-ear inflammation arises from inflammatory changes in the upper respiratory tract, especially the nasopharynx, an habitual inclination to recurrence may remain, so that with every acute cold, drum inflammation and bleb formation may recur. Sometimes the tympanic membrane atrophies as a result.

Subacute and chronic myringitis are quite frequent in childhood. In cases of adenoid or where the postnasal passage is obstructed through pathological changes, acute myringitis may go over into the subacute or chronic type. In these cases, after retrogression of the acute condition, certain symptoms such as slight deafness and injection of the blood-vessels remain for some time. A grayish-red, mottled, retracted drum may be looked upon in childhood as pathognomonic of adenoids. In many of these cases the subacute or chronic myringitis does not remain constant, transitory improvement occurring, during which time the drum membrane takes on a normal or nearly normal appearance. Adenoidectomy in such cases may cause the drum to return to normal. If the adenoid remains, every subsequent acute inflammation may bring about a periodic recurrence, during which hyperemia is increased and myringitis suddenly reappears associated with a serous or suppurative middle-ear inflammation. In chronic myringitis ulceration may occur. The ulcerations are on the mesial and also on the lateral surfaces of the drum. Myringitis ulcerosa develops in the course of chronic middle-ear suppuration, or as an isolated condition in weak, anemic, or tubercular individuals, without other known cause. The course of myringitis ulcerosa is in many cases unfavorable, leading to a chronic middle-ear suppuration. If treated early, however, a favorable outcome may be expected. The treatment consists of cauterization of the ulcerated blebs with chromic acid, with sesquichloride of iron or trichloracetic acid. The general condition of the patient is of great importance and one should give instructions as to diet, exercise, fresh air, bathing, etc. Sometimes one may observe a chronic myringitis which has resisted all efforts at local treatment improve when the patient increases in weight.

Acute Catarrhal Otitis Media.—Catarrhal diseases of the mucous membrane of the middle ear occur with swelling and exudation of clear serous or yellowish fluid. In chronic cases mucous exudate is of varying consistency. Microscopical examination of the exudate shows in some cases mononuclear leucocytes and mast cells as well as various degenerated forms of bacteria. Clinically the exudate plays a rather insignificant rôle and in chronic cases is of little importance. Politzer describes these types of middle-ear catarrh having considerable formation of exudate under the general term "Exudative middle-ear catarrh." These chronic middle-ear catarrhs usually hark back to acute or chronic changes in the mucous membrane of the nose or nasopharynx. In children the chief etiologic factor is adenoid. This is always associated with frequent catching cold. Those cases showing hyperemia and catarrhal changes in the mucous-membrane tract are commonly associated with catarrhal middle-ear inflammation. Disturbances in the ventilation of the tympanic cavity are always associated with catarrhal diseases of the middle ear. If the pharyngeal orifice of the tube becomes swollen or closed or narrowed, there is immediately a disturbance of the physiological functioning of the tube, leading to catarrhal middle-ear disease. There are disturbances of the motility of the tube muscles, which also occur in tumors of the nasopharynx or upper jaw and in cases of syphilis, tuberculosis of the nose, and rhinoscleroma. In a small number of cases catarrh of the middle ear follows traumatic perforation of the drum membrane. The inhalation of injurious gases or hot steam may bring about catarrhal middle-ear changes. These occur, however, rather as a direct consequence of the irritation to the nasal and nasopharyngeal mucous membrane with extension to the mucous membrane of the Eustachian tube and middle ear. It must not be forgotten that operations upon the nasal tract may result in infection and swelling of the tube with resultant acute middle-ear disease.

There is frequently a sensation of fluid in the middle ear, especially upon moving the head. The patient hears his own voice in the ear. Increase of temperature is seldom found unless the condition becomes suppurative. Examination shows merely a slight retraction of the drum. There is a heightened luster of the drum membrane and the light reflex is more intensive than normal. If air is still present in the tympanic cavity, there is a well-defined horizontal line which may be seen through the drum membrane if one looks sharply, representing the drum level of the fluid. Change of position of the head alters the position of this "level line." The increased luster of the drum is due to "saturation" of the drum membrane ("wet drum"). The hammer handle for the same reason appears thin and small. The functional tests show, in uncomplicated cases, merely the signs of acute middle-ear disease.

Treatment.—In the first stage of the condition one abstains from local treatment. The patient remains in a warm room in bed and is given hot lemonade. An effort is made to induce perspiration by the use of aspirin and hot baths. If the temperature is normal and if the nasal condition is satisfactory, one can resort to politzerization two or three times weekly, in expectation of great improvement in from one to two weeks. The patient holds a little water in the mouth and when he swallows, air is blown into the nose by means of the Politzer air-bag. If the exudate continues incision of the drum may be done. The exudate will then be discharged into the external canal and can be sponged out or washed out with a syringe under careful asepsis.

Following out the researches and experiments of Yankauer and others, it is now possible to treat both tubal catarrh and simple exudate in the middle ear directly through the nose and nasopharynx. The tubal region is swabbed with a five per cent. cocaine solution and a number two or three Eustachian catheter is passed into the tube. Accurate location of the tubal orifice is determined by a slight puff of air. A finely cotton-wound Eustachian bougie is then dipped in a mild cocaine-adrenalin solution (cocaine, one per cent., adrenalin, 1–10,000). This

bougie is passed through the catheter as far as the isthmus of the tube and allowed to remain for twenty minutes. It is then withdrawn and an attempt is made to draw off secretion from the tube and tympanic cavity by means of suction. When as much of the exudate as it is possible to remove has been withdrawn, a second cotton-wound bougie is saturated with a two per cent. argyrol or protargol solution and introduced into the tube. The above procedure is not always successful, but it is a rational and conservative method of treating acute middle-ear catarrh of whatever variety. Its trial in skilled hands is harmless.

Sheppard believes that many cases of secretory middle-ear disease are due to some vasomotor disturbance involving the mucosa of the nose, nasopharynx, Eustachian tube, and tympanic cavity in varying degrees. This he thinks is frequently a result of disturbed metabolism. Overeating and overdrinking, he says, are responsible for many of these disorders, and in treating the condition one should cut down the supply of red meats, soups, cream, and butter, and limit the supply of sugar and starches. He thinks one should drink as little as possible at meals and as much as possible between meals. Insufficient elimination of bowels, kidney, and skin is the most important factor in upsetting body metabolism. Local treatment without this supervision of diet is usually unsatisfactory.

Simple Serous Acute Middle-ear Inflammation (Otitis Media Acuta Simplex).—In both simple and suppurative middle-ear inflammations the existing cause is always a microorganism, with the difference that in simple middle-ear inflammation the microorganism is less virulent or completely attenuated. Most commonly one finds the staphylococcus pyrogenes aureus, the varying forms of the streptococcus and the influenza bacillus. Occasionally cases are observed in which the exudate shows a bacterial content upon microscopical examination, while the culture remains negative. Mechanical, thermic and chemical irritants produce active symptoms quite like microorganisms. Irritating vapors passing through the tube into the middle ear without destroying the membrane may, even in a very few minutes, produce a serous middle-ear inflammation. Sometimes inflammation of the tube takes place upon sneezing, severe blowing, vomiting or gagging, spraying out the nose or irrigating it with water. In traumatic rupture of the drum acute middle-ear inflammation may arise, if through the rupture a foreign body enters the middle ear and "insults" the mucous membrane lining. In such cases the developing exudate may be sterile, but infection is the rule.

Individuals with chronic inflammatory changes in the nasopharynx, especially children with adenoids, are exposed frequently to the danger of recurring middle-ear inflammations. Sometimes the *clinical* signs of a catarrh are more prominent, sometimes the *inflammatory*. Sometimes, moreover, there is not merely simple middle-ear inflammation but a perforating, suppurative condition. Simple acute middle-ear catarrh begins with more or less stabbing pain in the ear, deafness and fever. The pain may in the first stage of the inflammation be quite severe, but may lessen quite promptly. Severe pains and sleepless nights speak against simple, and in favor of, suppurative middle-ear inflammation. Deafness occasionally reaches a severe degree. In children a high temperature in the beginning of the inflammation is sometimes observed, which recedes in a very few days. The otoscopic examination shows varying degrees and forms of swelling and injection of the drum. In some cases we find the drum media thickened, the normal details, especially the hammer line, completely concealed by the swelling, the entire membrane diffuse and reddened. In other cases which are more or less atypical, the drum is only slightly swollen or damp, smooth and without luster. In these cases injection of the radial vessels and redness in isolated spots are distinctly to be seen. Pathognomic is the circular injection of the periphery of the drum. In cases of influenza and otitis associated with typhus, blebs frequently occur with loss of the superficial epidermal layer of the drum and of the bony canal. Sometimes there is a bluish-black color, and a sac filled with bloody or yellowish-colored serum. A small blood extravasation may occur. Inflammatory changes in the drum are either uniform over the drum membrane or are found chiefly in the upper part of the same, the posterior upper quadrant, or the membrana flaccida. In such cases we speak of an epitympanic type of acute middle-ear inflammation.

Functional tests show moderate impairment of hearing with no labyrinthine symptoms. The entire disease process usually lasts from eight to ten days. Sometimes it reaches the climax on the first or second day. From the third to the fourth day there are significant signs of recession of the inflammatory process. Hearing distance increases spontaneously, and pain occurs only occasionally especially toward evening. After the next few days the drum membrane takes on its normal color and pains entirely disappear. Trifling catarrhal changes may persist for some time. It may be three or four weeks before the hearing is completely normal. There is sometimes thick, hemorrhagic exudate or blood which darkens the drum. This is absorbed later as a rule, but there may occur a diffuse cloudiness of the drum or intermediate chalk deposits. The cloudiness and thickening of the drum are analogous to changes in the mucous membrane of the middle ear through which movement of the ossicles is diminished.

If the middle-ear condition is associated with chronic nasopharyngitis, this must be treated after the ear condition has subsided. Diagnosis is based on the symptomatic triad, pains in the ear, deafness, and fever.

It is difficult to differentiate simple from suppurative middle-ear inflammation. In both diseases the symptoms, especially in the beginning, are quite similar. Severe ear pains which disturb the sleep and make the patient otherwise restless, even if there is only a moderate increase in temperature and slight otoscopic findings, speak for suppurative and against simple middle-ear inflammation. If there is markedly diminished hearing, and if the ear of the patient was normal before the last illness, one usually finds suppurative middle-ear disease. A differential diagnosis is especially difficult in children because an exact determination of the hearing distance is not possible. Determination of the degree of pain is also impossible. High temperature, however, is an important sign in the diagnosis of acute suppurative middle-ear inflammation. But there are cases in which, in spite of the suppurative character of the middle-ear inflammation, there is no increase in temperature. In these, especially in sucklings, long persistence of inflammatory symptoms in the tympanum speak for suppuration. In the first year of life the child's drum is thicker than the adult's. With characteristic suppurative inflammatory symptoms and circumscribed yellow color of the drum, severe mastoid-like symptoms may develop, which latter are less marked than in adults. In older children there sometimes exists recurring middle-ear catarrh as a result of chronic nasopharyngeal changes. Thickening of the drum, may make diagnosis very difficult. We must, therefore, examine the ears daily.

Treatment.—In the beginning of simple acute middle-ear inflammations, it is well to introduce a strip of gauze or plugs of cotton saturated with quieting or astringent drugs, such for instance as carbolic acid or hyoscyamus:

℞. Acidi carbolici, 0.3–0.5; Glycerini, Aq. dest., āā. 5.0. (Alexander.)

℞. Aquæ carbolici (1–100), 10.0; Cocaini hydrochlor., 2.0; Atropini sulph., 0.5. (Lermoyez.)

℞. Olei hyoscyami, 0.8; Olei olivarum, 10.0. (Alexander.)

Favorable results are sometimes obtained from the use of warm adrenalin solution. The application of heat is often helpful. In other cases cold water does better. In many cases the bowels need to be kept open and the general health looked after. Aspirin and pyramidon may be indicated. Opiates are to be avoided. As long as the temperature is increased the patient remains in bed; when the temperature is again normal, which usually happens on the second or third day, it is well to aspirate the middle-ear exudate and inflate with Politzer's bag. When possible, hearing tests should be applied before and after inflation. If these conservative measures are not effectual, if the temperature goes higher and the pains increase, incision of the drum is indicated. There is little danger of changing the simple process into a suppurative process through incision of the drum if careful asepsis is carried out.

By the use of a special apparatus Wilkinson has found great aid from such drugs as compound tincture of benzoin, chloroform, menthol, and camphor.

In the subacute conditions tincture of iodine chloroform, menthol, and camphor are used. In obstinate chronic cases, five to twenty per cent. of iodine in chloroform and ether, and in certain cases spirit of turpentine are helpful. The bottle containing the solution is heated as hot as can be borne by the hand and the application is made. The more painful the application is, the more readily the disease yields.

Albrecht has published a novel way of obtaining anesthesia of the drum by driving solutions into it with the electric current.

He introduces a plug of cotton saturated with cocaine-adrenalin solution into the external auditory canal, and against this he places the positive pole of a specially devised instrument. The strength of the current varies from 1.5 to 2 milliamperes. In chronic inflammations of the drum certain difficulties are encountered, such as vertigo and pain. These are not met with in acute otitis. In chronic diseases the drum requires from three to four minutes' anesthesia by this method. Anesthesia is limited to the exact spot where the instrument has been placed. As a rule it is so complete, that incision of the drum can be carried out entirely without pain.

Chronic Catarrhal Otitis Media.—Although this condition has received much mention in the literature, especially the literature of American otology, it is probably rather infrequent. Many hospital records and reports show a preponderance of cases of chronic middle-ear catarrh. However, when the facts are sifted down many of these cases belong under the heading of chronic exudative catarrh already spoken of above, or of chronic adhesive process, or finally of otosclerosis. Most cases thus classified show a lusterless, apparently thickened drum, without other marked changes such as retraction, and complain of troublesome noises and deafness. The deafness while marked and progressive never becomes total, and these patients get on very well with a trumpet or other artificial aid to hearing. They have little difficulty at the telephone, which fact is not infrequently an index of what may be accomplished by a mechanical device such as an acousticon or auriphone. Inflation shows a patulous tube, in fact it is often *too open*, indicating an atrophic condition of the mucous membrane of both tube and middle ear. This is further confirmed by the improvement which in some cases follows the use of drugs which stimulate mucous membrane secretions, such as mild solutions of silver nitrate, argyrol, and protargol.

Randall of Philadelphia recommends dionin solutions for this purpose. After cleansing the nose and cocainizing the tubal region, a silver catheter is passed into the mouth of the tube and a few blasts of air are blown through to clear the way. Then three drops of a one to three per cent. solution of dionin are blown into the middle ear. The procedure is not repeated for from twenty-four to seventy-two hours.

Several authors recommend the use of pilocarpin for accomplishing the same purpose. This drug stimulates secretion from all mucous surfaces. Ordinarily one or two minims of a one or two per cent. solution of pilocarpin hydrochlorate are blown into the middle ear in the manner just described. One needs, however, to use this drug with care, and should remember that atropin is its best antagonist should any untoward symptoms appear.

Inflation in these cases accomplishes nothing, as a rule, save momentary relief. Noises are not helped in the least and improvement in hearing is ephemeral. Many patients complain more of noises than of deafness. In fact tinnitus is one of the most difficult symptoms to relieve. Recently several investigators have been applying radium in these cases. Professor Urbantschitsch of Vienna has reported a series of cases in the *Monatsschrift für Ohrenheilkunde*. His results were for the most part *nil* or indeterminate. W. S. Bryant of New York City had satisfactory results in eight cases. There was improvement in both reduction of noises and increased hearing. I have been using two milligrams of radium bromide applied directly to the drum for from three to ten minutes at intervals of one week. In a few cases the noises were temporarily lessened. Thus far there has been little or no change in hearing power. However, these studies are quite inconclusive as they have been carried on only a very short time.

Fibrolysin, a preparation of thiosinamin, has been used by several investigators. This is supposed to have a softening influence on scar tissue. Yearsley of London reported a series of twenty-six cases in 1911. Two were a chronic adhesive process, six were otosclerosis with mixed catarrhal symptoms. The remainder were late stages of chronic middle-ear catarrh. Three only showed improvement. In sixteen there was no improvement. One case was doubtful. Fibrolysin was injected into an arm in all these tests.

Acute Suppurative Otitis Media.—This is one of the commonest forms of ear disease. In children it is found with especial frequency, particularly in association with the acute infectious diseases. It is always the result of some bacterial infection, the path of ingress being sometimes questionable. Possibly the excitant enters by way of the lymph paths into the tympanic cavity without simultaneous infection of the Eustachian tube. In the majority of cases, however, infection follows acute disease of the nose and nasopharynx via the Eustachian tube. The external canal is a pathway only in traumatic cases. In all cases in which the infection of the tympanum occurs by way of the tube, there is a swelling first of the tubal mucous membrane which soon leads to closure of the tube. The swelling reaches a severe degree and extends to the middle-ear mucous membrane, to the drum and to the associated ear spaces, to the meso- and hypotympanum, the attic, the antrum and in many cases also to the pneumatic spaces of the mastoid processes. After a short time, perhaps a few hours, suppuration begins; frequently pus breaks through the drum and flows out of the canal. In the first stage after the perforation the secretion is bloody and later purulent. In about one week the secretion is mixed with mucus and is of a stringy character.

The swelling of the tympanic mucous membrane and drum then diminishes. After the secretion ceases, the perforation in normal cases heals spontaneously, and there is complete restitution to the normal.

The *symptoms* in the beginning are sudden, severe pain which quickly reaches a climax. The patient remains restless and sleepless. Impaired hearing, one to two meters conversation speech, is common. This, however, improves toward the end of the disease and finally becomes normal again. The temperature is seldom above 40° C. and usually recedes following incision or rupture of the drum. Sudden decrease of temperature or excessively high temperature in the first days of the disease, if unaccompanied by recession of other symptoms, is an unfavorable sign and may indicate an intracranial complication, poor resistance of the patient or especially virulent infection.

In early childhood the condition often begins with vomiting and chills. There are three stages: first, the *initial stage,* which begins with the first ear symptom and ends after a short time, sometimes a few hours or three to four days, with perforation of the drum and beginning discharge of pus from the external ear. Up to this point pain and fever are constant. Then comes the second stage or stage of *suppuration;* there is no pain, the temperature is normal or moderately increased and there is diffuse suppuration. After about eight days this decreases, becomes thready and continues thus for two or three weeks. In the later period there is preponderance of mucus. Thick and creamy pus when associated with much mucus leads to retention, adding the danger that the pus may extend into the mastoid and become putrescent. The final stage is indicated by *cessation of secretion* and gradual closure of the perforation, requiring from one to two weeks. The otoscopic picture shows a more or less pronounced swelling and redness of the drum throughout its extent or in certain areas. In middle-ear suppuration of the attic type the inflammatory process occupies the upper segment of the drum (Shrapnell's membrane) in the upper posterior quadrant. Intensive redness of the drum is not a reliable sign as to the severity of the process. The hammer handle line is completely invisible because of the swelling. In the course of influenza, even in slight cases, the drum may become deep red and the epidermis layer raise in blisters. In general, with increasing suppuration in the middle ear, the intensity of the redness and swelling in the drum diminishes. Previous to rupture the drum is red or yellowish and bulging. After rupture a free, more or less round or oval opening is to be seen. It may be impossible at first to see the perforation, but upon asking the patient to inflate, or by the use of the Siegle otoscope, the perforation can be recognized. Large openings usually mean extensive destruction, especially in scarlet fever.

The functional tests show in all uncomplicated cases marked disturbances of hearing, due to presence of fluid in the ear and the swollen condition of the drum. There may be slight, spontaneous nystagmus toward the diseased ear. This disappears after perforation and release of pressure. Pain is sometimes felt in the ear during the teething stage in children, in acute inflammation of the pharyngeal lymph glands, in tonsillitis, in swelling of the adenoid tissue and in cases where incompetent dentistry has been performed. Sometimes at the time of puberty severe pains in the ear with negative otoscopic findings presage otosclerosis. With the simultaneous presence of furunculosis in the external canal it is sometimes difficult at the first examination to decide whether middle-ear suppuration is also present, especially if the furuncles are multiple and the discharge is marked. Here three differential points are of value: Otitis externa in older children and in adults occurs without fever; in small children with a moderate temperature increase. If in a doubtful case there is a history that the ear disease started in with high fever, this fact speaks for a middle-ear suppuration. Secondly, in a case of otitis externa if we clean out the canal and introduce a small, thin ear speculum, we may be able to see the drum and to find out whether the hearing is normal or diminished. If there is an associated middle-ear suppuration, the hearing distance is not increased after introduction of the speculum. Thirdly, in children four years of age or more, the condition of the bony canal is an important point. Otitis externa is always limited to the membranous portion of the canal, therefore when we introduce a small, thin speculum into the narrow canal and find the bony portion of the canal of normal caliber and the drum uninjured we know that no middle-ear disease is present. If there is middle-ear inflammation and a narrowing of the bony portion of the canal due to associated disease of the antrum and mastoid, we find sinking of the posterior upper wall and swelling of the external canal in this bony portion more pronounced than in the membranous portion.

Treatment.—When the diagnosis is thoroughly established one must not wait for spontaneous perforation but must do an incision of the drum. Bacon's incision knife has proved very useful in my hands. It possesses a long, thin, sharp blade with a rather thick back so that the incision or puncture is somewhat triangular and provides a sufficient opening for drainage. Incision should be made from below upward in a curve just behind the long process of the malleus.

Alexander gives the following instructions for preparation for paracentesis. The pinna is thoroughly cleansed with a bit of gauze saturated with benzine and the head covered with a sterile towel, leaving only the pinna exposed. The canal is cleansed with six per cent. hydrogen peroxide solution. For anesthetizing the drum, novocain-adrenalin solution is used, 1 c.c. of a twenty per cent. solution of novocain or alypin solution heated to 40° C. with five drops of warm adrenalin solution. The fluid is left ten to fifteen minutes in the external canal. In Freiburg a mixture of Schleich-adrenalin solution is injected into the tympanic cavity. In America gas anesthesia is commonly used or ethyl chloride inhalation. The pain is of short duration, however, and if incision of the drum is done quickly, anesthesia is frequently unnecessary, speed being the chief consideration. The head should be carefully supported by an assistant in order that no injury be done the patient when he attempts to pull away. Immediately after incision there should be a serosanginous discharge or a sanguino-purulent exudate. If pure pus exudes paracentesis has been done rather late. The canal should be wiped out with bits of sterile cotton or gauze and a moist dressing applied to the ear, the patient being returned to bed.

In favorable cases profuse discharge occurs during the next few hours, the temperature drops quickly to normal or at the most in from three to five days and the pain disappears. A moist strip of gauze for drainage is introduced into the external canal and after twenty-four hours the protecting bandage is found saturated with pus. Renewal of the gauze strips thereafter should be done every hour or every two hours, or where the secretion is trifling two or three times daily. Care must be taken not to hinder the outflow of pus by tamponing the canal. Irrigation of the canal is not necessary in the ordinary case, only where the secretion is thick and tenacious. Here we may use sterile salt solution at a temperature of about 100° F. Decrease of the secretion occurs after the first week. The color usually becomes more yellow, changing finally to a whitish or watery character. When the secretion is greatly diminished and the perforation is about to heal

over, one should inflate the middle ear in order to prevent formation of adhesions. The hearing distance is thus quickly increased and should eventually return to normal in an uncomplicated case. The first sign of healing is a white margin about the perforation, which indicates young, healthy epidermis. Chalk deposits may occur in the drum. It is sometimes wise to keep the external canal protected with a bit of sterile cotton for some weeks after healing. In each and every case the nose and nasopharynx must be treated in order to prevent recurrence if possible.

R. H. Woods of Dublin says that the process in acute otitis media is in the beginning monoseptic and that the physician should bend every energy toward preventing polysepsis. Wood syringes the canal with slightly alkaline sterile water, repeated whenever the discharge reappears. After syringing, the ear is thoroughly dried. The meatus is then filled with some antiseptic such as boric acid and alcohol. Sodium salicylate he thinks is the best drug to use internally.

J. R. Page reports gratifying results from the use of hydrogen peroxide in his service at the Babies' Hospital, New York. In eighty-seven cases of acute purulent otitis media complicating other diseases, only three were operated upon for mastoiditis. Red and bulging drums were incised and treated with instillations of hydrogen peroxide and boric acid irrigations from the beginning.

Acute Middle-ear Infection in Infants.—The causes of the frequent middle-ear suppuration seen in infants are set down by Gompertz as follows: (1) The Eustachian tube opens in the nasopharynx. (2) Changes in the circulatory relations following birth mechanism, such as hyperemia and puckering of the tympanic mucous membrane. (3) The embryonal character of the middle-ear mucous membrane. (4) Incomplete development. (5) Hereditary constitutional disease, *e.g.* scrofula, tuberculosis, syphilis, rachitis, and alcoholic parentage. (6) Traumatic injury to the middle ear before and during birth, the influx of liquor amnii and fragments of membrane into the middle ear. (7) Infectious diseases, above all, croup. More rarely, influenza, measles, whooping-cough, varicocele, diphtheria, scarlet fever. In other cases during coughing, sneezing, crying, and vomiting, the infection is introduced into the middle ear. (8) Hematogenous infections. (9) Diseases of the stomach and intestines and brain affections which through vomiting produce infection of the tympanic cavity.

According to the investigations of Preysing and S. Weiss, the healthy tympanic cavity is germ free. In the majority of cases otitis in infants is caused by the pneumococcus.

It is of importance to recognize that not only catarrhal middle-ear diseases but also the suppurative types in infants and children in the first year of life may exist without symptoms in spite of marked pathological changes. It is also possible that fever, which is in most cases a constant and early symptom, may not be ascribed to the ear, but to infection of the respiratory or alimentary tract; therefore, in all cases of fever in infants and young children both ears should be carefully examined.

Quite frequently a child will grasp the affected ear or will cry out when it is touched. It may also avoid lying on the diseased ear and sudden increase of pain may cause a sudden outcry during feeding. The drum of the infant is thicker and more resistant than that of the adult, therefore it may be one or two weeks before the middle-ear suppuration has gained sufficient headway to cause rupture of the drum. Owing to the short, wide Eustachian tube, drainage may take place into the nasopharynx. This is probably infrequent.

Breast-fed children are more rarely affected with middle-ear disease than are bottle-fed children. The danger of otitis in breast-fed children is greater if the suckling is allowed to close both nostrils when taking the breast, for, when swallowing occurs, particles of milk may be aspirated into the tympanic cavity.

The onset is acute, with a sudden, rapid rise in temperature to 103° or 104°. Fever is of a constant type. Transitory remissions to normal or subnormal usually indicate a complication. In the first days before perforation, chills and vomiting are seen. Cerebral symptoms may also be present, such as stupor, partial ptosis, dilated nostrils, unrest, cramp-like movements of the extremities, crying out, disturbed sleep or sleeplessness. Ortner has classified these symptoms under the name "Meningismus." They disappear immediately after perforation or incision. If they appear in a case after suppuration has occurred, meningitis is imminent, and the prognosis doubtful. Unfavorable symptoms are late perforation, long duration of the stage of secretion and abundant granulations. All these indicate retention of pus with a probable mastoid abscess.

The resorptive power of the tympanic mucous membrane in children is greater than in adults. In examining a child the technique is of importance. First, the light must be excellent; second, the ear speculum must be of a proper size and should be warmed before introduction. Blood extravasation in the tympanic membrane is sometimes observed. The line of the hammer handle is completely absent. Sometimes the drum shows several projections (blebs). If perforation has occurred the margin of the perforation may be markedly swollen, so that there is no free opening save when rendered such by pressure of the pus or by aspiration.

After a few days, granulations develop on the margin of the perforation, but as soon as the secretion ceases, the perforation closes. Granulations disappear with the quantitative diminution of the pus.

In strong, well-nourished infants, otitis media of all types offers a good prognosis. There is a complete return to normal in all respects. In weak, anemic, badly nourished or rachitic children there is danger that the acute middle-ear inflammation may become chronic with resultant diminution of hearing and pathological changes. This is especially to be feared if diagnosis is belated or if the case is neglected. Not infrequently such cases show an eczema and narrowing of the canal with pus retention, ulceration, granulation and polyp formation. There are then carious changes of the ossicles and bony walls of the middle ear. Intracranial complications are rare but do occur.

Treatment.—Early diagnosis is most important, followed by prompt incision, thorough drainage and irrigation when necessary. A soft rubber bulb syringe, thoroughly sterilized, should be used. Normal salt solution or a mild alkaline wash is usually sufficient. The greatest care should be taken to protect the canal from ulceration and constriction. If eczema is present, alkaline medication should be used. Repeated paracentesis may be necessary. Tonsils and adenoids should be removed as soon as possible, consistent with the condition of the ears.

Chronic Suppurative Otitis Media.—This is in many respects the most important of all middle-ear diseases. Considering all the factors in an acute middle-ear suppuration, it is surprising that so many cases completely recover. The acute condition is commonly caused by a virulent germ in a patient whose general health is "run down." The pockets and folds of mucous membrane in the Eustachian tube and middle ear are well supplied with blood-vessels. Heat and moisture and absence of sunlight are constant, all of which furnish an ideal culture field for the multiplication and growth of disease germs. When, therefore, the bactericidal

elements of the blood (leucocytes) are no longer able to cope successfully with the enemy, the stage is set for a continuous performance in which all the local structures in the ear suffer permanent damage or indeed complete destruction. In so far as we know every chronic ear discharge is caused by one or more types of pathogenic microorganisms. The infection is of the "mixed" variety and is often resistant to treatment, because we are dealing with an unseen enemy entrenched in a citadel studded with crypts and hidden chambers and not to be routed out save by the most direct active and radical means. To be sure the human body builds up barriers and fortifications against the intruders. The opsonic index is increased, at least for a time, but all the while the disease germ is also building and planning against extermination. The wonder is, therefore, that any case of chronic middle-ear suppuration ever gets well.

Anatomically, conditions for "drainage" are of the worst possible kind. The attic region, the hypotympanum, the antrum area, and the angle at the tympanic orifice of the Eustachian tube all favor retention with consequent stagnation and putrefaction of discharge. It is easy to imagine the result of such a process when long continued. The mucous membrane lining of the tympanic cavity becomes thickened and edematous. There is chronic passive congestion and round-cell infiltration. Finally this thickened protective lining becomes denuded at some point laying bare the periosteum which in turn becomes involved also. It is only a step from this process to caries of bone and subsequent "complications," as the otologist terms those disorders which occur adjacent to the tympanic cavity.

Some authors call any middle-ear discharge chronic which lasts more than six weeks. This is, perhaps, a trifle too short a time to decide what the outcome of an acute condition is likely to be, but in general, ten weeks is a satisfactory limit. The signs are chiefly a large perforation and foul discharge irrespective of how long this has been going on. The perforation may be single or multiple, central or marginal, round or oval, or irregular. Multiple perforations speak for a tuberculous process especially if situated in the posterior or inferior quadrants of the drum near its margin. Marginal perforations usually indicate bone involvement. Central perforations and those at the level of the Eustachian tube are not as a rule associated with caries, and hence this type of suppuration is more amenable to treatment. If a perforation is in the antrum region there is often necrosis of the area about the horizontal semicircular canal, sometimes with fistula formation and "circumscribed labyrinthitis." This is quite likely if cheesy masses (cholesteatoma) are also present. A small perforation in Shrapnell's membrane (membrana flaccida) just above the short process of the malleus indicates suppuration in the epitympanum, a type especially difficult to treat successfully. There is often an associated necrosis of the heads of the malleus and incus with involvement also of the roof of the tympanic cavity. Attic suppuration is therefore a type very favorable to the formation of temporal lobe abscess.

In some chronic cases destruction of the drum is complete, but ordinarily Shrapnell's membrane is quite intact. When the perforation takes in the whole membrana tensa, it is kidney shaped, the handle of the malleus hanging free in the open tympanic cavity. The margin represented by the tympanic ring is always to be made out..

Necrosis of the ossicles and casting off of the same in the discharge occurs in old cases. The incus is the first to go, followed by the crura of the stapes, finally by the long handle of the malleus. The head of the malleus is seldom lost entirely, and therefore the short process is usually to be found and serves as a guide in judging the duration and extent of the process.

In every chronic middle-ear disease the mucous membrane lining the tympanic cavity has undergone definite pathological changes. These changes are evidenced by the formation of granulations, polypi, and discharge of fetid secretion. Granulations are the result of nature's superlative efforts to heal. Polypi are simply granulations undergoing fibrous change. Brühl has made a thorough study of both and finds that they are capable of changing into other tumor forms such as fibromata and myxofibromata. For the most part they are formed of round cells mixed with polynuclear leucocytes, small and large mononuclear leucocytes, formative cells of connective tissue (fibroblasts), giant cells, plasma cells, and mast cells. In only about five per cent. of all cases does an aural polypus assume a myxomatous character. Both granulations and polypi are easily recognized if care is taken to cleanse the ear thoroughly from obstructing secretions. They bleed easily and therefore an admixture of blood in aural discharges is a significant sign of their presence. In every case their presence means neglect, bone disease, or malignant disease.

Polypi should be removed with a fine ear snare or grasping forceps under gas anesthesia. No force should be exerted as there is danger of setting up a labyrinthitis, especially if the polyp is attached to the inner walls of the tympanic cavity. Some bleeding will inevitably ensue, but it can readily be controlled by peroxide, or adrenalin or narrow sterile strips of gauze.

Granulations should be cauterized with chromic acid or trichloracetic acid crystals fused on a probe, or with the silver bead. The former penetrates very deeply, the second less so and the third least of all; therefore some care should be taken in selecting the caustic agent to fit the individual case. It is especially important that only a very small area be touched at each sitting. The treatment after polypi and granulations are cleared away will be described later on.

A word must be said at this point about cholesteatoma formation. One of the ways in which nature attempts to heal a suppurating aural cavity is by an attempt to epidermatize it. We have seen that granulations and polypi are really conservative measures, the same is true of cholesteatoma. Unfortunately these attempts are rarely successful, in fact are frequently harmful. Many authorities regard cholesteatoma, for instance, as sufficient reason for performing a radical mastoid immediately because this condition so often leads to facial paralysis, labyrinthitis, sinus thrombosis, or brain abscess.

In the epidermatizing process, skin grows into the tympanic cavity from the external auditory canal. This occurs most frequently at the antrum region because here the tympanic ring is defective and a line of least resistance is mapped out across which the skin can propagate. Concentric rings of epithelium grow out and invade the Haversian canals in the bone. Bacteria infect and destroy this new skin layer which rolls up and forms a plug of detritus in the antrum extending in both directions into the mastoid spaces and into the tympanic cavity. Bone destruction now goes on apace and the conservative process becomes a menace to all the important structures in its vicinity.

Diagnosis of cholesteatoma is usually easy. Any masses of dead epithelium which come away in the discharge or washings should be examined under the microscope. The presence of cholesterin crystals can frequently be demonstrated. The associated discharge is always particularly foul. There is a marked tendency for cholesteatoma to recur even after a radical mastoid operation, unless every vestige of the invaded bone has been removed which is hardly possible in some cases.

Study of the discharge from all running ears should be carried out as a matter of routine. We need to know how long the discharge has been present, whether it has been continuous or interrupted, great or small in amount, thick or thin in quality. The odor must always be noted. Smears should always be made and, if possible, a culture also. It is not enough to know that there is a "mixed infection" as that is nearly always the case. We must determine the prevailing microorganism, and when other treatment fails we should be ready to proceed with an autogenous vaccine made from it.

Wyatt Wingrave has reported a study of the aural discharge in 100 cases and his results may be tabulated as follows:

Types of Bacteria Causing Middle-ear Suppuration

Staphylococci	41
Diplococci	20
Streptococci	7
Proteus vulgaris	14
Micrococcus tetragenus	4
Bacillus coli	3
Gonococci	33
Bacillus subtilis	2
Aspergillus niger	1
Leptothrix	1
Bacillus diphtheriæ (Klebs-Loeffler)	1
Yeast	1

In addition to these the spirillum of Vincent and the *Bacillus tubereulosis* should be mentioned. At the New York Eye and Ear Infirmary especial attention has been paid to the streptococcus mucosus capsulatus which is capable of causing extremely severe destruction without marked symptoms. The influenza bacillus in certain years also works havoc. It is significant that a chronic disease of the middle ear may persist for years without any especial discomfort to the patient save discharge and slight impairment of hearing, but let any other new organism appear on the scene, and the whole process is lighted up. Conditions are then ripe for a grave complication. These so-called "latent" cases, where the discharge has been intermittent and the ear has seemed apparently dry for months at a time are especially prone to sudden grave issues. An ocean bath, an attack of grippe or pneumonia may furnish the incendiary cause for a fatal result.

As to impairment of hearing during the undisturbed course of chronic middle-ear discharge, it is surprising how good this sometimes remains even with rather marked destruction of the tympanic contents. Defects are chiefly in the sound-conducting apparatus, the auditory nerve being spared for years together. Much depends upon the condition of the foot plate of the stapes and the inner wall of the tympanic cavity and round window in general.

The effects upon the general health while often noticeable are seldom severe during a series of years. There is some anemia, dulness of comprehension, paleness or sallowness of the skin, headaches, lassitude, etc. Occasionally there are more marked evidences of chronic sepsis but this is not the rule. From an insurance viewpoint chronic otitis media is looked upon with marked disfavor, many applicants being repeatedly rejected because of the danger to life even when active evidence of the disease is not to be found.

Treatment.—There is a growing tendency to the conservative treatment of chronic aural discharge unless the symptoms become suddenly active. The radical mastoid operation which it was thought at one time would solve the problem for most cases has not given uniform satisfaction for the following reasons: It may stir up an infection which can result in a complication and death. There is a long period of healing, and sometimes, in spite of every effort, a little discharge still persists. Hearing is sometimes diminished after operation, sometimes improved; one never knows which is likely to follow. Permanent facial paralysis may occur.

The conservative treatment offers comparative comfort and lessened danger. Most patients prefer occasional visits to the doctor and daily home treatment to the uncertainties of a hospital operation. However, unless the conservative treatment is carried out conscientiously, thoroughly, and constantly it is only a makeshift and operation had better be undertaken.

Two guiding principles are paramount, the securing of efficient drainage and surgical cleanliness. Efficient drainage means both *via* the external canal and the Eustachian tube; *i.e.* reinfection must not be allowed to take place from either of these avenues. Exostosis in the canal must be removed. A small perforation in the drum must be enlarged to secure satisfactory medication. Granulations and polypi must be cleared out. From the tubal approach the nose and nasopharynx must be kept free from growths and discharge. Nasal breathing must be made permanent. Mouth hygiene should be insisted upon and all bad teeth must be treated by a dentist. To prevent reinfection the tube may have to be closed. This can be done sometimes by cauterization of the tympanic tubal orifice and the encouragement of scar-tissue formation. Yankauer has worked out a procedure of curetting the tube to induce closure. In 1910 he published his technique and described the special instruments for closure of the Eustachian tube through the external meatus and tympanic cavity. It was found that the time required for the ear to become dry was from a few weeks to eighteen months, the average being sixteen months. Sixty per cent. of all the cases remained dry for more than four years.

He maintains that the closure of the Eustachian tube is necessary in order to secure healing after a radical operation, and notes that spontaneous healing does occur even in cases where there is destruction of bone. This spontaneous or natural healing takes place if reinfection of the ear is prevented through the Eustachian tube.

Methods for insuring surgical cleanliness are: Fluid antiseptics for irrigation or instillation. Insufflation of finely divided powder. Packing with dry strips of sterile gauze.

The antiseptics most commonly employed are carbolic acid (phenol) 1 in 40, bichloride of mercury 1 in 1,000 or 1 in 3,000, boric acid from 5 to 20 grains to the ounce, solutions of iodine, zinc sulphocarbolate, resorcin 2 to 3 per cent., lysol ½ to 1 per cent., peroxide of hydrogen 50 per cent., and borolyptol (containing 0.2 per cent. formalin) 5 to 10 per cent.

Instillations are made once or twice a day after thorough cleansing of the ear. A medicine dropper is convenient for this purpose. A good formula is:

Zinci sulphatis	gr. vi.
Acidi carbolici	gr. i.
Glycerini	ʒ ss.
Aquam ad	fl. ʒ ii.

M. ft. guttæ.
Sig. Warm and instill ten drops twice daily.

Resorcin, carbolic acid, salicylic acid, and hydrogen peroxide may be used. The latter must never be warmed—all other solutions should be heated gently before instilling.

Powders used for insufflation are boric acid, boric acid with iodoform, iodoform alone, aristol, europhen, orthoform, etc. Care should be taken in using all of these to insufflate only a very small quantity just a thin layer, not enough to cake in the ear or set up a dermatitis and external otitis. Whatever powder is used the ear should be thoroughly irrigated at least once in twenty-four hours to avoid the possibility of "caking" and damming back of discharge.

Within the past three years much interest has been manifested in the vaccine treatment of chronic otitis media. At the Ninth International Otological Congress held in Boston, August, 1912, Dr. Evelyn W. Nagle reported a series of successful cases from the use of autogenous vaccines. Great care was taken in getting the pus from the ear free of contamination. The canal is wiped clean with sterile cotton swabs dipped in alcohol or benzine. A sterile platinum loop is then passed into the purulent area, and cultures made on agar agar or blood agar in the usual way. Sometimes it is necessary to inflate the ear first in order to drive a sufficient quantity of pus through a perforation into a position where it can be seen. Injections were given at intervals of three or four days, usually into an arm, alternating left and right, or into a thigh, alternating thighs. After the first or in some cases the second dose of vaccine there were malaise, slight headache, and occasionally nausea. A depression of twelve hours' duration, occurred followed by a sense of exhilaration lasting about two and one-half days, followed in turn by a slight depression. The injection was given as the sense of exhilaration wore off. Patients gained weight and their physical endurance was increased; no complications or ill effects were noted. In addition the ear was catheterized or politzerized to blow any free pus out of the Eustachian tube. The meatus was then irrigated with peroxide solution, and the canal was dried out. This was all the local treatment used. For twelve hours preceding injection the ear was not treated locally. This in order to secure a satisfactory transplant of pus.

Of seventy reported cases sixty remained dry, five discontinued treatment, two recurred and three were still under treatment. In several of these cases capable specialists had already advised radical operation.

In 1914 Christie reported his results during three years' experience with vaccines in chronic aural discharge. Those cases were chosen which had resisted local treatment for three weeks or more. The local treatment was also continued, however. Twenty ont of twenty-five cases are said to have been successful. All of these were of a severe type. Christie thinks that the large number of patients who suffer from chronic aural discharge proves that many acute cases do not terminate favorably.

C. L. McDonald has published thirty cases of subacute and chronic otitis media treated with vaccines. In cases where the staphylococcus, streptococcus, or pneumococcus were the causative organisms either alone or combined, the patients were markedly improved or entirely cured. The combination of staphylococcus and bacillus pyocyaneus improved more slowly than those showing the simple staphylococcus. McDonald concludes that in subacute otitis no other means of treatment produces such uniformly good results as vaccines, and believes that their early use would greatly diminish the large number of chronic cases.

Since attic suppuration is the most persistently chronic of all types of aural suppuration it is somewhat surprising to note the satisfactory result from autogenous vaccine in the case reported by Cocks of New York. This patient had an attic discharge of many years standing. There was a small perforation just above the short process through which the patient could blow a drop of pus. Eight months of conservative treatment with catheterization and bichloride drops brought no improvement. A culture was then obtained from pus coming through the perforation and upon examination the pneumococcus was found in pure culture. An autogenous vaccine was made and administered twice a week for eight weeks, beginning with 400,000,000 bacteria and ending with 800,000,000 at each injection. At the end of eight weeks the ear became perfectly dry and the perforation remained closed.

One should remember, however, in all these cases that involvement of bone was probably not present. The mucous membrane and perhaps superficial layer of periosteum being concerned alone. Nevertheless, by curing the discharge conditions are made favorable for bone healing also, and caries can then be dealt with more effectually by known surgical principles. There is no doubt that in autogenous vaccines the otologist has a remedy of proved efficiency.

Chronic Adhesive Process.—Under the name of chronic adhesive process (chronic adhesive middle-ear inflammation) one classifies those forms of disease which arise from a catarrhal or suppurative middle-ear condition, the most important feature in which is retraction of the drum. In the majority of cases this process results from a chronic exudative catarrh. There is thickening and contraction of the mucous membrane folds in the tympanic cavity. The tube becomes narrowed by connective tissue which causes a diminished motility. The swallowing act produces little influence upon the tube or its lumen and narrowing or stricture results. Such stenosis occurs especially at the isthmus of the tube. Finally at the pharyngeal tubal orifices one finds connective-tissue folds and strands through which the mouth of the tube is narrowed or entirely occluded. The motility of the ossicular chain becomes diminished or entirely absent. The niche of the labyrinth window is filled with connective tissue and may become entirely occluded. In unfavorable cases, chronic adhesive process leads to complete connective-tissue organization, "atresia" of the middle-ear spaces, in other cases to circumscribed connective-tissue growth in the middle ear, which produces irreparable functional disturbances. Sometimes the drum membrane participates in these changes, in other cases not.

Examination with the help of the Siegle otoscope shows a diminution or suspension of the mobility of the drum, but there are cases in which the mobility of the drum remains good, and in atrophic conditions may be increased. Inflation often produces a negative result. Air may be unable to pass through the constricted tube because closure of the tube is so nearly complete. Catheterization shows in some cases a tube of normal width, but in most cases there is significant stenosis or stricture, which can be determined by means of tubal bougies.

If in a case of middle-ear catarrh there is no improvement in hearing after inflation, it is suspicious of a chronic adhesive process. With advancing age there is danger of gradual spontaneous transition of a simple middle-ear catarrh into an adhesive process. If the pharyngeal ostium of the tube is narrowed or constricted by connective tissue, then catheterization becomes difficult and sometimes impossible. Functional tests prove the labyrinth normal, but there is a typical disturbance of sound conduction. Contrary to simple middle-ear catarrh the hearing power cannot be secondarily or perhaps at all improved by physical means—air douche, catheterization, aspiration or pneumomassage.

In every pathological connective-tissue formation in the middle ear, danger always exists that this process will extend into the labyrinth. If it occurs, the basal turn of the cochlea becomes affected and the pathological ligamentous formation extends into the perilymphatic spaces, followed by atrophy of the labyrinthine nerve endings. If, therefore, the functional tests show diminished perception of high tones and lowering of the upper tone limit, the prognosis is absolutely unfavorable. Cases of chronic adhesive process with intact labyrinth show a varying course. A few cases quickly improve upon suitable treatment. In other cases the condition

becomes progressively worse, no matter what therapy is used. This difference in result depends upon the kind and location of the adhesions in the tympanic cavity. If the connective tissue is excessively strong and firm, prognosis is more unfavorable than in those cases in which it is circumscribed and elastic. Local management consists first in treating the nasopharynx. Politzerization and catheterization improve the hearing in cases where the connective-tissue bands are not especially strong. However, there is always danger of inducing atrophy and relaxation of the upper posterior quadrant of the drum membrane. Politzer recommends the use of turpentine oil spray, the formula of which is oleum terebinthinæ 15.0, menthol 1.0. Urbantschitsch recommends camphorated ether ten per cent. In many cases there is significant improvement in the hearing power and also in subjective noises after such treatment.

Various fluids may be introduced through the Eustachian tube when the patient is lying down. At the first treatment only a few drops should be used. The fluid may be driven into the middle ear by inflating the tube following the instillation. One or two drops of a one to two per cent. aqueous solution of pilocarpin hydrochloride is recommended by certain authors. Potassium iodide, oleate of zinc, and adrenalin have also been used. Recently fibrolysin injections have been employed but they may be followed by acute inflammatory changes in the middle ear. Ruttin of Vienna uses a very fine curved hook in those cases which are not amenable to ordinary middle-ear treatment. This hook is introduced just beneath the short process of the malleus and by a quick movement the drum membrane is pulled outward. The hook is now disengaged and the little operation is at an end. In some cases the hearing is improved markedly and immediately, but within a few weeks or months the procedure must be repeated.

If there is stenosis or stricture of the tube, the latter should be treated by bougies and applications of drugs. One begins with the finest bougie and increases gradually to that of largest caliber. This should be done twice a week and continued for from four to six weeks.

The nasopharyngoscope is of value in watching the progress of these cases and in introducing the catheter and bougies into the Eustachian orifice. The tube can be opened in many cases by blowing a drop of cocaine-adrenalin solution through the catheter. If a bougie tipped with cotton and saturated with cocaine-adrenalin is passed through the catheter to open the tube it should be left in place from ten to fifteen minutes. This can then be withdrawn and a solution of argyrol or protargol five to ten per cent. or silver nitrate two to five per cent. can be applied and withdrawn after a few seconds.

Politzer recommends vibratory massage in the external ear canal by means of Breitung's or Delstanche's massage apparatus. This treatment should not be repeated oftener than three times a week, or the early favorable result may become unfavorable. Subjective symptoms may in many cases be relieved by massage of the nasal and pharyngeal mucous membrane. A very good massage apparatus is made by Wappler of New York.

Tenotomy of the tendon of the tensor tympani is sometimes recommended but is of doubtful value.

Yearsley and Frey have published an extensive article on the treatment of chronic adhesive process. These authors say that accurate diagnosis especially the relative acuity of whispered speech and spoken speech is especially important in prognosticating the outcome of treatment. Inflation and bougies are of value but one must guard against overstretching the drum membrane. The Eustachian tube and Rosenmüller's fossa are to be studied and treated as necessary.

Hot air and fibrolysin have not been of value in their hands. Massage of the drum has been of some help when used with discretion. Yearsley recommends the intratympanic injection of a solution of red iodide of mercury with seven drams of lanolin made up with four ounces of parolein. This has given good results in conjunction with otomassage after inflation had failed. Electricity is useless and certain operative procedures also, such as mobilization of the malleus, incision of the posterior fold, tenotomy of the tensor tympani, and tenotomy of the stapedius, exploratory tympanotomy, the division of adhesions, removal of portions of the drum membranes, and removal of the ossicles.

Ossiculectomy is best only in occasional cases. Frey says there are two chief complaints in these cases: deafness and subjective noises. There is no specific treatment for the noises. Anything that improves the middle ear will improve the noises, and anything which does not improve the middle ear, cannot be expected to help the noises.

The bougie for the dilatation of the Eustachian tube helps, and vibratory massage of the tube with the bougie also. External application of hot air is of some value. Internally, the iodides are of the most value and should be continued at least six weeks in medium doses.

Tuberculosis of the Middle Ear.—Tuberculosis of the middle ear is probably much more frequent than statistics show, for the diagnosis is often not made because the disease is so insidious. When seen by the otologist the condition is usually no longer simple tuberculosis, but a mixed infection.

It is probable that the tubercle bacillus enters by way of the respiratory tract, digestive tract, or by way of the lymph and blood streams. In any case it is secondary to tuberculosis elsewhere in the body. There is usually associated also abnormal conditions of the upper respiratory tract. Enlargement of the tonsils and adenoids are common. Likewise anterior nasal obstructions. Certain anatomic conditions especially in childhood, favor Eustachian-tube infection. The channels of infection are through the Eustachian tube direct from blowing the nose, or infection along the Eustachian tube by way of the blood channels or lymphatics, or by the extension of an intracranial infection from the internal auditory canal, or, finally, by way of the external auditory canal. The latter mode of infection is quite frequent. Bacilli may gain entrance through a perforated drum or through an abrasion without other discoverable cause.

There are two forms of middle-ear tuberculosis, the acute and the chronic. Rapid loss of tissue is characteristic of the acute form resulting as it does from laceration of the mucosa. Perforation of the drum finally supervenes usually at two or more points, so that multiple perforation of the drum is almost pathognomonic. After perforation there is mixed infection with rapid destruction both of soft parts and bone.

In the chronic form there are infiltration, caseation, and necrosis. The granulations are flabby, pale, and anemic. They may protrude from the perforated drum or fill up the external auditory canal. The periosteum and dura show marked resistance to extensive destruction, and the sheath of the facial nerve is also resistant. The chain of ossicles is early affected, and becomes necrotic. Blood-vessels may be affected with resulting hemorrhage, and mastoiditis is a frequent complication. Not infrequently there is enlargement of the mastoid and preauricular glands, and of the retropharyngeal and deep cervical group. The symptoms are those of a tubercular condition elsewhere in the body, plus the special ear symptoms. The temperature is usually low, increasing only when the infection becomes mixed, or when a complication such as mastoiditis, etc., ensues. Absence of pain is

the essential symptom which differentiates tuberculous otitis from other otites. The discharge usually contains the tubercle bacillus together with other bacilli when the infection is mixed. Fistulous openings in the bone of the tympanic cavity are found quite frequently. Facial paralysis may be sudden and complete.

G. N. Biggs states that facial paralysis in children with aural discharge and unaccompanied by any symptoms of labyrinthine or intracranial disease is pathognomonic of tuberculosis of the middle ear.

Diagnosis rests upon finding the tubercle bacillus, giant and epithelioid cells, and caseation in the tissues. Also by experimental inoculation, reproducing tuberculosis.

Prognosis is usually unfavorable, the patient dying of a complication or of general tuberculosis. The middle-ear process may recover either as a result of conservative treatment or radical operation. Many cases, however, cannot be cured even by operation because of the extensive involvement of bone.

The *treatment* is that prescribed for any case of tuberculosis. Tuberculin has been used with favorable results but only in the hands of those who are thoroughly familiar with the technique. The greatest difficulty lies in correlating the size of the dose and the tolerance of the patient. Granulation tissue should be cauterized with chromic or trichloracetic acid, or scraped away with the curette. The latter method is unsafe where there is much deep destruction, as alarming hemorrhage may occur. Iodoform or iodine in oil have given good results. Certain chronic cases are said to have been benefited by sunlight reflected from a concave mirror into the auditory canal for five or ten minutes each day. In the light of our present experience with radium it would seem wise to make a thorough test of this active agent wherever it can be thoroughly tried.

IRVING WILSON VOORHEES.

Ottawa, Canada.—Ottawa, the capital of the Dominion of Canada, is situated upon the river of that name, in the eastern part of the Province of Ontario, about 110 miles west of Montreal. It has a population of 87,062 (1911), and is the center of a large lumber traffic. The extensive government buildings are noteworthy for their architecture and material; and in the vicinity are various points of scenic interest —the Chaudière and Rideau Falls, and the Rideau Canal with its series of locks. A journey down the Ottawa River to Montreal (ten hours) is one of great interest, and affords many views of imposing scenery. The climate is a cold one, comparable with that of northern New York and New England; the winters are long and there is much ice.

The accompanying chart will indicate the various climatic features. EDWARD O. OTIS.

Ovaries, Anatomy of.—See *Genital Organs, Female.*

Ovaries, Diseases of.—The ovaries are two small ovoid or rounded bodies, one of which is attached to the posterior surface of the broad ligament just internal to and below the fimbriated extremity of each Fallopian tube. They are of a pinkish color and vary in size and shape, even in health, without being actually malformed.

The average measurements are: Length, 2.5–4 centimeters; breadth, 1.5–3 centimeters; and thickness, about 1–2 centimeters. Ovaries greatly exceeding the above in size are rarely met with, but Altoukhov reported before the members of the Moscow Obstetrical and Gynecological Society the case of a patient whose right ovary measured 35 × 13 × 7 millimeters, and the left one 80 × 14 × 6 millimeters, and at the same time mentioned a patient of Nega's in whom the left ovary was 54 and the right 108 millimeters in length. In the latter case the uterus was infantile and the patient a pronounced nymphomaniac; but whether or not the enlarged ovary caused the nymphomania it is very hard to say. Probably excessive irritation of the vulva caused the hypertrophy of the ovary.

The function of the ovaries of producing and discharging ova has long been known, but of late they have been credited with producing an internal secretion which alleviates or prevents the troubles of the menopause. On investigation, the corpus luteum has been proven to produce some substances which have a markedly beneficial effect upon pregnancy, the administration of extract of the corpus luteum enabling patients, who had habitually aborted previously, to carry ova to full term. It also may occasionally be found useful in cases of pruritus vulvæ of the menopause, amenorrhea (functional), ovarian dysmenorrhea, etc.; but too much reliance must not be placed upon it in the latter troubles.

ABSENCE OF OVARIES.—One or both ovaries may be congenitally absent. When both are wanting there is usually a lack of development of the mammæ and other sexual organs, and when only one is missing the corresponding side of the uterus is poorly developed. When a woman has absolute amenorrhea, without any molimina, and sterility, you may suspect that she has no ovaries; but as long as one ovary and tube are present maternity and menstruation will

CLIMATE OF OTTAWA. LATITUDE, 45° 26′ N.; LONGITUDE, 75° 41′ W.—PERIOD OF OBSERVATION, FOURTEEN YEARS (BROKEN PERIODS).

	January.	March.	June.	August.	October.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature, degrees Fahr.:										
Average or normal, degrees	10.6	20.5	64.9	65.7	45.0	38.3	66.4	43.9	12.7	40.3
Average range	18.3	16.5	19.8	18.9	18.5					
Mean of warmest	35.3	43.2	76.2	79.9	62.9					
Mean of coldest	17.0	26.7	56.4	61.0	44.4					
Highest or maximum	53.1	55.1	96.3	98.5	80.4					
Lowest or minimum	−33.0	−32.0	34.7	34.1	17.0					
Humidity:										
Average relative, per cent	88	83	72	77	82	74	75	82	88	80
Precipitation;										
Average in inches (rain or show)	2.81	3.02	2.08	1.81	2.73	7.13	5.79	7.84	8.64	29.40
Wind:	N.W. &			W.,						N.W. &
Prevailing direction	N.E.	N.W.	W., E.	N.W.	N.W., E.	N.W., E.	N., E.	W., N.E.	N.W.	N.E.
Average hourly velocity in miles	8.1	7.5	4.9	3.8	5.1	6.6	4.2	5.4	7.6	6.0
Weather:										
Average number of clear days	7.5	7.5	10.7	12.3	6.5	27.0	31.0	18.7	17.9	94.6
Average number fair days	10.2	9.2	13.7	13.3	9.7	32.7	41.0	33.2	27.7	134.6
Average number of clear and fair days	17.7	16.7	24.4	25.6	16.2	59.7	72.0	51.9	45.6	229.2

likely go on undisturbed. The only way to make sure about the presence or absence of both sets of appendages is to open the abdomen and explore the pelvic cavity.

Transplantation of Ovaries.—On account of the serious results, matrimonially and otherwise, of the absence of both ovaries, either congenitally or as a result of operation, the procedure of transplanting ovaries is of considerable interest. J. Lankashevitsch interchanged ovaries between rabbits, dogs, etc. The operations were carried out with the strictest aseptic precautions. Each ovary was removed along with its mesentery, the cut edge of which was attached to the broad ligament of the new host near the spot from which the corresponding ovary had been taken, but sufficiently far from the cornu of the uterus to avoid compression. In a few instances, however, the ovary was fastened to either the mesentery or the peritoneum of the abdominal wall; the sutures used were fine silk and were placed very close together.

The only dog used was killed nine months after operation, and the transplanted ovary was found firmly adherent in its new situation, and to be but slightly diminished in size. Capillaries and muscular tissue ran from the ovary to the subjacent tissue. Germinal epithelium was seen in places and a few normal follicles lay in the cortex side by side with others which had undergone atrophic change. Yellow areas of degenerated tissue were scattered here and there throughout the organ. In the case of animals which were killed two or three years after operation, the large ovaries remained, whereas the smaller ones had almost entirely disappeared; and in the latter case the genitals also had become atrophied if the animal's own ovaries had been removed. Conversely, it may be stated that the transplantation of large (*i.e.* from large animals) ovaries exerts an inhibitory action upon the atrophy of the genitalia, and also upon the deposit of fat in the pelvis which usually accompanies the menopause.

B. A. Katsch has also investigated this subject, and practically obtained similar results to the above.

The ages of the animals from which the ovaries are taken have an important bearing upon the result as regards rapidity of regeneration of the follicles, etc., this rapidity of regeneration being inversely proportional to their age. When the ovaries are first implanted their tissues tend to degenerate to some extent in the following order, viz., connective tissue, germinative tissue and its derivatives, and lastly, the medullary layers, the Graafian follicles undergoing a change similar to that which occurs at the menopause. Their death takes place centripetally, but they may become regenerated from the germinal epithelium. When this rejuveneseence of the ovaries, as one might call it, does not take place, the genitals atrophy.

In none of the animals operated upon did pregnancy follow, although ample opportunity for this to take place was given.

The conclusions to be drawn from the consideration of the above facts are: (*a*) Ovaries can be transplanted from one animal to another; (*b*) ovaries from the carnivora will take the place of those of herbivora and *vice versa;* and (*c*) the transplanted organs flourish and partially functionate. These reported results open up visions of the practicability of performing the same operations upon women, but the field of feasibility would necessarily be very limited by the difficulty of obtaining absolutely healthy ovaries to transplant, as well as for other reasons which it is unnecessary to mention.

R. T. Morris adds as further proof of the possibilities of this operation that the occurrence of pregnancy after oophorectomy is due in many cases to the transplantation of portions of the ovary. As early as 1895 Morris began ovarian grafting in the human being, having had twelve cases up to 1901. He places the ovary in normal saline solution at a temperature of 100° F. In his early cases he made a slit in the fundus of the uterus and placed the ovary in it, but in his more recent ones the ovary was attached to the broad ligament as near the seat of attachment of the patient's own ovary as possible. The result thus gained is the avoidance of a premature menopause, thus showing that the ovarian graft has retained its vitality. In one case pregnancy resulted, but an early abortion occurred.

Ovarian grafting has now a recognized position in pelvic surgery, both autoplastic and heteroplastic operations having been followed by most excellent results. Of the two forms, the autoplastic is, as one would expect, the best. B. Whitehouse in 1912 removed both sets of uterine appendages from a woman but planted an ovarian graft in the muscular wall of the abdomen. The patient, when seen nine months later, stated that she menstruated painlessly and regularly very month, and that her sexual characteristics had not been affected in any way. Luffier of Paris relates a case in which ovarian grafts were still functionating three years after operation.

Accessory or Third Ovaries.—These have been described, but were probably merely pieces of an ordinary ovary, which had become separated from the rest of the organ by fissures. It is significant that during the thousands of celiotomies which have been performed of late years, no competent observer has definitely reported a case in which more than two ovaries have been found in any one patient.

Displacements of the Ovary.—While the ovaries are developed in the abdomen they usually descend into the pelvis, but now and then one or both fail to do so and remain at the level of the pelvic brim. This malposition, however, gives rise to no symptoms, but will prevent the physician from feeling the organ during an ordinary bimanual examination. It may be diagnosed by not discovering the ovary in its usual place, or in thin subjects by feeling it at the pelvic brim during deep abdominal palpation.

Hernia.—A more important form of displacement, on account of the discomfort to which it may give rise, is hernia of the ovary. Here it descends along the round ligament and lies in the sac of an ordinary inguinal hernia, or it may lie in one of the labia majora, or even form part of a femoral or obturator hernia. In addition to the usual symptoms of a hernia, one gets an exacerbation of pain at the menstrual period and also an increase in size and tenderness at the same time. Pressure gives rise to a peculiar nauseating pain, which is almost pathognomonic of pressure on either an ovary or a testicle.

Treatment.—If in a position in which it is subjected to much irritation or pressure, the ovary may be protected by a cap or pad; but if these fail, it may be removed by an ordinary herniotomy operation.

Prolapse of the Ovary.—In health the ovary lies to one side of the uterus, at the level of or slightly below the fundus. In certain conditions, however, it falls considerably below that level, in which case the position may be considered to be pathological. It is due to a retroposition of the fundus dragging it out of place, or to adhesions due to an old pelvic peritonitis, acting in a similar manner. A general want of tone of the parts or prolonged ovarian congestion will also cause the ovary to become prolapsed. Other causes of this condition are sudden strains or any enlargement of the organ.

The *symptoms* are caused by the congestion consequent upon the displacement of the organ and by the disturbance of and pressure upon it by the distended bladder or rectum, and the various movements of the pelvic muscles. These all cause a dragging, aching pain in the pelvis, which is exaggerated at the onset

of the meustrual congestion. More or less severe paroxysms of pain are caused by coitus and the passage of hard fecal matter along the rectum.

When the organ is not embedded in adhesions, the *diagnosis* of a prolapsed ovary is comparatively easy. On making a vaginal examination a tender ovoid, mobile body is to be felt, either low down behind the uterus or in one or other lateral region of the pelvis.

The *treatment* consists in finding and removing the cause wherever possible. If the uterus is prolapsed or retroverted, restore it to its normal position, and keep it there by tampons or a pessary. If there is a general want of tonicity in the parts, try to improve the condition by hot douching, local counterirritation per vaginam, and the insertion of a tampon of boroglyceride or glyceride of tannic acid, as well as by the local use of electricity, especially faradic. The bowels should be kept regular, and gentle exercise (walking) be encouraged. Some writers advocate pelvic massage for this condition, and claim to have obtained striking results from this line of treatment. It is questionable, however, if the doubtful good obtained is not entirely eclipsed by the ill effects which the necessarily prolonged handling of the genitals produces.

When the ovary is adherent, and the above treatment fails to relieve the pain, etc., an operation will be required. The indication will then be to separate the adhesions and possibly stitch the ovary in a more favorable position on the broad ligament. In order to prevent the formation of fresh adhesions the raw surfaces may be covered with Cargile's animal membrane or with a small portion of omentum, which may be cut off and carefully sutured over them. The abdominal route is the one recommended for this operation, as you are able to expose the parts thoroughly, and treat any small pockets of pus which are so apt to be present in old cases of pelvic peritonitis. You can also stitch the ovary in place better by the abdominal than by the vaginal route.

Atrophic Disturbances.—*Atrophy of the ovary* may be physiological (as when it follows the menopause) or pathological. Pathological atrophy is apt to accompany excessive obesity, while prolonged pressure by adhesions or tumor, interference with the vascular supply and removal of the uterus, are also causes of this condition. It is also said to follow alcoholism, acute exanthemata, rheumatism, etc., but the condition then is not one of true atrophy but of cirrhosis.

In *cirrhosis of the ovary* there is an increase in the fibrous tissue of the organ at the expense of the glandular and muscular elements. In the early stages the ovary is of normal size, but is firmer than usual; while later it is small and very hard, its surface is glistening white and thrown into brain-like convolutions by contraction of the fibrous tissues.

The *symptoms* are pain, sterility, and various reflex neuroses, the patient often complaining of gastric disturbance, visual defects, and headache. The pain is usually related to menstruation, or is of a peculiar dull sickening nature, coming on from ten days to two weeks before the onset of the flow. Local examination of the pelvis is not apt to reveal very much, as the ovaries are too small to be felt except in particularly favorable cases, when they are felt to be very hard, painful, and small.

In the way of *treatment*, not much can be done, although in the earlier stages electricity may possibly check the condition. When fully established, however, oophorectomy is indicated.

The *etiology* of the condition is unknown.

Hypertrophy.—This is caused by anything which produces chronic congestion, or by any inflammatory process which stops short of the formation of pus. As examples of those causing congestion may be cited chronic constipation, prolapsus ovarii, too frequent coitus, etc. Pure hypertrophy, however, is where there is an increase of all of the constituent parts of the ovary, and is extremely rare, the above conditions being much more likely to be followed by cystic or fibrous enlargement than by true hypertrophy.

The *symptoms* of hypertrophy of the ovary *per se* are practically *nil*, but will be those of the condition giving rise to it; consequently no *treatment* is necessary.

Inflammation of the Ovary.—In the ovary, as elsewhere, *congestion* is an early stage of inflammation. Just as in other regions, it has its own symptoms and may be checked without going further.

The causes of congestion are exposure to cold, especially during menstruation; chronic constipation, in which case the left ovary is the one chiefly affected, owing to its proximity to the rectum; excessive sexual excitement, prolapse of the ovary, inflammation of neighboring structures, bacterial toxins or germs (invasion by the latter rarely stops short of producing pus), and twisting of the pedicle of the ovary. Sometimes the removal of one ovary produces an hypertrophy of the other, which, as a rule, is transitory. It may, however, go on to chronic inflammation and cystic formation; but if promptly, properly, and patiently treated by rest, hot douches, and boroglyceride tampons, the congestion should subside in a few months' time. One can readily understand how disappointed a patient is when the removal of one ovary has simply resulted in the transference of her pain to the opposite side. She will often blame the operator for not having removed both ovaries, and want him to perform a second oophorectomy; but if he is firm in his refusal to do so until a more or less prolonged course of local treatment has been tried, both he and his patient will time and again be rewarded by the return of the diseased ovary to health and usefulness.

Besides the above pathological forms of congestion a physiological variety occurs during menstruation, pregnancy, and sexual excitement, but this does not require consideration in this article.

Oöphoritis, or inflammation of the ovary, may be either acute or chronic, the former usually passing on to the chronic variety if untreated, and if the infection is not sufficiently acute to carry off the patient before the affection reaches the chronic stage.

Acute oöphoritis is practically always caused by the presence of germs. These may be carried to the organ by the blood or lymph vessels from some more or less remote source of infection, or else may attack it by a more direct route, as where there is an acute infectious inflammation of the Fallopian tube, or where the ovary is adherent to the rectum, appendix, or other portion of the bowel, and the germs reach it from thence.

The two most common forms of infection are gonorrhea and puerperal septicemia, both of which may cause a most severe disease. In addition to these, however, acute inflammation may be set up by injury, by poisons, such as arsenic and phosphorus, by the acute exanthemata, mumps, acute rheumatism, etc. The writer, some years ago, saw a woman who was suffering from an ordinary attack of typhoid fever; she was quite suddenly seized by a sharp pain in the region of the right ovary, the pulse became more rapid and the temperature rose. Appendicitis and perforation of the bowel having been excluded, the abdomen was opened and the right ovary was found to be enlarged and acutely inflamed. The removal of the organ was followed by relief of all pain, with ultimate recovery of the patient.

Inflammation of the ovary may follow an attack of acute appendicitis, the appendix in that case becoming adherent to the ovary.

Symptoms.—The patient suffers from an acute agonizing pain in one or other ovarian region, the pain radiating up toward the umbilicus, into the loin,

down the leg, etc. More or less nausea is present. Defecation and micturition are frequently painful. Examination of the lower abdomen reveals great tenderness over the affected region, and the same will be found per vaginam, by which passage also one can feel the ovary to be somewhat enlarged if the parts are not too tender.

Treatment.—Absolute rest in bed is distinctly indicated, as is also the application of ice, or, if that fails, heat, over the lower abdomen. The parts may be too tender to allow of hot douches being used, but they usually give great relief. The water ought to be as hot as the patient can possibly stand it, and at least one gallon should be used. The force of the water may be regulated by the height of the douche pail above the patient's bed, and ought not to be too strong. Lavage of the rectum is often of service, especially when the left ovary is the one affected. Blistering the abdomen over the diseased area will often be of service.

The tincture of aconite, given in doses of one or two drops every hour, often benefits the condition by quieting the circulation, but there is no drug which has any specific action upon the malady. The bowels should be well emptied early in the attack and then kept at rest. The best way to influence them is by sulphate of magnesia in dram doses every hour for five or six hours; the drug being dissolved in hot water. After this has taken effect keep the bowels closed by tinctura opii, or by a pill plumbi cum opio. As regards diet, it should be fluid, light, and non-stimulating, consisting principally of milk and its preparations.

Prognosis.—If the patient is seen in time and if the infection is not too virulent, the above treatment suffices to cure the vast majority of cases. But the disease may pass into the chronic variety, or else an abscess may be formed. This abscess if not interfered with may either resolve, remain quiescent, or rupture. If the organ has become adherent to either the bladder or the bowel, it may rupture into them and its contents be discharged externally. Otherwise it will rupture into the general peritoneal cavity, causing acute inflammation of its lining membrane and the death of the patient. After the escape of the contents through either the bladder or the rectum the sac may refill, and should then be removed by the surgeon; in fact, when an abscess of the ovary exists which will not yield to milder measures, the surgeon must interfere. It is better if he can wait until the virulence of the germs is lessened, as this greatly reduces the risk of the operation and occurs within a few weeks, probably not more than five or six.

Diagnosis.—This is sometimes a matter of great difficulty and importance. The conditions with which it is most likely to be confused are: (*a*) appendicitis (when the right ovary is attacked); (*b*) intussusception; and (*c*) pelvic tumor with a twisted pedicle.

In appendicitis the pulse and temperature are more liable to be interfered with, there is more vomiting, the tenderness is higher in the abdomen, and it is more than probable that a vaginal examination will give a negative result, whereas in acute oophoritis the examining finger will probably feel the diseased ovary.

Intussusception rarely occurs in adults. It gives rise to a sausage-shaped tumor, and either to complete constipation or to bloody and mucoid stools.

A tumor with a twisted pedicle makes itself evident either to sight or touch, if not to both. An ovary enlarged by an abscess would give a more chronic history, *i.e.* it would not give rise to the sudden acute pain which torsion of a pedicle causes.

Chronic oöphoritis is much more common than the acute form which it may follow. It frequently, however, comes on quite independently of the acute variety, and is much more insidious in its onset. Women are most liable to it during the period of greatest sexual activity, from which statement it may be correctly inferred that it is much more common among married than among single women. Excessive sexual excitement, especially without gratification of the desires, is one of the commonest causes of this condition. In addition to this, mumps, masturbation, operations upon the cervix (?), and prolonged congestion of the ovary are prolific causes.

Pathology.—When an ovary which is the seat of chronic inflammation is examined, it is found to be somewhat enlarged, and to contain more or less numerous small cysts. The organ is firm, and its peritoneal covering is tough and thickened. There is also an increase in the fibrous tissue.

Fig. 4212.—Left Ovary Bisected to show Cysts Caused by Chronic Inflammation. Right Ovary Divided to show a Hematoma. Pathological Dept., McGill University.

Symptoms.—Chronic inflammation of the ovary produces pain in one or both sides of the pelvis, according as to whether or not one or both ovaries are affected. When the disease is unilateral, the left is the one usually the seat of the trouble on account of the proximity of the rectum. This pain may radiate down the thighs, across the abdomen, or up toward the umbilicus, and is aggravated by defecation, by any sudden movement, as on taking a jump or misstep, by jolting, coitus, etc. It also becomes more marked a week or ten days before the menstrual flow appears, being relieved by the local depletion which is thus caused, in proportion to the amount of blood lost. A sharp pain in either one or both breasts, and especially in the left, is often experienced. Pressure through the abdomen over the diseased organ causes pain, as does also coitus. On making a local vaginal, or, better, rectal examination of the pelvis, the ovary is felt to be enlarged, tender, and often more or less prolapsed.

The *diagnosis* is not difficult as a rule. The location, in the ovarian region, of a pain which becomes more severe several days before menstruation; the reflex mammary pain; painful defecation and the presence of an ovoid tender mass in the region usually occupied by the ovary, will point strongly to chronic inflammation of the ovary. Of course the inflamed organ may be plastered against the pelvic wall by adhesions, in which case you will have to be guided by symptoms alone.

Treatment.—This consists in finding and removing the cause wherever this is possible. Regulate the bowels and diet and limit the patient's exercise. This may require to be entirely prohibited in obstinate cases, the patient being confined to bed. Stop excesses of all kinds, whether bacchanalian, gastronomic, or sexual. The domestic duty most likely to aggravate, or at all events keep up the trouble, is

working the treadle of the sewing-machine, which should be strictly forbidden. Depletion of the pelvis may be effected by accelerating the action of the bowels by means of sulphate of magnesia or one of the many aperient waters, by hot douching, by hip-baths, by medicated tampons, or by vaginal cones or bougies. For the douchings plain boiled water cannot be improved upon, but it must be used in quantities of not less than a gallon, and must be as hot as the patient can possibly bear it. The vagina, not being a very sensitive organ, can tolerate a much higher temperature than the skin of the perineum and vulva, but these parts may be protected by a towel wrung out of warm water. The tampons are better if they are made small, about the size of a large walnut, using two or more if necessary. They will thus fit more snugly and cause the patient less discomfort than if a single large one is used. While tampons saturated with boroglyceride or pure glycerin are useful, the employment of a ten-per-cent. solution of ichthyol in glycerin, or a combination of ichthyol, tincture of iodine, glycerite of hydrastis, and boroglyceride is to be preferred. Counterirritation through the skin of the abdomen, or per vaginam, is a valuable adjunct to the above course of treatment. The first may be carried out by painting the skin of the abdomen with the tincture of iodine, or blisters may be employed. When these are used a small blister should be placed over the center of the painful area. When this one heals a second is to be placed at its side, and so on until the first one has been completely surrounded; each one being allowed to heal before applying the next. The counterirritation per vaginam is best effected by painting the lateral fornices with a mixture of equal parts of the liniment and tincture of iodine.

Little can be done in the way of internal medication for this condition. The bromides, especially a combination of those of ammonium and sodium, have been highly commended and may be of some use in quieting the circulation and pain. The chlorides of gold and sodium have also been employed with benefit. Temporary exacerbations of pain must be combated by the local application of heat and the administration, by the medical attendant himself, of morphine. Alcohol should be absolutely forbidden as it only aggravates the condition eventually, although it may relieve the pain for the time being.

The above line of treatment ought to be conscientiously persisted in for many months before abandoning it as useless—that is to say, when the woman can give up the time for it. When she cannot do this, and it is necessary to cure her quickly so that she may return to her ordinary sphere of usefulness in a comparatively short time, as also in those cases in which all non-operative means have failed, removal of the offending organ is the only resource left. This may be done per viam abdominalem or per vaginam, but this operation will be fully described in another article. (*Cf. Ovariotomy.*)

Hematoma of the Ovary.—During the course of acute fevers, as a result of injury or pressure upon or torsion of the broad ligament containing the ovarian vessels, one of the capillaries within the stroma of the ovary or wall of a Graafian follicle may rupture and give rise to a collection of blood, which is called an hematoma ovarii. It may also be caused by the impregnation and rupture of an ovum in the ovary, the possibility of the occurrence of which has been but recently demonstrated. Hematoma of the ovary is not at all uncommon, but is rarely of any clinical significance. On inspection, the ovary is seen to have a larger or smaller bluish-red mass projecting from its surface, which mass is semi-fluctuating. Microscopic examination reveals a mass of blood clot lying within a more or less well-formed capsule.

Ovarian hematoma rarely gives rise to any symptoms or calls for any treatment. If symptoms are present they are usually those of chronic ovaritis and call for the same treatment, except that where operation is indicated nothing should be removed but the diseased portion of the ovary. The hematoma may rupture and give rise to most marked symptoms of internal hemorrhage, the patient being most collapsed and her abdomen being filled with fresh blood. One is apt to consider the condition one of extrauterine gestation but the tubes will be found to be quite healthy and microscopical examination of the ovary will reveal the entire absence of villi.

Ovarian Pregnancy.—In Clifford Allbutt's "System of Medicine," published as recently as in 1896, the writer on "Diseases of the Ovaries" says: "It is extraordinary that belief in the occurrence of ovarian pregnancy should have obtained currency," and that "until some specimen is forthcoming in which an early embryo in its membranes can be demonstrated in a sac inside the ovary, we need not trouble ourselves to discuss ovarian pregnancy." Only three years later Croft and van Tussenbroch each reported an undoubted case, and since then at least three other cases have come to light, viz., those of Anning and Littlewood in 1901, Mayo Robson in 1902, and Thompson in 1902. It is a curious fact that of the five cases no less than three occurred in Leeds, England.

Symptoms.—Ovarian pregnancy gives rise to very much the same symptoms as those of ordinary tubal gestation, except that, as a rule, rupture is not preceded by the dull aching pain in the side, to which the latter gives rise. The absence of this pain may be ascribed to earlier rupture and to there being no firm muscular fibrous tube wall to distend.

The patient passes her time by a week or ten days, or else her last period has been replaced by a dribbling of blood which has persisted. This is followed by a sudden sharp pain in one ovarian region, accompanied by faintness, with possibly actual loss of consciousness, by sighing respirations, pallor, a cold clammy sweat, and rapid thready pulse. Although the temperature is usually subnormal, some elevation of it is quite compatible with the condition, as was recently seen in a case which the writer had under his care in the Montreal General Hospital.

On examining the patient the surgeon will find some tenderness over the affected organ, slight dulness in the flanks, and the seat of the effused blood will be warmer than the rest of the abdomen. Attention was first drawn to this sign by Grandin, and while it cannot be always distinguished, the writer has seen it in at least one case since the publication of Grandin's paper. Vaginal examination will reveal an oozing of blood from the vagina, a softened velvety cervix, normal uterus, and a rather vague mass in one fornix.

The *etiology* is still *sub judice*. Pregnancy occurring in the ovary is extremely rare but its existence as a distinct pathological entity is undeniable. It is quite possible that many of the cases of hematoma of the ovary which have been reported have really been cases of ovarian pregnancy, it being probable that villi and other signs of gestation would have been observed if they had been carefully searched for. On the other hand, it is almost certain that many of the older cases of reported ovarian gestation have really been nothing more than hematomata, as proved by microscopic examination. In order to be certain that the gestation is ovarian, it must be shown that the original attachment is inside the ovisac, and that the ovum derives its nourishment from thence. This can be done with certainty only in the very earliest weeks of pregnancy, as the ovarian tissue is liable to become so displaced in cases of tubo-ovarian pregnancy as to appear to have been the original seat of implantation of the ovum. In a true ovarian gestation, the ovum immediately upon im-

pregnation attaches itself to the wall of the ovisac; villi are thrust into this wall, and by this means the ovum is nourished. In the majority of cases the ovum continues to grow until between the fifth and sixth week, at which time it ruptures into the peritoneal cavity. This is followed by severe intraperitoneal hemorrhage, although, judging from the small number and size of the vessels, one would not expect such a result. In at least two of the fully reported cases the abdomen was found to be filled with blood at the time of operation.

Treatment.—This will vary according as to whether or not hemorrhage has ceased and the patient can be kept under observation and constant readiness for operation, and also whether or not the clot is undergoing absorption. If seen some time after rupture has taken place and if the patient can be kept under close observation, temporizing measures may be adopted. In such a case one of the most important points to be remembered is that all cardiac stimulants are absolutely contraindicated, as their exhibition is very liable so to increase the force of the heart's action that the clots, which are plugging the mouths of the ruptured vessels, will be forced out and a fresh hemorrhage take place. The very best way to improve the patient's condition is to use decinormal saline solution, either per rectum, subcutaneously, or intravenously, according to the acuteness of the symptoms. It is only in the most urgent cases that the latter method is required, as the solution is very quickly absorbed from either the bowel or the submammary region. Absolute quiet and rest in bed are strongly indicated, and the circulation and pain may be calmed by the subcutaneous injection of morphine. Ice should be applied to the abdomen over the point of rupture, and hot vaginal douches may be begun some days after cessation of the bleeding. The diet should be nutritious but non-stimulating. Where under this treatment the clot does not become absorbed within a reasonable time, it may be cleared out by means of an incision through the posterior vaginal wall.

When the patient is seen soon after rupture, or when she cannot be kept under observation, the quicker the abdomen is entered, the bleeding controlled, and the gestation removed, the better it will be for the patient, shock or no shock. This condition of shock is to a very great extent due to loss of blood, and will not be lessened by allowing this to proceed. While some few of these patients will recover without operation, a much larger percentage of recoveries will take place if the knife is used early, energetically, and judiciously.

Tuberculosis of the Ovary.—Tuberculosis of the ovary is extremely rare, the ovary being only the third in order of frequency of the female genitals to be affected. In fact so rare is the disease that the older writers did not deem it worthy of consideration in their works. The rarity and almost impossibility of occurrence of primary ovarian tuberculosis can be readily understood when one realizes that in order to have such a condition the bacilli would require to enter the body from the exterior and then traverse a more or less complicated system of blood-vessels or lymphatics before entering the ovary. No case of primary tuberculosis of the ovary in the human subject has yet been reported. Although Acconi experimentally produced it in animals, Spaeth, Blebs, Oppenheimer, Sippel, and others have recorded cases in which the ovary was the only genital organ to show the disease in patients who were otherwise tuberculous. In the majority of cases it was the superficial part of the organ which was the seat of the disease, the presence of which in the deeper layers was frequently unsuspected until the ovary was examined under the microscope.

The form of tuberculosis present is the miliary form, and it may affect either the superficial or the deep layers. When the latter part is affected, the disease is apt to proceed until an abscess is formed, and this may rupture into the peritoneal cavity. The germs may reach the ovary either through the blood or the lymph current, by direct continuity, as in the case of tuberculosis of the peritoneum or tubes, or by bacilli working their way through a weak spot in the bowel wall and falling upon and infecting the ovary.

No age is exempt from this disease, but those under fifty are the most liable to be attacked. Out of 17 cases reported by Griffith 5 were under fourteen, 8 were between fourteen and twenty-five, 3 between twenty-five and forty-five, and 1 was fifty-five years of age.

The *clinical history* is very vague and there is no symptom or series of symptoms which can be considered to be at all pathognomonic of this condition. There may be absolutely no symptoms or else those described as occurring in chronic oophoritis may be present. Where such is the case and you have a semi-fluctuating, rounded, non-sensitive mass occupying the region of the ovary, together with an evening rise of temperature, in a young woman who is otherwise fairly healthy, and who has not been exposed to the two common causes of pelvic abscess, viz., gonorrhea and sepsis, you may suspect the presence of a tuberculous abscess of the ovary. Anything short of abscess formation cannot be definitely diagnosed previous to operation, as both physical signs and symptoms are too indefinite. Menstruation may or may not be affected, but when it is interfered with amenorrhea is the form usually taken, and is more the result of the general than it is of the local condition.

Once diagnosed the only *treatment* to be adopted is removal, but this can be advocated only in the absence of extensive disease of other organs.

Tumors of the Ovary.—The ovary itself may be divided into the oöphoron which contains the ova, and the paraoöphoron or part nearest the ovary. Although this latter is anatomically quite distinct, it might be considered clinically to be part of the ovary. Of these three parts, the oöphoron is the most active as far as the formation of tumors is concerned. From it are derived: 1. Fibromata; 2. Myomata; 3. Sarcomata; 4. Carcinomata; 5. Cysts; 6. Adenomata; 7. Dermoids.

The paraoöphoron gives rise to papillomatous cysts, and from the parovarium are developed unilocular, thin-walled cysts. Of the above tumors cystomata form about ninety-five per cent., the multilocular cysts being the commonest. The following is the classification of ovarian tumors adopted by Adami and Nicholls in their Principles of Pathology: viz.,

- I. New growths of epithelial type.
  - Benign.
    - Cystadenomata.
    1. Arising from the follicles.
    2. From the corpus luteum.
    3. From the germinal epithelium.
    4. From the Wolffian rests.
    5. From the remains of the paroophoron.
    6. From tubal "rests."
  - Malignant.
    1. Cystic carcinoma.
    2. Solid carcinoma.
- II. New growths of connective-tissue type.
  - Benign.
    1. Fibroma.
    2. Papilloma.
    3. Hemangioma.
    4. Lymphangioma.
  - Malignant.
    1. Endothelioma.
    2. Perithelioma.
    3. Sarcoma.
- III. Teratomas.
  1. Epidermoid cysts.
  2. Pure dermoid cysts.
  3. Compound dermoids.
  4. Compound teratomas.

IV. Mixed tumors.
- Combined and cognate forms.
  - Benign.
    1. Myofibroma.
    2. Adenofibroma.
    3. Cystic fibroma.
  - Malignant.
    1. Myosarcoma.
    2. Adenosarcoma.
    3. Sarcocarcinoma.
    4. Cystic carcinoma.
    5. Cystic sarcoma.
- Teratogenous blastomas.
  - Benign. 1. Cystadenoma with teratoma.
  - Malignant.
    1. Sarcoma with teratoma.
    2. Carcinoma with teratoma.

1. *Fibromata.*—These are the rarest of all ovarian tumors, muscular tissue being found along with fibrous in most benign solid ovarian tumors. When pure, these tumors consist of many bands of white fibrous tissue which interlace and include in spaces round cells, and here and there among the fibers a few small spindle cells are seen. No blood-vessels or nerves are found in the substance of the growth. Fairbairn divides them into three groups: (1) Where the whole ovarian stroma is replaced; (2) where part of the stroma only is affected; and (3) where a pedunculated fibroid springs from the surface of the ovary.

Fibroids of the ovary are more likely to develop in women who have passed the menopause than are fibroids of the uterus, and they occur twice as often in married as in single women.

Herbert Spencer found the tumor to originate in the fibrous capsule of the Graafian follicle in three cases. Peter Horrocks asserted that when carcinomatous and sarcomatous tumors are bisected the cut surface remains flat, whereas in fibroids it becomes concave, owing to the elasticity of the fibers. But this diagnostic sign is untrustworthy. The disease is usually unilateral, but Cleeman recently reported before the Philadelphia Obstetrical Society a case in which a pure fibroma of each ovary was found in a patient. Ascites was also present.

Symptoms are often absent until the tumor has been present for a long time. The patient may, however, complain of dysuria, dragging pain in the pelvis, dysmenorrhea, and enlargement of one side of the lower abdomen. Ascites is frequently present, but it does not form a constant sign. On account of the mobility of these growths, torsion of the pedicle very commonly occurs. This may be so extreme as to cause complete separation of the tumor when it occurs, the woman complains of great pain in the side which may be sudden in onset or else be slight at first, becoming worse as time goes on and all the evidences of peritonitis are present. Local examination reveals an extremely hard, firm tumor of ovoid shape, situated to one side of the uterus; it is non-sensitive and usually mobile.

The only *treatment* is removal, and this ought to be effected as soon as the tumor is discovered, on account of the difficulty of diagnosis between it and sarcoma.

The *prognosis* is unfavorable if the fibroids are not removed, as, unlike uterine fibroids, they are liable to take on active growth at any period of the patient's life.

2. *Myomata.*—Tumors of the ovary composed wholly of muscular tissue are almost as rare as pure fibromata. They usually develop from near where the ovarian ligament joins the ovary, as this ligament contains an abundance of muscular tissue. In 1896 Gessner found a small fibroid tumor on the ovarian ligament, situated at an equal distance from both the ovary and the uterus, and he inferred from this "that a myoma of the ovarian ligament might invade a healthy ovary and convert it into a myoma of the ovary." Baldy, in "American Gynecology," reports a case which occurred in a married woman, thirty-six years of age. Operation revealed multiple uterine fibroids, and that the right ovary was replaced by a fibroid mass of the shape and size of a lemon. This mass was attached to the posterior layer of the broad ligament and had the Fallopian tube running over its upper surface. The fimbriated extremity of the tube ended on the external surface of the capsule of the tumor. This latter itself was composed of smooth muscular fibers and a little connective tissue. A band composed of connective tissue and large blood spaces separated it from the true ovarian tissue which was apparently normal.

3. *Sarcomata.*—The ovary is not infrequently affected by tumors of a sarcomatous nature. Apart from regular sarcomata, masses of tissue indistinguishable from sarcoma sometimes occur in dermoids, the removal of which in these cases may be followed by malignant disease of the pelvis. When the ovaries are affected by these growths the disease is frequently bilateral, here differing from what takes place in other parts of the body where the affection is usually unilateral.

The ovary may be invaded by either the round- or the spindle-celled variety. The former is usually found when both sides are affected and in young patients. At the Würzburg Frauenklinik, out of 295 cases of ovarian tumors 20 were sarcomatous; the ages of the patients ranged from twelve to sixty-three, 7 being over fifty years old. Out of 4 which occurred in females under twenty, 3 were of the round-celled variety. Seven died after operation, 3 within the first four days and 4 before six months had elapsed.

Cohn states that their occurrence in relation to ovarian cystomata is as 1 to 100, and that they form ten per cent. of all malignant tumors of the ovary. In 400 cases of ovarian tumors of all kinds, including endothelioma, he found 5.38 per cent. to be sarcomata.

The tumors may grow either rapidly or slowly, and often attain a weight of from twenty to thirty pounds. Their consistence varies, some being hard (the spindle-celled variety), and others (the round-celled) soft and brain-like. They are surrounded by an outer wall, which sometimes is very soft and friable. The pedicle is usually short, and it is but seldom that adhesions to neighboring organs are formed, but ascites is usually present.

On section the surface may be yellowish-white or pinkish-gray, this depending upon the number of blood-vessels present as well as on the structure. Small cysts are often seen, and are due either to hemorrhage into the tissue with subsequent softening or else to fatty degeneration of the tumor cells.

Of the two varieties, the small round-celled is the most malignant; the greater the amount of fibrous tissue present, the less danger is there of any secondary trouble. This secondary infection attacks structures in the following order: viz., peritoneum, omentum, stomach, pleura, lungs, uterus, liver, diaphragm, and kidneys. The tumor may undergo degeneration, the commonest being fatty and myxomatous.

The *symptoms* are few at first, but ascites may develop early, and this forms one means of differentiating sarcomata from fibromata or myomata of the ovary. Pain and disturbance of menstruation are also more frequent than in benign solid ovarian tumors. Physical examination yields similar results in both fibroma and sarcoma ovarii. Metastases are indicated by ascites, edema, enlarged abdomen, and rapid decline in the patient's health.

The only *treatment* is prompt and thorough removal of not only the ovary of the opposite side but the whole uterus, even if these organs macroscopically appear to be healthy, on account of the danger of recurrence.

Postoperative *prognosis* as regards recurrence is not good, but is better than when the ovary is the seat of

cancer. When both ovaries are diseased or when the round-celled variety is found, the prognosis is decidedly more grave than when one side only is affected or when the growth is composed of spindle cells.

Endotheliomata.—These are malignant tumors which begin by a proliferation of the endothelial lining of the blood or lymph vessels of the ovary. They may be said to occupy a place midway between carcinoma and sarcoma, differing from them in structure but possessing similar clinical features. Billroth regarded them as being as malignant as carcinomata.

Endotheliomata were thus named on account of their origin, by Marchand, who first described them in 1879. They are usually solid, but may contain spaces. The surface is smooth, but may present tuberosities, composed of tissue which is of a brain-like or spongy consistence. They occur mostly at middle age, although Leopold has seen one in a girl of eight, and Olshausen one in a girl aged seventeen. In size they vary from that of a closed fist to that of a fetal head. Usually they are unilateral and rounded, but may be bilateral and lobulated. The pedicle is short and the tumor prone to form adhesions.

On section, the cut surface may be either gray, yellow, or white, the tissue being soft and friable and easily torn by the fingers.

Pick differentiates endotheliomata into three types, of which the first is of a rosary-like form, consisting of chains of cells in rows lying in narrow clefts of fibrous tissue. The borders of the rows are parallel and frequently anastomose. In the second form the structure resembles glands and it is difficult to distinguish it microscopically from adenocarcinoma, the spaces being encroached upon by several layers of polymorphous cells. In the third variety the cells are grouped as in alveolar sarcoma. All three forms may occur in the same tumor.

Endotheliomata may occur in connection with other tumors, Pfannenstiel reporting a case in which an endothelioma and epithelial cyst adenoma were present in the same patient. These tumors may degenerate, the usual form of degeneration being either hyaline or myxomatous, but colloid and fatty have been seen to take place.

Carcinoma.—Cancer of the ovary may be either primary or secondary. The latter usually accompanies malignant disease of the uterus, but it may complicate an affection of the stomach or mammary glands. It may originate in either the Graafian follicle or the germinal epithelium. It is convenient to divide cancer of the ovary into medullary carcinoma and adenocarcinoma.

I. Medullary Carcinomata. These are solid tumors which are usually oval or rounded, but are also often nodular. They vary in size, but are rarely larger than the head of a full-term fetus. There is usually a pedicle which is short and thick, but at times they are intraligamentous. Both ovaries are but seldom affected.

Medullary cancers have a dense, well-defined, fibrous capsule, and on section the cut surface is seen to be more or less homogeneous, of a yellowish or grayish-white color. At times, extravasations of blood into the substance of the tumor produce a mottled appearance. Degenerations, especially caseous or fatty, are common, resulting in the formation of cyst-like cavities with irregular walls and turbid or yellowish contents.

Histologically the growth consists of carcinomatous cells infiltrating a fibrous stroma, which may predominate and form alveoli filled with cancer cells, but usually the cellular elements predominate.

II. Adenocarcinomata. Adenocarcinomata are tumors which closely resemble ordinary serous cysts of the ovary. They are oval or rounded, and rarely exceed an adult head in size. They usually have a short pedicle, but may develop between the layers of the broad ligament and often form adhesions to neighboring structures. Although they may appear to be unilocular, they are usually multilocular. The disease is generally bilateral.

In about half of the cases examined, Pfannenstiel has seen papillæ on the surface. The cyst wall is composed of connective tissue which is quite friable. This wall may be thickened in spots, owing to the development of carcinomatous nodules. Papillary and cauliflower growths may spring from the internal surface of the cyst wall and may nearly fill the cavity. The cyst contents may be clear, turbid from cellular elements, or blood-stained from hemorrhages into the cyst.

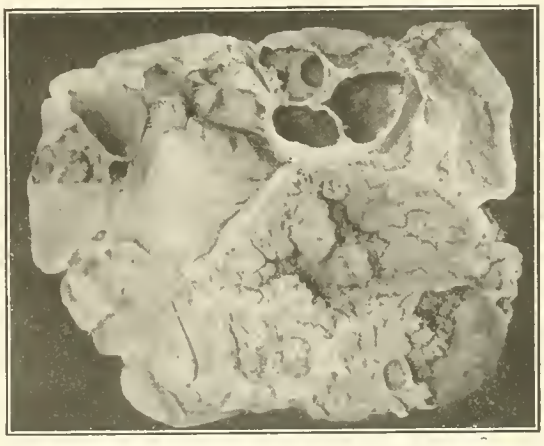


Fig. 4213.—Mixed Sarcoma and Carcinoma of Ovary Specimen in Pathological Museum, McGill University.

Cystic carcinoma of the ovary is usually papillary, the papillæ usually resembling ordinary papillomata, but on section the microscope reveals the presence of cancer cells, and the carcinomatous structure may at times even be observed by the naked eye. Any individual tumor may contain masses which vary greatly in structure from one another. One form consists of a diffuse infiltration of a medullary character. More often the masses are composed of papillæ and glandular structures with their lumen still apparent. An atypical proliferation of epithelial cells is everywhere seen and the papillary growths are covered with several layers of cells asymmetrically arranged. A similar arrangement of the epithelium is seen in the glandular forms of the disease, this giving rise to their alveolar appearance. Lime salts become deposited in the tumors, especially those of a papillary nature, and give rise to psammomata.

It is almost impossible to tell when an adenomatous tumor of the ovary is benign and when malignant, as the gradation from an ordinary cyst-adenoma to primary carcinoma is so gradual. Ziegler holds that no clear line of demarcation between the two can be drawn, and Pfannenstiel estimates that one-half of ovarian papillomata are carcinomatous. He, however, is rather an extremist, claiming that tumors which become carcinomatous should be classified as primary carcinomata, whereas most writers would consider these to be merely cases of carcinomatous degeneration of benign growths. Metastases frequently occur, affecting, in the following order, the peritoneum, omentum, liver, stomach, intestine, the ovary of the opposite side, and, but rarely, the pleura.

Differential Diagnosis of Solid Ovarian Tumors.—During the following brief consideration of this subject, it must be remembered that it will often be quite

impossible to differentiate between a solid ovarian tumor and a solid subserous tumor of the uterus with a long pedicle, as, even where this is felt on palpation, the pedicle may be mistaken for the Fallopian tube, unless it be thicker than is commonly seen in the case of a long pedicle. A kidney may be prolapsed into the pelvis and give rise to some difficulty in the diagnosis, but it can usually be replaced.

First, these solid ovarian growths have to be distinguished from tumors of other organs; and secondly, from one another. The tumor is one of the ovary because (1) it is situated in one side of the pelvis or lower abdomen; (2) it is unconnected with any other abdominal organ, as ascertained by palpation and percussion; and (3) uterine movements are not influenced by those of the tumor.

A *fibroid* is the hardest, slowest growing, and least liable to produce other than pressure symptoms of any tumor of the ovary. It is more liable to appear after the menopause than a fibroid of the uterus.

Sarcomata are firm, and may be quite hard, but they grow rapidly, occur at an early age, and produce ascites, emaciation, secondary deposits, etc. They usually also have longer pedicles than the next variety.

The *malignant solid ovarian tumors* are more apt to be nodular than the above and produce the other signs of malignancy (ascites, emaciation, etc.) more quickly.

Ovarian Cysts.—Cystomata of the ovaries may arise from infolding and downward prolongations of the germinal epithelium, or else by enlargement of follicles which have failed to rupture, this failure frequently being due to inflammatory thickening of the outer coat of the ovary. Herman says that this latter "is such a simple and natural way of explaining the development of ovarian tumors that one would think that any other must only apply to exceptional cases," and there is much wisdom in this statement.

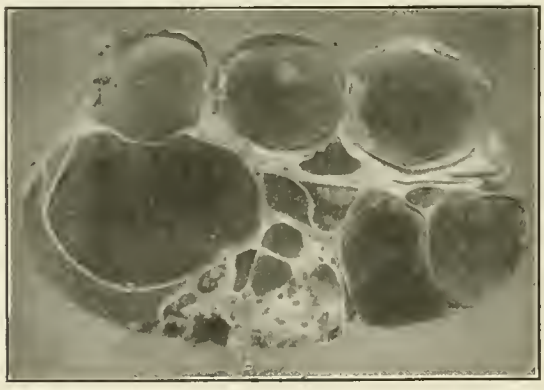


Fig. 4214.—Multilocular Ovarian Cyst with Solidified Colloid Contents. From Pathological Museum, McGill University.

Why these follicles develop into large cysts in some cases and not in others is not really known, although various theories have been advanced. They may occur at all ages and in every condition, but are more often seen in women who have borne few children than in those who have large families. Cheney reported an instance of an ovarian cyst which weighed nine and one-half pounds in a girl sixteen years of age.

The size of these tumors varies from one pound up, Knight removing one which weighed 111 pounds from a woman whose weight was only eighty-seven pounds after operation.

Hydrops folliculi is a condition in which one or more follicles become distended by fluid to the size perhaps of a cherry, retaining their globular form. One variety of this affection has been called Rokitansky's tumor, which consists of many distended follicles which have become pedunculated in some cases or compressed laterally in others. They contain a thin serous fluid and sometimes ova. This variety of tumor is both bilateral and rare.

Neoplastic Cysts.—Most ovarian cysts are of the proliferating variety, which Waldeyer divided into the proliferating glandular and the proliferating papillary cysts; but this is merely a clinical division. A more scientific classification is that of Pfannenstiel. He found that the contents of the two varieties differed from each other. In one there is a clear, thin, serous fluid, while in the other class the fluid is dark and turbid and contains a substance called pseudomucin. Using this fact as a basis, he named the two groups pseudo-mucinous and serous.

The *pseudo-mucinous* are the most numerous of all ovarian cysts. They are usually unilateral and the size may vary from that of a hen's egg to a tumor weighing 240 pounds; but one rarely now sees an ovarian cyst weighing over thirty or forty pounds, as they are usually removed as soon as discovered. No age beyond puberty is exempt from these growths, but they are more liable to attack women between the ages of thirty and forty-five, especially if they are sterile or unmarried. The shape is usually ovoid and the surface may be either even or lobulated, the latter being most often seen in the case of the smaller tumors due to the presence of daughter cysts. The color is usually bluish or purplish white and glistening, with here and there blood-vessels running over the surface. At times bands of unstriped muscle are also seen upon the surface, on which portions of ovarian tissue may become flattened out.

When opened up, the tumor may consist of one large sac with its contents, but if the interior is carefully examined bands of tissue, the remains of the walls of previously existing loculi, will usually be seen. More frequently many smaller cysts with their walls agglutinated together are discovered making up the large tumor. The contents of these numerous loculi may vary from a thin serous fluid to that of a jelly-like consistency. The inner surface of the cyst wall is usually smooth, especially if the tumor is of large size, this pressure causing atrophy of the epithelium; but in the small cysts, small papillæ and other excrescences are often seen. This lining is composed of a single layer of cylindrical mucous-like cells, which stain very readily with eosin and hematoxylin. These cells are implanted upon a layer of connective tissue and at times ovarian or unstriped muscular tissues. Outside this again is a layer composed of germinal epithelium.

The *serous cysts* are much less common than the above, nor are they so large, rarely exceeding the size of a pregnant uterus at term and usually being much smaller. Externally they resemble the pseudo-mucinous, but have a greater tendency to adhere to the surrounding organs by means of bands. They are usually multilocular, but contain fewer divisions than do the pseudo-mucinous cysts. They contain a clear, thin, yellowish or greenish fluid, in which albumin is present to a large extent. This fluid is produced partly from the blood-vessels and partly by secretion by the glands in the lining membrane. The composition of the cyst wall is the same as that of the pseudo-mucinous; the cells of the epithelium are columnar and ciliated.

Symptoms of Ovarian Cysts.—The patient may merely have a vague sense of fulness of the abdomen or of weight in the pelvis, or else she may experience no sensations whatever until she accidently discovers a lump in the lower abdomen. There may be no interference with menstruation, so that when it ceases suddenly one should always be on guard lest pregnancy has occurred. At times the flow is in-

creased, in which case an endometritis may be found to exist.

The physical signs will vary according to the size of the tumor. Where this is small and confined to the pelvis, a bimanual examination will reveal an ovoid, tense cystic swelling to one side of the uterus. Rarely it may occupy the middle line, as occurred in a case of the writer's, the tumor lying in front of the uterus, where it was held by an adhesion on one side and the Fallopian tube on the other. A tumor of this size would cause a downward bulging of the vaginal fornix and could be easily felt by the finger in the vagina, as would also be the case when the contents of a large tumor were very fluid or the cyst was unilocular. When, however, the tumor has risen out of the pelvis it rests upon the brim, and the only sign of its presence to be made out by the examining finger is the depression of the uterus. On inspecting the abdomen, an enlargement is to be seen of the lower part and usually to one side, this enlargement being either regular or uneven. Upon palpation the mass will usually be felt to be tense, but fluctuating, though when the contents are gelatinous the sensation may be similar to that caused by a soft myoma. When the tumor is unilocular, or one loculus is especially large with very fluid contents, a thrill may be obtained by flicking the mass with the finger on one side, while the other hand is placed on the opposite side. This may be intensified by requiring an assistant to exert pressure on the mass by means of the outer edge of his hand placed mesially on the abdomen. Percussion will show that the intestines are pushed into the upper part of the abdomen and to the sides, and turning the patient on one side produces no change in the areas of dulness, an ovarian cyst differing in these two points from free abdominal ascites in which the percussion note is clear in whichever part of the abdomen happens to be uppermost at the time.

Diagnosis of small ovarian tumors (*i.e.* while they lie wholly in the pelvis) is not as a rule difficult. The peculiar tense, semi-fluctuating sensation imparted to the examining finger by an ovarian cyst is felt in practically no other conditions than hydro- and hematosalpinx and encysted peritonitis. In the two former conditions the mass is elongated or sausage-shaped instead of ovoid as in the case of a cyst. Encysted peritonitis is fixed and has not the clearly defined margin of the ovarian tumor. When the cyst is adherent the diagnosis is more difficult, but space forbids further consideration of the subject. Of course, a parovarian cyst may be mistaken for an ovarian growth, but the treatment is the same and a definite diagnosis can be made only by opening the abdomen.

When the tumor has risen out of the pelvis it may be mistaken for ascites, a distended bladder, a tumor of the uterus (fibroma, myoma, or fibrocyst), cyst of the mesentery, ovarian dermoid, renal cysts, hydronephrosis, phantom tumors, cyst of the parovarium, and pregnancy with hydramnios.

In *ascites*, unless encysted, the flanks bulge and the enlargement does not stand up prominently, as in the case of an ovarian cyst. Percussion will give a clear note over the highest point in the abdomen. That is to say, with the patient on her back a tympanitic note will be heard in the region of the umbilicus, while the note in the flanks will be dull; whereas if she is turned on her side, the flank which is uppermost will yield a clear note. Exceptions to this rule, however, occur now and then, as was well illustrated in a case which came under the writer's observation some years ago. An immigrant woman was brought into hospital and found to have a swelling of the abdomen which progressed rapidly. The fluid impact wave was readily obtained and percussion gave a dull note all over the abdomen, except just below the sternum. Posture made no change in this note. The uterus and vaginal fornices were depressed. The heart, liver, and kidneys were healthy, and a diagnosis of a rapidly growing parovarian cyst was made. On opening the abdomen for its removal a large quantity of fluid was removed from the general peritoneal cavity and the pelvic organs were found to be healthy. Shortness of the mesentery preventing the intestines from floating to the surface and the excessive quantity of fluid present accounted for the absence of the clear percussion note from its usual situation.

A *distended bladder* occupies the median line of the lower abdomen and appears as a tense pyramidal mass above the pubes. There is generally dribbling of urine, and careful catheterization of the bladder will clear up the diagnosis. For this little operation a male metallic instrument is the best, as something may be pressed against the bladder diagonally, thus cutting off the part into which the ureter of one side opens. A rubber catheter will coil up in the free part of the bladder, and this also will be the only part of the organ which can be emptied by the ordinary short glass catheter, while the long metallic instrument can be cautiously guided past the obstruction into the dilated portion.

Myomata and *fibromata* of the uterus are hard, and palpation fails to elicit any fluctuation. They move with the uterus, the cavity of which is enlarged. If they are interstitial or submucous, menstruation is increased.

A *fibrocyst* of the uterus gives fluctuation, but moves with and is evidently attached to the uterus. It is a very rare form of neoplasm, and if it is punctured and if the fluid is allowed to stand spontaneous coagulation quickly supervenes.

Cysts of the mesentery have a clear percussion note all around them, if they are not large enough to fill the whole abdomen, in which case a history of the growth having proceeded from above downward and not *vice versa*, as is the case of ovarian affections, can usually be obtained.

A *dermoid of the ovary* is of slow growth and may occur in a very young girl.

Renal cystic tumors and hydronephrosis give a history of progressive enlargement from above downward and can usually be separated from the pelvic organs. In the case of hydronephrosis ureteral catheterization will usually clear up the diagnosis.

Phantom tumors disappear when the patient is anesthetized.

Pregnancy with hydramnios may be diagnosed by observing the rhythmical uterine contractions, by auscultation, and by the softening of the cervix and the changes in the breast coexistent with pregnancy. There will also be the history of amenorrhea, and when all else fails time will clear up the diagnosis.

A *cyst of the parovarium* grows quickly, is never nodular, and, owing to its being unilocular and containing very limpid fluid, gives the wave impact very distinctly.

Complications of Ovarian Cysts.—Any organ or structure in the body may become diseased contemporaneously with tumor formation in the ovary, but the most common complications are albuminuria, ascites, adhesions, pregnancy, rupture of the tumor, and torsion of the pedicle.

The coexistence of *pregnancy* and ovarian cyst is grave and requires care before, during, and after labor. If the cyst is large an abortion is very apt to result. The tumor is very liable to rotate, causing torsion of its pedicle after labor, owing to the change in the intraabdominal pressure. Infection and consequent suppuration of the cyst are also apt to occur. When pregnancy goes to full term the fetal and maternal mortality is high. In 271 cases of ovarian tumor complicating labor, there was a maternal mortality of 25 per cent. and a fetal of 75 per cent., while Zitter and Litzmann place the maternal death rate at 30 and 43 per cent. respectively.

Torsion of the pedicle is a not infrequent compli-

cation of ovarian cysts; dermoids, probably on account of the difference in consistence and weight of various sections of the growth, being the variety most often affected. Its onset may be either acute or gradual, the former being naturally the more grave.

The *symptoms* of a twisted pedicle are a sudden, acute pain, followed by rapid enlargement of the tumor. The abdomen becomes tender and the patient may show evidences of most profound shock, the respirations becoming rapid, the pulse small, thready, and rapid, with later on a rise of temperature.

When the onset is more gradual there may be few or no special symptoms. There may be an increase of the previous pain and some enlargement of the tumor. The rapid increase in size of the tumor is due to congestion, which may be so great as to cause hemorrhage into the tumor substance or even into the peritoneal cavity.

The only *treatment* is to operate without delay.

Ascites may accompany an ovarian tumor, especially if it be malignant. Its chief importance lies in the probability of there being disease of the heart, kidneys, or liver, and in its rendering the diagnosis difficult.

Albuminuria should be looked for and cured if possible before any operative interference is carried out. It *may* be caused by pressure of the tumor on the ureters, in which case it will disappear after removal of the growth and no casts will be found in the urine.

Adhesion of the tumor to neighboring organs forms a serious complication when an operation is called for. These adhesions may be so intimate as to offer sufficient nourishment to the tumor even after it has been freed from its usual attachment, as sometimes occurs in torsion of the pedicle. They also complicate the diagnosis, as, for instance, when the tumor becomes adherent to and moves with the uterus.

Rupture of the cyst may occur and may be followed by permanent disappearance of the growth, or this may refill. When the contents are either irritating, as in the case of a dermoid, or malignant, a general peritonitis or secondary infection of the peritoneal cavity will follow. In some cases a blood-vessel will be torn through and a more or less severe hemorrhage into the peritoneal cavity may take place.

Prognosis.—If left alone ovarian cysts are apt to increase in size until they prove fatal through interference with the alimentary, cardiac, digestive, and respiratory systems.

Treatment.—Removal of the cyst by either the abdominal or the vaginal route is the only treatment indicated. Formerly frequent tapping of the tumor and withdrawal of the contents were practised, but ovariotomy is now so safe a measure as to have no rival in the treatment of this condition. Tapping is not only useless, but is distinctly dangerous, as it sets up adhesions and may allow leakage into the peritoneal cavity, is liable to cause sepsis, and puncture of bowel or blood-vessels may occur, and the fluid tends to accumulate more rapidly afterward. Even when the tumor has ruptured spontaneously operation may be indicated by peritonitis or by hemorrhage. In a case of the writer's, rupture took place half an hour before the time appointed for operation, and on opening the abdomen, the cavity was found to contain a large quantity of fluid blood which had escaped from a vessel that had been torn across.

Ovarian Dermoids.—In women, dermoid tumors have never been found growing from any other organ in the abdominal cavity than the ovaries. They are comparatively rare, only between three and four per cent. of all ovarian tumors being of this nature. They may occur at any age, but are more liable to occur before puberty than any other form of ovarian tumor. Usually only one ovary is affected, but now and then the disease attacks both.

Until recently it was maintained that they were due to inclusion, in the developing ovary, of cells from the other layers, but Wilms has lately suggested the probability of their being caused by some eccentric development of ova, and he supports this theory by the facts of their being found occasionally in the fetus, and of the tumor containing traces sometimes of nearly every organ in the body, which is not the case with dermoids situated elsewhere.

Ovarian dermoids are not large tumors, rarely being seen larger than a man's head. They contain a cheesy material, in which may be found almost any organ of the body, sometimes in a very rudimentary state. One of the commonest structures found is hair, which may measure five feet in length but which is usually short. In addition to these substances, teeth are often found embedded in the cyst wall, where also rudimentary mammæ may be seen. A heart with a mitral valve and chordæ tendineæ has once been described as having been found in a dermoid of the ovary. The more fluid contents are extremely irritating to the peritoneum, and if they escape into the peritoneal cavity they are almost sure to set up a most intense inflammation of its lining.

An ovarian dermoid gives rise to the symptoms of an ordiuary ovarian cyst, from which it may be diagnosed by its slow growth and the peculiar want of elasticity which it imparts to the examining hand. An ovarian tumor seen in a girl before puberty is much more likely to be a dermoid than one of any other variety.

The proper *treatment* is to remove the tumor.

Papillomatous Tumors of the Ovary.—This variety of ovarian cyst is of sufficient importance to warrant some special consideration, and is divided into two groups, according as to whether the papillomata occur inside the cyst or on the outside of its wall.

1. *Papillomatous cystoma of the ovary* may be shortly described as a cystic tumor of the ovary containing masses of papillæ; from the tendency to form secondary growths, it may be looked upon as malignant.

Olshausen, in 1877, noted the difference between simple cysts and those containing papillary projections. Inspection of the tumor with the naked eye reveals numerous papillæ on the inner surface of the cyst wall. These may be few in number or else so numerous as completely to fill the cavity of the cyst and even at times cause its rupture. The papillæ are pedunculated and vary from a simple projection to a most complicated branching structure. Not only does this shape vary, but the color may range from almost white to a pinkish hue, this depending on the supply of blood going to the papillæ and also on their consistence. They are usually soft, but may contain sand-like bodies which cause the growths to feel gritty. After perforation of the cyst wall the peritoneum and other organs may become infected.

These cysts usually contain a clear, thin, watery fluid of a yellow color and alkaline reacton. It has a specific gravity of from 1.005 to 1.040, and does not coagulate on standing. It responds to the tests for albumin. On examining the fluid with the microscope, it may be seen to contain epithelial elements, compound granular bodies, and sometimes cholesterin and hematoidin crystals. Instead of the fluid being clear, however, it may be dark and turbid or even grumous, the character varying at times even in different parts of the same tumor.

Microscopical Appearances.—In a pedunculated cyst, the wall has an outer layer which is thin and dense. It is composed of laminated tissue, a few cells, and occasionally non-striped muscular tissue may be seen. The next layer is thicker and more

cellular. Both contain blood-vessels. Internal to this second is a third layer, composed of epithelium which sometimes rests upon a thin homogeneous basement membrane. The epithelial cells may be cuboidal, cylindrical, or, in fact, almost any shape. Cilia may or may not be present, and even in the same tumor some cells may bear cilia while their neighbors do not, their absence or presence being purely accidental and having no bearing upon the case (J. W. Williams). These cells may be in one layer or in several, and in small cysts they are not usually so high as where they simply cover papillæ, the low merging gradually into the high. In the smaller cysts also, part of the outer wall may be replaced by true ovarian tissue. The stroma of the cyst wall, which may be dense and well formed, or else somewhat myxomatous, continues up through the pedicle into the papillæ, and is usually well supplied with blood-vessels, which are thus enabled to pour out a portion of their serum and so contribute their quota toward the fluid contents of the cyst.

The sand-like bodies, above referred to, are called psammomata, and consist of particles of carbonate and phosphate of calcium arranged in concentric rings.

Papillomata may extend from their primary site by three methods. They may do so by direct extension to contiguous structures, by the attachment of small broken-off fragments of the growth to the peritoneum, and lastly by true metastatic formation.

In the early stage no diagnosis of the exact nature of the pathological process is possible. This is clear only when the ascites can be made out, when the psammomata can be felt per vaginam, or when papillomatous masses burst into the bladder or rectum. Freund considers that the simultaneous appearance of ascites and hydrothorax favors the diagnosis of papilloma ovarii.

These cysts are apt to burrow between the layers of the broad ligament, both toward its base and laterally toward the uterus. They occur most frequently between the ages of twenty-five and fifty.

2. *Superficial papillomata of the ovary* are more rare than intracystic growths, and like them are nearly always bilateral. They are formed of branched, usually pedunculated masses, springing from the surface of the ovary. Their histological structure resembles that of the intracystic form of the disease, the epithelium being continuous with the germinal epithelium, as is also the case in some intracystic growths, although the etiology of the latter is uncertain.

The *treatment* of papillomatous disease of the ovary is prompt and thorough removal of the diseased structures, and this is usually followed by permanent relief.

F. A. L. Lockhart.

Ovariotomy.—Ovariotomy is the term applied to any operation for the removal of one or both ovaries, irrespective of the indication for such a procedure. Many operators, however, restrict the meaning of the word to the removal of the ovaries when they are sufficiently diseased and enlarged to warrant their being spoken of as "tumors," whereas "oöphorectomy" indicates their removal for some other condition, as, for instance, chronic ovaritis.

The operation of removal of the ovaries is not a new one, its history extending back into remote antiquity. In his "Denosophists," Athenæus relates that "Adamythes, King of the Lydians, was the first man who ever castrated women, and used females instead of males as eunuchs." It is said that Athenæus was not the only offender against the integrity of the female abdomen in this respect but that the custom was followed by other rulers of his time. Considering the enormous rate of mortality after the earlier cases of invasion of the peritoneal cavity for medical purposes, this story savors more of legend than of authentic history and we must take a long leap forward, *i.e.* until the early part of the eighteenth century for the first authentic case of deliberate ovariotomy, casting aside the story of the German swineherd who castrated his own daughter in order to lessen her amatory wanderings.

Ephraim McDowell of Kentucky is usually credited with being the first ovariotomist, but in August, 1701, Robert Houston, of Edinburgh, opened a woman's abdomen for a large ovarian tumor. The patient survived the operation for thirteen years and her recovery may have been largely due to the fact that the incision and whole abdomen were covered with cloths wrung out of "French brandy." What better antiseptic than this? It was 108 years later, viz., in 1809, that McDowell, a pupil of John Bell of Edinburgh removed an ovarian cyst from a patient. During his studies in Edinburgh, he had probably heard of Houston's operation and been inspired by it. Nathan Smith, of New Haven, Conn., performed a similar operation a few years later and it is said that he had not heard of the work of McDowell, news traveling but slowly in those days. The operation then fell into desuetude until 1843, when J. L. Atlee revived it, performing the first double ovariotomy. A namesake of his, Washington Atlee, continued the work and was so enthusiastic that by 1841 he had performed no less than 246 ovariotomies. To Lizars, Clay, Granville, and, later, Spencer Wells is due the successful reintroduction of the operation into Great Britain. During this time it was performed once or twice in Germany, but it was Kœberlé and Péan who thoroughly established it in France, they probably having been inspired by Nélaton, who had visited England in 1862 to see the work of Spencer Wells. Kœberlé, Péan, and Wells were considered to be most successful operators and performed a large number of ovariotomies, but the real success only came with the introduction of antiseptics, for which the whole world is under such a debt of gratitude to the late Lord Lister. The originators of the germ theory had a hard fight before it became established, and it is interesting to read the views of Lawson Tait, published as recently as 1883, he claiming that the question was still very much *sub judice*.

Mortality.—In the earlier history of the operation, palliative measures, such as tapping, were practised and one frequently saw cysts of huge proportions, owing to the tremendous mortality following ovariotomy, but now, thanks to anesthetics and Listerism, the abdomen may be opened and tumors removed with comparative impunity with the result that patients are submitted to operation at a comparatively early stage of development of the growth.

In "The Works of Sir James Y. Simpson," published in 1872 but written at an earlier date, he gives the mortality tables of four of the principal operators of the time, viz.,

Fock	292 cases with	120 deaths.
Atlee	179 cases with	59 deaths.
Simon	44 cases with	32 deaths.
Clay	93 cases with	29 deaths.

Now, thanks to earlier interference and improved technique, the evil results have been so greatly lessened, that, to quote the words of an experienced and reliable English gynecologist, "at the present day it may be truly said that ovariotomy has scarcely any legitimate mortality;" it has been reduced, in the hands of experienced operators, to less than one per cent.

Indications.—When one discovers in a woman of forty a fibroid tumor of the uterus which is giving rise to no symptoms, the conscientious physician does not advise operation, as he knows that after the establishment of the menopause there is a fair possi-

bility of the tumor simply remaining *in statu quo* or even undergoing some diminution in size. In the case of a tumor of the ovary, however, it is a different question as it never ceases to grow but increases in size either steadily or intermittently. Therefore, once an ovarian tumor is discovered, it should be removed. If the ovaries have not assumed the dignity of tumors, when is one justified in their removal?

1. Occasionally, a patient who has a large uterine fibroid tumor is too greatly exhausted by hemorrhage to stand the shock of such an operation as its removal would necessitate. In such a case, it is possible to check the hemorrhage and even cause some diminution in the size of the tumor by removing both ovaries. This was almost the recognized method of treatment of such cases up until a few years ago, but now our increased knowledge of how best to support the strength of such patients and to increase their powers of resistance has rendered this operation almost obsolete.

2. Removal of the ovaries is indicated where the patient is afflicted with osteomalacia.

3. In some women, the ovaries become cirrhotic, causing such intense pain during menstruation that one is justified in removing these organs for its relief. Such cases are but rarely met with, however, so that we must be sure that the diseased ovaries are the cause of the pain and that its origin does not exist elsewhere before submitting the woman to such a mutilating operation. Where it is indicated, good results have been reported following the implantation of a portion of ovarian tissue into either the muscle of the abdominal wall or the fundus uteri.

4. Where the ovary is the seat of abscess formation, it is seldom that anything short of its complete removal will cure the patient.

5. In certain cases of epilepsy, removal of the ovaries is indicated. This is only justifiable, however, when the attacks begin after puberty and their subsequent occurrence bears a definite relationship to the menstrual periods.

Preparation of Patient.—This will depend a good deal upon whether or not the patient is exhausted by the steady growth of a large tumor or extensive hemorrhage or the case is simply one of removal of chronically diseased appendages. Where greatly debilitated, the patient should be put to bed and kept there and her bowels regulated. Her strength must be built up by light but nourishing diet and general tonics. When at last ready for operation, she should be given a light lunch in the middle of the day before operation and tea with bread and butter, jam or other sweet if desired, or a poached egg. Her bowels should be evacuated by giving an ounce of oleum ricini or magnesium sulphate during the afternoon, followed by a soapsuds enema at 6 o'clock the next morning. At 7 A.M. she may be given a cup of tea, warm milk, or light broth and one hour before the time of operation, hyoscine hydrobromate, gr. $\frac{1}{100}$, is given hypodermically. This somewhat interferes with the pupillary reflexes during the administration of the anesthetic but greatly lessens the secretion of mucus and, therefore, of postoperative vomiting.

The *anesthetic* used may be either chloroform, ether, or one of the mixtures, or spinal anesthesia may be employed, but ether, in the absence of any contraindication, is the most reliable.

Assistants, Etc.—The assistants necessary are two in number, one for the anesthetic and one to assist the operator, but where the patient is not in good condition it is well to have a third who can watch the pulse, etc., and administer any restoratives or stimulants, such as an instillation of saline solution under the breasts. The anesthetist wears a sterilized coat while the operator and his principal assistant don sterilized coats, caps, facial masks, and rubber gloves, after having thoroughly sterilized their hands and arms.

There ought to be at least three nurses in the operating room, but it is a mistake to have too many as they only interfere with one another. One nurse is to look after the sutures, etc., one the gauzes and the third be ready to handle the cautery, change the solutions and do whatever may be required of her. All three ought to wear sterilized gowns and have their hair covered with sterile gauze, while the suture nurse and gauze nurse are to wear rubber gloves.

The operating room ought to be bright and, where at all possible, have a north light, as well as be supplied with good artificial illumination. It ought to be quite free from draughts and be kept at a temperature of 80° F.

The operating-table is to be placed in such a position that the best light is obtained, with stands for instruments at the right hand of the operator. The basins for the gauzes are to be placed on stands to the left of the assistant and as near the table as possible in case the operator himself wishes a gauze. Basins containing cold sterilized water should be so situated that the operator and his assistant may readily rinse their hands, the cold being very refreshing when the fingers are tired from separating adhesions deep down in the pelvis. The nurse who is looking after the sutures ought to stand slightly behind and to the right of the operator.

For keeping clean the field of operation, pads from six to eight inches square (it is well to have both sizes) and made of four layers of gauze or cheese-cloth, the edges turned in and well sewn together so as to leave no loose threads which might be left in the abdomen, are used. The number required will vary with the case, from one to six dozen being used. In addition two gauze towels, of a similar thickness to the pads but measuring about eighteen inches square and having long tapes attached to one corner, will be found most useful in walling off the actual abdominal cavity while working in the pelvis. They not only keep the intestines warm but they prevent their being soiled by the contents of, say, an ovarian abscess. These pads and towels must be most carefully counted just before the operation and again immediately before the abdomen is closed, the counting being checked by one of the other nurses. The ligature material employed should be of catgut of various sizes, using a No. 4 for the pedicle, No. 1 for the peritoneum and No. 2 for the fascia and subcutaneous tissue. For the skin, one may use either interrupted or continuous sutures of silkworm gut or else pins or clips. Where there is not much tension, and this is avoided by a running suture in the subcutaneous tissue, the writer uses either pins or a subcuticular silkworm gut. The ligature for the pedicle should be about seventy centimeters in length but the sutures will vary with the length of the incision and amount of subcutaneous fat present.

The instruments required are:

Two scalpels.

One pair of dissecting forceps.

One dozen pairs of artery forceps.

Two pairs of clamp forceps.

Two pairs of scissors (one angled and one curved on the flat).

One needle driver.

Four or five assorted needles (curved and straight), one of which should be a cambric needle in case the intestine is wounded or it is found necessary to remove the appendix.

One MacEwan's needle of large size.

Clips or pins for the skin, if they are to be used.

One graduated glass douche, with a piece of rubber tubing at least three feet long and having a glass irrigator nozzle at its end.

One thermocautery.

One pair of swab forceps.

One pair of retractors.

Two pairs of tenaculum forceps.

The usual restoratives and stimulants, such as camphor oil, strychnine, saline for hypodermic use, etc., ought to be ready at hand in the operating room, together with the apparatus required by the anesthetist, such as tongue forceps, masks, small basin, etc. Plenty of sterilized sheets and towels ought also to be at hand, and a stool for the anesthetist must be provided, together with a stand for his appliances.

The patient having been anesthetized and placed upon the operating-table, the abdomen is scrubbed with soft soap and water, which are thoroughly rinsed off with plain sterile water. It is now well rubbed over with alcoholic bichloride, 1 in 500, and all except the field of operation is covered with sterile sheets and towels. This method of sterilizing the field of operation has now been employed for some years by the writer and found to be perfectly satisfactory. The bladder is now emptied by the catheter no matter how recently the woman has voided, as the anesthetic frequently increases the secretion of urine. She is then placed in the Trendelenburg position and the abdominal cavity opened by means of an incision through its wall, the surgeon standing on the right side of the patient. This incision is to be made through the skin and subcutaneous tissues in the middle line, the lower end beginning about four centimeters above the upper margin of the pubic bone. The length will vary from five to ten centimeters, according to the thickness of the abdominal wall, the skill of the operator, etc. While making the incision as small as possible, the opening should not be too small to admit of free access to and manipulation of the affected parts. After cutting through the skin and subcutaneous structures, you come upon the white glistening fascia which forms the anterior sheath of the rectus muscle. An incision is made through this just to the side of the middle line so that only the sheath of one muscle is opened. The inner border of this muscle is defined and the muscle held to one side, thus exposing the fascia posteriorly. This is caught between two pairs of forceps opposite to one another and divided between them. The subperitoneal tissue is now brought into view and divided in a similar manner until the peritoneum is exposed. This appears as a thin glistening membrane of a bluish color. It should be also caught up by two pairs of forceps and simply be nicked between them by the point of the scalpel. This allows air to enter the peritoneal cavity so that its contents recede from the anterior wall, when the opening may be enlarged. This may be effected by either scissors or knife, a pair of angled scissors with the lower blade blunt pointed being the best. Great care must be taken in making this enlargement to keep the point of the scissors close against the abdominal wall so as to avoid any possibility of cutting the intestine. It is well now to push the intestines well up into the abdominal cavity and to retain them there by one or two abdominal towels, these serving to protect them from injury and exposure to cold or contamination. The contents of the pelvis should now be examined, each ovary and tube being lifted into the incision and inspected. Where adhesions between the appendages and the surrounding structures exist, they must be separated with the greatest care, using either the finger tips to break them down or wiping them off with gauzes. Occasionally some of these adhesions will be found to be so dense as to require cutting with the knife or scissors but this is seldom required and must only be done when all of the structures can be distinctly seen. If they extend between the ovary and bowel and part of either organ has to be sacrificed, it is best to leave a slice of the ovary as this does not weaken the bowel wall, but the surface ought to be well cauterized. Where the bowel has been injured, the edges of that portion should be inverted by a continuous suture of fine catgut, or it may be covered by cutting off a thin piece of omentum and stitching it in place. Once freed from its adhesions, the ovary is lifted up into the wound and held there while the blood-vessels, etc., of its pedicle are being secured. This may be effected by either ligating the broad ligament *en masse* or else by clamping it, cutting off the ovary on the side of the clamp distal to the uterus, ligating any individual vessels and bringing both layers of the broad ligament together by a running suture of fine catgut in such a manner that no raw surface remains uncovered by peritoneum. When ligature *en masse* is practised, one of two methods may be employed, viz., by the Staffordshire knot or the chain ligature. In both cases, the broad ligament is to be perforated in the center by a MacEwan's needle carrying a double ligature. The needle is withdrawn, leaving the ligature with the loop on one side and the two ends, equal in length, on the other. In the Staffordshire knot, the loop is carried up over the ovary, and one end is passed through the loop and over it. On tying these two ends over the loop, the pedicle is found to be tightly embraced by the ligature. When the chain ligature is adopted, the loop is divided, thus making two ligatures, the ends of which are brought around the opposite sides of the pedicle and tied, after crossing the two ligatures. Each half of the pedicle is now seen to be compressed by a ligature, the two interlacing and making two links of a chain. The latter is the best method as the ligature is less likely to slip. After the ligatures are tied, in either method, the attachments of the ovary to the broad ligament are divided between the ovary and ligature, taking great care to leave a button of tissue sufficiently large to prevent the ligature from slipping, and the raw surface is thoroughly cauterized or the edges are united by continuous sutures of catgut. The pelvic cavity is now gently cleansed with gauze and the pedicle is inspected to see that the hemorrhage has been completely controlled.

Where the ovary is the seat of abscess formation, especial care must be taken in packing off the pelvis with abdominal towels and an endeavor to remove the sac intact must be made. It may even be considered wise to empty the sac by aspiration and closing the opening made by the aspirating needle by clamp forceps before attempting its removal but this is rarely necessary as operation is seldom called for until the pus has become entirely or partially sterile. Should pus escape and soil the field of operation, the latter may be cleansed by gauzes saturated with 1–500 hot formaline solution and the bed of the sac may remain packed with these gauzes for some minutes, this usually ensuring sterility of the parts. All towels and gauzes must now be removed from the abdomen and the parts carefully inspected to see that there are no free bleeding points. (The question of drainage will be discussed later.) The abdominal wound is to be now closed but, before doing so, the gauzes and towels must be carefully counted to see that none remain in the abdominal cavity. The edges of the wound in the peritoneum are now caught in at least four pairs of forceps, one at the center on each side and one at each extremity, after which, if the wound is of any size, a gauze should be spread out over the intestines, one end being caught in forceps to ensure its final removal. These edges are now united by a continuous suture of fine catgut, but before the last two or three stitches are taken remove the gauze pad and fill the abdomen with normal saline solution if it is deemed advisable. Having closed off the peritoneal cavity, bring the edges of the fascia together with a continuous catgut suture and also the opposing surfaces of the subcutaneous tissue. If the patient has suffered from undue separation of the recti, these and the anterior layers of their fascial sheaths ought to be united by two layers of mattress sutures of catgut, one for the fascia and one for the muscles, but other-

wise it will be unnecessary to touch the latter, their action being vertical and parallel, this tending to approximate them. It only now remains for us to unite the edges of the skin incision, which may be effected by spring pins, Michel clips, or a subcuticular suture of silkworm gut. Where the incision is small or but little tension is expected, the pins or clips are excellent as they are quickly applied, otherwise the subcuticular suture is to be highly commended. Where for any reason it is considered necessary to hasten the operation, "through and through" sutures may be used for the abdominal incision. These are sutures which are passed through the entire thickness of the abdominal wall and usually consist of either silk or silkworm gut. The latter is to be preferred as it is not so liable to absorb infective material and is much more smooth, which makes its withdrawal easier. For inserting these sutures, a large, strong curved needle is necessary. The abdominal wall of one side is lifted up and the needle passed from the skin through all of the layers into the peritoneal cavity and then on the opposite side through from the peritoneal cavity to the skin. They are placed about one centimeter apart and their points of entrance and exit are one centimeter from the cut edge of the skin. As soon as the last suture is in place, remove the gauze which has been protecting the intestines from the abdominal cavity. Make the assistant hold up the ends of the sutures so that there will be no danger of catching any bowel or omentum between them and the skin and then proceed to tie them. When all are tied, cover the wound with boracic and a few layers of gauze, over which the ends of the sutures are folded, and then apply the absorbent cotton. The line of incision is now smothered with powdered boracic acid and two or three layers of gauze applied. If the suture has been used, the ends are now tied over the gauze, cutting the ends short and taking care that there is no tension put on the ends where it enters and leaves the skin. The whole is now covered with a thick layer of absorbent wool, which is held in place by adhesive straps two inches wide and sufficiently long to go well around onto the flanks. The patient is then taken back to the ward and placed in bed with hot-water bottles around her.

When the ovary is the seat of tumor formation, the procedure is somewhat different. The patient will probably require a longer period of rest in bed and general building up before operation and it may be well to start giving her a submammary injection of normal saline as soon as she is completely under the anesthetic on the operating-table and allow it to run during the operation. In addition to the instruments enumerated above, one should have two pairs of strong curved clamp forceps, a trocar for emptying the cyst, and two pairs of short but strong-bladed clamp forceps. After opening up the abdominal cavity as before, except that the incision will have to be larger, the hand should be passed all around the tumor in order to determine its origin, its consistence, and the presence or absence of any adhesions. Having done this and separated any adhesions which are not too strong, one should proceed to deliver the tumor from the abdominal cavity. In view of the latest pathological findings which indicate that many of these tumors are malignant and that there is danger of the occurrence of secondary growths if any of the contents escape into the peritoneal cavity, many authorities strongly recommend the removal of the cyst intact, irrespective of the size of the incision required for the purpose. In the absence of the slightest sign of malignancy, however, where the tumor is very large, it may be emptied with immunity before removal, provided care is taken not to allow any of the contents to escape into the peritoneal cavity. When it has been determined to withdraw the contents of the cyst, it should be packed all around with abdominal towels and, by pressing upward in the flanks, the assistant must keep the tumor well up against the abdominal wall. A blunt-pointed cannula is now thrust through the cyst wall and the contents allowed to escape into some receptacle, but this escape must not be too sudden, as then the abdominal vessels become distended too quickly, which is liable to be followed by syncope. As soon as the cyst becomes sufficiently relaxed, the wall is caught up by strong clamp forceps by which it is held up. Frequently these tumors are made up of several cysts, one inside of the other, so that only one is emptied by the trocar at first. This may be thrust deeper and so open up one after another until the whole mass may be drawn out of the abdomen. Where this fails increase the size of the opening in the cyst wall so that you may put one or two fingers, or possibly the whole hand, into the interior of the cyst and so be able to thoroughly break down the walls of the loculi. As soon as sufficient of the contents have been evacuated, the cyst wall is drawn through the incision, after having closed any openings in the wall by means of the curved forceps. If there still remain any adhesions, they are to be separated, and some may be so dense and tough that it will be necessary to tie them off and then cut them between the cyst and the ligature. The pedicle is now tied off, as above described, divided and cauterized, and dropped back into the abdomen, the toilet of which is made as before and the abdomen closed after filling it with normal saline solution.

When the tumor is solid, after separating any adhesions it is simply delivered out through the incision and the pedicle tied off and divided.

In some cases, the tumor has burrowed between the layers of the broad ligament, which complicates the operation very greatly. An attempt may be made to enucleate it from its bed by making an incision through the peritoneum covering it and trying to dissect it out. At times this is successful, in which case the pedicle is treated as before, but very frequently the separation will be found to be so difficult or to cause so much hemorrhage that it will be necessary to remove, not only the tumor but the uterus as well, going down one side of the uterus and up the other.

Incomplete operation is seldom necessary but one meets occasionally with cases where part or parts of the cyst cannot be removed. This may be due to either malignancy or such dense and extensive adhesions to the intestines or pelvic wall, that complete removal would be both dangerous and useless. In such cases, as much of the growth should be excised as possible and an attempt made to marsupialize the sac, *i.e.* the edges are to be brought up to the incision in the abdominal wall and sutured there, or, if this is impossible, they may be attached to the edges of an opening in the vaginal vault. In either case, the sac is to be packed with sterile gauze, which tends to destroy the epithelial lining of the sac, the latter gradually contracting and becoming obliterated. As an alternative, the lining may be destroyed by carbolic acid or the cautery or it may be curetted, after which it is to be lightly packed with gauze, the end of which may be brought out through either the abdominal or vaginal incision.

Where the bladder or bowel has been opened during operation, immediate closure is indicated and is to be effected by a series of Lambert sutures. Where it is the bladder which has been wounded, and the urine is sterile, as it usually is, very little harm is to be expected to result, but the condition is much more serious when the bowel has been the seat of injury owing to the danger of infection.

Drainage.—In the early history of ovariotomy, drainage was always considered necessary but is now never practised in clean, uncomplicated cases. At present, we drain the abdomen: (1) In cases of extensive adhesions, when the oozing cannot be completely stopped; (2) when the bowel has been

wounded; (3) when the bladder containing non-sterile urine has been opened; (4) when pus has escaped into the peritoneal cavity; (5) in cases of dermoid tumors which have ruptured, as their contents are very irritating and liable to set up an irritative peritonitis; (6) in incomplete operations.

Drainage may be effected through the abdominal incision, through an opening in the posterior vaginal fornix or by both and the method will largely depend upon the individuality of the operator, but where one has to deal with an infection which is very virulent the combined abdomino-vaginal method is much the best.

The *materials used* are (a) rubber tubing with or without gauze; (b) "a cigarette drain;" (c) or plain gauze. The rubber tubing is the best where it is decided to drain by the combined method, but ought to be avoided if possible as it is liable to impinge upon and injure the bowel. The "cigarette drain," consisting of gauze surrounded by rubber tissue, is excellent, as it allows of good drainage and is not liable to do any damage, but, when the field of operation requires to be packed, gauze is absolutely essential.

When is the drain to be removed? Where the infection is slight it may be taken out at the end of forty-eight hours and the incision simply covered with powdered boric acid. In more acute cases, the dressings ought to be changed once or twice a day, according to the amount and condition of the discharge the drain being gradually removed as the latter lessens in amount and virulence. Where the wound discharges for some days, it will be found useful, after removal of the drain and washing the wound with antiseptics, to syringe it out with hydrogen peroxide, as this is often the only method of cleaning out the lower portions of the wound.

After-treatment.—Although the administration of hyoscine before operation will tend to check the vomiting, there are cases in which it will fail and, where such an event is suspected, it will be well to wash out the stomach while the patient is still on the operating-table and under an anesthetic. If it persists, the application of counterirritation, such as that caused by a mustard paste, over the epigastrium, will often be found useful. Where the vomites contain an excess of bile, gastric lavage may be effected by allowing the patient to drink a quantity of tepid water, thus provoking emesis and flushing out the deleterious material. In other cases, the administration of small doses of calomel or vin ipecac frequently repeated will stop the gastric irritation. Cold effervescing fluids, such as ginger ale or champagne, are good. They should be given in very small quantities at a time on cracked ice. Sips of hot water or fragments of cracked ice placed on the tongue and allowed to dissolve there are at times comforting. Elevation of the head of the bed sometimes stops nausea. When especially obstinate, stop giving anything by the mouth for some hours, keeping up the patient's strength by rectal alimentation, using enemata of beef tea or peptonized milk repeated every four or six hours, or even saline enemata may serve to tide the patient over until her stomach can retain and digest food. Spirits of chloroform or spirits of camphor are also beneficial at times. Once the stomach is quieted down, you may begin to give nourishment. It is best to start with sips of either hot or cold water. Then a little hot tea without sugar may be tried and this may be followed by small quantities of milk and soda or Vichy, adding more and more milk until it is being taken undiluted. The milk may be replaced by, or alternate with, albumin water. The above should be followed by plain broths or soups, these in turn being followed, or supplemented by, fish or boiled or poached eggs, milk puddings, etc., in three or four days, from which time the patient ought to be gradually worked up to full diet.

If the pulse is not good just after leaving the operating room, stimulants such as camphor or strychnine must be administered hypodermically, or saline may be injected under the breasts. It is essential that the patient should rest the first night after operation, and this may be ensured by giving sedatives, such as morphine or pantopon, preferably the latter as it has less effect upon the stomach and bowels. Some operators oppose this but a small dose, repeated two or three times during the first two days after operation, will do the patient no harm and allow the most critical and painful period to be tided over. Of course, it is well to avoid this if possible but the patient ought not to be allowed to work herself up into a nervous condition for want of a sedative. Where she is not in much pain but simply nervous, good effects may follow the hypodermic injection of $\frac{1}{16}$ grain of heroin. Gaseous distention of the bowel is a frequent cause of postoperative pain. Where this is suspected, the patient may be given an enema as soon as six hours after operation. This often gives most marked relief and may be repeated as often as indicated. Now and then, when enemata fail to act, the simple expedient of turning the woman on one or other side will produce the desired result. It is a great mistake to keep the patient flat upon her back. If this is insisted on, she becomes tired, nervous, and restless, so that it is a good practice to gently turn her on one side, supporting her back with pillows, as soon as four or five hours after operation, if she so desires. If the constipation is obstinate, one drop of croton oil in sugar of milk, given by the mouth, will work wonders. Later on you may give the patient any purgative she is accustomed to take, but the pill of aloes, belladonna, and strychnine will usually be found excellent, giving one or two at night, as required.

The wound is not to be disturbed until it is time to remove the sutures unless it is specially indicated, as by elevation of temperature together with pain in the region of the incision, which should then be inspected under the strictest aseptic precautions. If either clips or pins are used, they should be removed on the fourth day as they are liable to cause sloughing if left longer, and, if the skin has united perfectly, the line of incision is to be covered by a strip of gauze saturated with collodion. Over this place gauze pads, held in place by broad strapping as before. Sutures are best left until the twelfth day, as by that time perfect union ought to have been secured and the sutures will have become so loose that they may be removed with little difficulty. The incision is then to be covered with gauze and collodion and the dressing and straps may be dispensed with. If, however, at any one or two points, the skin has not united, dust on boracic acid powder and apply fresh pads of gauze and strapping, and on their removal a few days later complete healing will have taken place.

Opinions differ as to how soon the patient is to sit up. While many allow their patients to get out of bed on the tenth or twelfth day, it is better not to permit them to even sit up until the eighteenth or twenty-first day after operation, the operator being guided by the recuperative power of the patient, as one cannot expect the tissues of an old woman or one who has been debilitated by a long period of invalidism to heal as quickly as one who is younger or stronger. She may be allowed to sit up for a very short time the first day and for two separate periods the second day, after which she may get up in a chair from day to day, usually leaving hospital on the twenty-eighth day.

F. A. L. Lockhart.

Oviducts.—Unlike the male, the female has a direct potential communication between the peritoneal cavity and the outer air, the route being up through the vagina, uterus, and oviducts or Fallopian tubes, the latter being two tubular structures entering the

uterus, one at each of its upper angles, where they pierce the wall.

Development.—In early fetal existence, the Fallopian tubes and uterus are represented by the two Müllerian ducts or cords. Later on, these become medullated and finally unite at their lower parts to form the uterus, leaving the upper parts free to become the Fallopian tubes.

Anatomy.—Each tube is a trumpet-shaped structure, measuring from ten to twelve centimeters in length, having a caliber which is barely sufficient to admit a fine bristle at the uterine end but which expands to such a degree that it will permit the passage of a uterine sound or the end of a pair of artery forceps at the outer extremity. Running first outward, then backward and finally inward, so as to almost encircle the ovary which lies behind and below it, it terminates in a funnel-shaped extremity, the walls of which are broken up into several finger-like processes or fimbriæ, one of which is attached to the ovary. Very often, a small cyst, called the "hydatid of Morgagni," arises from one of the fimbriæ, to which it is fastened by a fine stalk or pedicle.

Fig. 4215.—Hydatid of Morgagni Attached to the Tube by a Long Slender Pedicle.

Each tube has three coats: peritoneal, muscular, and mucous. The *peritoneal coat* consists of a fold of the broad ligament which envelops about five-sixths of the tubal circumference, the remaining sixth being in contact with the loose areolar and fibrous tissue lying on its inferior aspect between the anterior and posterior layers of the broad ligament.

The *muscular portion* of the wall composes the greater part of its thickness and consists of muscular bands arranged in two principal layers, an outer longitudinal one and an inner, which is circular, but near the uterus this again is lined by a few longitudinal fibers.

The *inner layer* consists of a mucous membrane with practically no submucous tissue, and at the fimbriated extremity the peritoneal or serous and mucous coats unite. This membrane is thrown into numerous longitudinal ridges, with branching terminals, and consists of a layer of ciliated columnar cells with numerous glands interspersed through it. The cilia have a distinct waving motion toward the uterine cavity, thus assisting the descent of the ovum and preventing the ascent of the spermatozoa.

The *blood supply* of the Fallopian tubes is contained chiefly in the muscular coat and is derived from the ovarian artery, although a few arterioles from the uterine artery also enter it. The veins carry the blood from the tube and enter the pampiniform plexus in the broad ligament.

The *lymphatics* join those from the ovary and enter the lumbar glands, while the nerves arise from the inferior hypogastric plexus of the sympathetic.

The tube is divided arbitrarily into four parts: Interstitial, where it is contained in the actual wall of the uterus; Isthmic, which is just exterior to the interstitial, and so is that part nearest the uterine wall; Ampulla, or middle two-thirds; and Infundibulum, which is the outer third, thus including the fimbriated extremity.

The Fallopian tube has only one function, viz., to carry ova toward the uterine cavity and, possibly, spermatozoa from the latter so that the two elements may meet.

Anomalies.—These are very few in number. One or both tubes may be absent. While no record exists of the undoubted presence of a third tube, it is not infrequent to find one tube having one, or possibly more, separate fimbriated openings, which may be so marked as, at times, almost to amount to supernumerary tubes. Occasionally, one finds one or both tubes to be present but impervious, but this is extremely rare.

Displacements.—The mobility of the inner end of the tube is governed by the motions of the uterus and is, therefore, somewhat limited, but as it proceeds outward it becomes less and less firmly attached until we find the infundibulum practically floating free in the peritoneal cavity. This outer end may be prolapsed down into the pouch of Douglas, usually being drawn there by adhesions or a prolapsed ovary, or else it has fallen down as the result of the weight of some tubal mass.

Occasionally the tube is found in the sac of a femoral hernia in a female, in which case it is removed together with the sac. Where inversion of the uterus has occurred, both tubes are drawn down into the sac until there is frequently nothing left in the peritoneal cavity but the fimbriated extremity.

Benign Neoplasms.—Remembering that the Fallopian tube is merely a prolongation of the corner of the uterus and that the walls of both consist of similar elements, it will be readily understood that both may be affected by similar forms of growth. However, distinct tumors of the tube itself are very rare.

Either *adenomata* or *papillomata* may be present, but have no distinguishing characteristics.

Fibromata occasionally affect the tube but are rarely of large size. Simpson's classical case is of doubtful origin, the fibroid, "the size of a fetal head," being attached by a long pedicle to the tube, which was quite healthy. When present, the tumor is usually of the subperitoneal variety and is too small to give rise to symptoms, being usually discovered accidentally at postmortem or during an operation for some other condition. In many cases, a tubercular mass in the tubal wall has been mistaken for a fibroid, as are also irregular nodular thickenings of the muscular wall of the tube, seen in many cases of uterine fibroids, but these are not true fibroid tumors.

Cysts may develop in connection with any of the coats of the tube, but they rarely attain large size and are usually inflammatory in origin. Occasionally, cysts of the broad ligament grow up over the tubes and must not be mistaken for cysts of that structure, which may on dissection be found to run around or under it and to be quite distinct from it. In tuberculosis and some forms of inflammation, small cysts may be seen on the walls of the tubes. These are lined by epithelium and contain thin serous fluid.

Lipomata are now and then observed arising from the wall of the tube but they are always very small and are quite unimportant.

Malignant Neoplasms.—Malignant affections of the tube are sarcoma, chorioepithelioma, and carcinoma.

Sarcoma of the tube is the rarest of the malignant affections of that structure. It may be primary or may spread from the uterus or ovary, but in the event of the latter being the primary location the other

surrounding structures are more apt to be implicated than is the tube. (Doran.)

The symptoms of the case reported by Gosset in the *Annales de Gynécologie et d'Obstetrique* may be considered as typical. The patient was a woman forty-four years of age who had suffered from a discharge from the uterus of a thin, glairy, watery fluid for three years. This fluid had no bad odor and there was no pain. Her periods were quite regular. The abdomen had become distended one year previously and had remained so, but recently she had noticed it to increase in size. The woman had given birth to three full-term children, the youngest being twelve years old. On vaginal examination, there was felt a smooth, firm, movable, non-sensitive tumor which was distinct from the uterus and lying in the left iliac fossa. On operation, there was found a sausage-shaped tumor with the uterus and ovaries normal. The right tube was the seat of an hydrosalpinx. The tumor was adherent to a coil of intestine from which it required to be dissected. The bowel appeared to be healthy but a metastatic nodule the size of a walnut was removed from the omentum, the uterus and both sets of appendages being taken away at the same time. On section, the tube was found to contain a medullary mass in the wall.

The prognosis is bad, and the only treatment is removal of the uterus with both sets of appendages.

Chorioepithelioma of the Fallopian tube is not at all commonly met with unless as an extension of the growth from elsewhere, but in 1905, Risel collected eleven cases of this disease in connection with tubal gestation, and in 1911 Miles Phillips added three more.

The symptoms are similar to those of chorioepithelioma occurring elsewhere, viz., repeated uterine hemorrhage which does not yield to treatment other than extirpation of the affected organ. There are also emaciation and foul vaginal discharge. Pelvic examination will reveal an ovoid spongy mass to one side of the uterus.

The only treatment is early and complete removal, but the prognosis is very grave as recurrence locally is almost certain with metastases in other parts of the body.

Carcinoma affects the tube usually by spreading from the uterus or ovary. While even this is uncommon, the tube is occasionally attacked primarily, about 140 cases having been recorded to date.

Here, as elsewhere, irritation is supposed to be a causative factor so that it often follows salpingitis of gonorrheal or other origin.

It usually begins as a small, warty excrescence on the inside of the tube. This spreads into a large flowery mass which perforates the tube wall and may become attached to the surrounding parts. Microscopically, either the glandular or papillary type may be seen and it is extremely difficult to differentiate the benign from the malignant form. It is only when the cells are atypical, becoming irregular and infiltrating the wall of the tube that one is able to pronounce the growth to be malignant. Age incidence is similar to that in carcinoma elsewhere, except that no instance of its presence in a very young subject has yet been recorded.

The symptoms are those of chronic pyosalpinx, so that it is rarely diagnosed previous to operation. However, when a woman between the ages of thirty-five and forty years comes with a history of prolonged but slight uterine hemorrhage with a foul, thin, watery discharge, and with cachexia and loss of flesh, and you find a small uterus with an elongated, sausage-shaped mass to one side, you may be fairly sure that you have a case of malignant tubal disease to deal with.

As in all other cases of malignant disease, early and complete removal is the only line of treatment indicated, taking away the uterus as well as both sets of appendages at the same time.

On account of the difficulty of antcoperative diagnosis, radium and *x*-rays have not yet been used for this condition, but they might be of some utility in warding off recurrence or diminishing the rate of growth of the carcinoma.

The prognosis is very grave, the growth usually recurring at or near the original site of the disease. This has been shown by the statistics given by Tedenat. He reported that (1) both tubes were affected in twenty-five per cent.; (2) grafts occur in the uterus in ten per cent.; (3) there are frequent extensions of the growth to the lateral angles of the uterus, and (4) frequent invasions of the broad ligament are seen.

Hematosalpinx.—In the vast majority of cases in which blood is discovered in the Fallopian tube the cause is gestation. It may, however, also be caused by (1) rupture of a small blood-vessel in the wall of the tube, following a sudden shock or strain; (2) perforation of the vessel wall by malignant disease; (3) torsion of the tube; (4) or, very rarely, by menstruation in the tube. As the histological construction of the uterus and tube is practically identical, is it not possible that the function which takes place periodically in the one, and which is considered normal, may occur in the other in rare instances?

Torsion occurs usually in a tube which is the seat of an inflammation, forming either an hydrosalpinx or pyosalpinx, without setting up enough inflammatory action in the surrounding parts to produce adhesions which might limit the movements of the tube.

It presents similar *symptoms* to those seen in cases of ovarian tumor with a twisted pedicle, viz., sudden, sharp pain in one lower quadrant of the abdomen with the signs and symptoms of a localized peritonitis. The twisting may, of course, take place gradually, in which case the pain is not sharp but dull and gnawing in character.

Enforced quiet in bed, with the application of ice to the lower abdomen, will often relieve the condition temporarily, but the removal of the offending organ will usually be indicated and is, as a rule, followed by complete recovery.

Tubal Gestation.—See the article *Gestation, Ectopic.*

Tuberculosis.—Tuberculosis of the tube is not uncommonly observed and may be either primary or secondary, the latter being much more frequently seen than the former.

No age is immune. Chaffey reported a case of a child four years of age, who died of general tuberculosis, in whom both of the tubes were the seats of caseous deposits. Silcock also relates an instance where a child of five had tuberculous meningitis and both of whose tubes "were enormously distended with caseous material." Cullingworth has stated that the majority of cases of salpingitis occurring in virgins are of tuberculous origin, and was undoubtedly correct, although frequently the *Bacillus tuberculosis* cannot be isolated.

The route of the invasion of the tube may be (1) by the blood current; (2) by direct extension from surrounding structures; (3) from the peritoneal cavity, or (4) from below through the uterus and vagina, as where the woman has coitus with a male who is the subject of genital tuberculosis. Janin found the *B. tuberculosis* in the mucous membrane of a healthy tube in a patient who died from tuberculosis of the intestine and lungs.

The investigations of Schramm, Münster, and Orthman have shown that in the early stages of tuberculous affection the tube presents the microscopic picture of ordinary inflammation; in other words, it is the mucous membrane and adjacent tissues which are first attacked. Now and then, however, the mucous membrane is seen to be studded with minute tuberculous

nodules. In other cases the peritoneal surface of the tube is seen to be covered with small, glistening, white tubercles, but these must not be confused with the small cysts caused by a low grade of inflammation of the peritoneum covering the tube. The latter are small and glistening and incision shows them to be cystic, whereas tubercles are white, hard, and solid. At later stages, the wall of the tube is seen to be infiltrated by tubercles and the interior of the tube may be filled with caseous material, placques of which may also be found in the actual tubal wall.

The *symptoms* of tuberculous salpingitis are of a more or less chronic character or type. In a typical case the patient has shown evidences of tuberculosis in either the lungs or intestine, but later on begins to have a dull aching pain in the pelvis, usually equally well marked on either side. This pain increases slowly in severity. A whitish leucorrheal discharge may make its appearance owing to the increase in the congestion of the uterus caused by the affection of the appendages, and on most careful microscopical examination it may, now and then, be found to contain tubercle bacilli. The periods become painful, the pain beginning some days previous to the onset of the flow and remaining until shortly after the latter is finished. The flow also tends to become irregular, either in time or amount; occasionally it is increased, but it may become so diminished in quantity as to produce actual amenorrhea. When the tubes are occluded in any part of their course, complete sterility is caused. There will be an evening elevation of the temperature of from half to one or two degrees.

On making an examination of the appendages through the vaginal fornices, a mass will be felt to one side of the uterus, but connected with it. This mass is irregularly club-shaped, the handle of the club being toward the fundus uteri. It is firm and, as a rule, fixed to the side or back of the pelvis. Palpation of the tube will cause pain which will vary in intensity in different cases and, in very thin subjects with lax abdominal walls, the surface of the tube may be felt to be covered with small tuberculous nodules, when such are present.

The *diagnosis* is frequently a matter of some difficulty, as sometimes it is not easy to determine whether the salpingitis is due to tuberculosis or some other infecting organism. In determining the nature of the process, the history is of extreme importance. Where the inflammation has been caused by some organism other than that causing tuberculosis, careful inquiry will elicit the fact that the patient at some time or other has had an attack of gonorrhea or a previous prgnancy has terminated in sepsis with consequent infection of the tube or tubes.

The exclusion of cancer of the tube may cause some trouble, as it is an extremely difficult malady to diagnose previous to opening the abdomen, but cancer is more rapid in its growth, usually produces a thin, bloody discharge from the uterine cavity and the cancerous cachexia will probably be present. From a practical standpoint, the diagnosis of the one condition from the other is not a matter of vital importance as the treatment of the two is the same, although some authorities disapprove of surgical interference in pelvic tuberculosis, claiming that the removal of the diseased areas favors the dissemination of the bacilli to other portions of the body.

Where, however, the history points to a long, chronic inflammatory condition of the appendages without any evidence of a previous attack of gonorrheal or septic infection and the patient has tuberculous disease elsewhere in the body, the diagnosis of tuberculous salpingitis may be made with a fair prospect of its being correct. Where there is no such other focus, one or other of the various inoculation tests for tuberculosis may be of benefit. As the uterus is frequently affected together with the tubes, a curettage, followed by a careful examination of the removed mucosa by a competent microscopist, will often reveal the presence of tubercle bacilli.

The diagnosis of this condition from either hematosalpinx or hydrosalpinx ought not to be difficult as in neither of these do you find the emaciation of tuberculosis nor are the diseased tubes as hard and nodular when felt bimanually.

The *treatment* should consist of rest in bed, combined with good nourishing diet of an easily assimilated nature. The patient ought to remain as much in the open air as possible, even sleeping on a veranda or in a room which is light and with plenty of open windows in it. Cod-liver oil aud general tonics will be useful. Locally, some good may be expected from the application of tincture of iodine to the vaginal fornices. Boroglycerin tampons and hot douching will be of benefit in promoting absorption of the inflammatory products present. If a course of the above treatment, carefully carried out for several months, does not produce very marked benefit, complete removal of the tubes and ovaries of both sides, together with the uterus, should undoubtedly be effected. Even if it be found impossible to remove them, on account of adhesions, during operation, the opening up of the peritoneal cavity will sometimes be followed by some relief. Where an appeal has to be made to surgery, it always ought to be followed by a course of the treatment of tuberculous disease by open air, etc., which is too well known to require further description.

Salpingitis.—Salpingitis, or inflammation of the Fallopian tubes, is rarely seen as a simple entity, but is usually complicated by disease of the uterus or ovaries. While usually occurring in married women or those leading an irregular life, it is occasionally seen in females whose virginity cannot be doubted. De Rouville, for instance, in the *Revue de Gynécologie et de Chirurgie*, Nov., 1911, cites the case of a female, aged forty-six years, of undoubted purity from whom he removed both tubes which were the seat of pus formation. There was not a trace of tuberculosis to be found in the patient and the only germs produced by cultures from the pus were staphylococci and a diplococcus which could not be identified.

Tubal inflammation usually spreads from or through the uterus, although it is by no means rare to have infections of the tube following infections of the gastrointestinal tract. Of these, the most common is where the appendix and right tube are lying in close contact, in which case an inflammation of the appendix readily spreads to the tube, especially where the latter has been the seat of previous disease, nor is it at all uncommon to find that the tube has become adherent to the diseased colon or rectum through which it has become contaminated with the *Bacillus coli*, in which case the pus at operation will possess the characteristic fetid odor of the colon infections. Improper and careless operations on the uterus, as where the sound or probe has been carelessly passed or inflammatory material has been introduced into the uterine cavity by the curette or intrauterine douche nozzle, will prove frequent causes. This mode of infection is less common now that intrauterine tampering in the physician's office is less frequently practised than formerly was the case. Sexual excesses in either the newly married or young prostitutes are liable to cause congestion and subsequent inflammation of the tube, as does also coitus during menstruation. Violent exertion or exposure to cold just before or during the latter process is often the starting-point of inflammatory affections of the adnexa. Any cause of imperfect uterine drainage, such as anteflexion, stenosis or displacements of the uterus, predisposes to inflammation The two causes which are much the most important and common, however, are gonorrhea and septic infection in connection with pregnancy. The public cannot be too strongly warned of the great danger of gonorrheal infection. The most minute drop of dis-

charge from an old gleet is quite sufficient to place the life of an innocent and trusting young wife in the gravest peril and if she survives the acute attack her ability to fulfill her function in life, viz., procreation, is very greatly lessened and is usually completely abolished. Any man who has once had a gonorrheal infection and contemplates marriage should be most rigidly examined by a genito-urinary specialist of the very highest standing before entering upon the married state. In the same way, a woman who has been so unfortunate as to contract a vaginal gonorrhea ought to be treated with the greatest care in order to endeavor to prevent the entrance of the gonococcus into the uterine cavity. The gonococcus of Neisser usually travels by direct continuity from the vagina along the surface of the uterus and so into the tube, from whence it not infrequently reaches the peritoneal cavity, where it sets up a peritonitis. It will thus be readily seen that in a salpingitis caused by the gonococcus both tubes tend to be similarly affected at the same time. While this is the common route of invasion, the germ may enter the lymphatics and so attack the tube. When salpingitis follows puerperal infection, the organisms most frequently encountered are the streptococcus and staphylococcus, although the *B. coli* and pneumococcus are occasionally present. These organisms, viz., the streptococcus, staphylococcus, pneumococcus and *B. coli*, may follow the example of the gonococcus and proceed to the tube by the easiest route, *i.e.* along the uterine cavity. They are, however, usually admitted into the patient's economy through some gross lesion, as a laceration of the cervix or perineum, or a wound of the endometrium, so that we usually have them traveling along either the lymphatics or blood-vessels. Consequently, one is more likely to see a unilateral than a bilateral affection following pregnancy. It is not always easy to isolate the gonococcus from the contents of the infected tube, but the following method, as practised by Dr. L. J. Rhea, pathologist to the Montreal General Hospital, will often prove effective: "(1) Sterilize the outside of the tube by searing with a hot spatula. (2) Open the tube through the seared area with sterile instruments. (3) Make cultures from the contents of the tube. (4) With sterile cotton, dry an area of the tubal mucous membrane. (5) Scrape off from this area with a sterile scalpel some of the mucous and submucous membrane. (6) Plant on appropriate media. The best results have been obtained from a sterile hydrocele fluid mixed with one-third ($\frac{1}{3}$) dextrine agar, 2.4 per cent. It is very important that the reaction of the medium is correct. The plate method is employed for isolating the organisms after the hydrocele dextrine agar has been poured into sterile Petri dishes and allowed to cool, the material for examination being then carefully stroked over its surface. The colonies should be well developed in eighteen to twenty-four hours. The greatest number of positive cases result from the scrapings of the mucosa."

I have to thank Dr. C. C. Birchard for the following statistics culled from 338 cases of pelvic inflammation admitted to my ward in the Montreal General Hospital:

Directly due to pregnancy.....	92 or 27 per cent.
Doubtful origin and organism...	62 or 18 per cent.
Gonococcus	166 or 49 per cent.
B. tuberculosis.....	18 or 6 per cent.

Of the gonococcus infections, seventy-six were diagnosed on bacteriological findings and ninety on purely clinical manifestations.

So much for the bacteriology and causes of tubal inflammation. We must now consider the pathology.

For all intents and purposes, salpingitis may be divided into (1) acute and (2) chronic, in either of which one may find pus in the tube.

The disease is classified into: (*a*) Simple acute without pus. (*b*) Simple chronic without pus. (*c*) Pyosalpinx: 1. acute; 2. chronic.

Hydrosalpinx is a condition seen at times as a sequela of an either acute or chronic low-grade infection of the tube or where the fimbriated end has been interfered with. As its name indicates, this condition is one in which both ends of the tube are closed and the interior is filled with thin, serous fluid, which is non-irritating and sterile, the tube at times attaining the size of the three months' pregnant uterus. The symptom usually complained of is a dull aching pain in one or other side. On making a vaginal examination, an elongated, cystic mass is felt on one side of the uterus. It is regular in outline, tense and fluctuating and not at all tender. The only treatment is removal.

Fig. 4216.—Large Hydrosalpinx.

Acute Simple Salpingitis.—In this, the first stage is one of congestion in which all of the tissues of the tube become soft, friable, and pulpy. The plicæ of the mucous membrane lining the tube are club-shaped. There is a general infiltration of small round cells which eventually press upon and constrict the blood-vessels, although at first these are enlarged. The tube becomes enlarged and swollen and the cilia of the mucous lining soon become destroyed. There is a tendency to the formation of fibrous tissue in the walls of the tube which thus become harder than normal. At an extremely early stage, the fimbriated end closes and the fimbriæ become drawn into the tube, thus preventing the escape of the contents into the peritoneal cavity. At the same time, swelling of the mucous membrane causes closure of the end of the tube where it opens into the uterus. All of these changes make the tube heavier so that it becomes prolapsed. It may also become adherent to any of the surrounding organs, as the uterus, ovary, or bowel. Under appropriate treatment, the inflammation subsides and the tube may undergo complete resolution, the inflammatory products being absorbed, and the patency and utility of the tube be restored, but much more frequently it proceeds on to the formation of pus within the tube. Finally, the inflammatory condition may subside and it becomes chronic. Occasionally, one comes across cases of subacute or

chronic salpingitis where no history of an acute attack can be obtained, the original disease having been of such a mild character as to produce almost no marked disturbance. In chronic salpingitis, the tube usually becomes greatly convoluted, this being due to the implication of its peritoneal covering which contracts longitudinally, thus drawing the tube together. The mucous membrane undergoes the changes described above, while the muscular wall becomes hard, thickened and fibrous, thus forming a hard, nodular, sausage-shaped mass. It is very frequently attached to the surrounding structures by adhesions, which may at times be slight or at other times very extensive and tough on account of their having become so highly organized. When the right tube is affected, it is not uncommon to have synchronous disease of the vermiform appendix with more or less intimate adhesion of the one to the other.

Where pus formation has taken place, leakage from the fimbriated extremity into the peritoneal cavity may occur setting up an acute peritonitis, but usually nature protects this region by sealing up the openings. The tube becomes distended with pus and at times forms a mass the size of a fetal head at term or the fimbriated ends of both tubes unite behind the uterus making a mass as large as the uterus at the fifth month of gestation. On opening such a mass, the pus may be creamy with no odor, sometimes dark and blood stained where the tubal circulation has been interfered with, or it may become intensely fetid when the infection is due to the *B. coli*. Any of the usual pathogenic organisms may be found in this pus, but it is usually sterile when examined after removal as one usually waits until the activity of the organism has been subdued before opening the abdomen. When no germs can be found in the pus, careful examination of the tubal wall will sometimes result in their discovery.

Symptoms.—In acute salpingitis, with or without pus formation, the patient is seized by a sudden sharp pain in one or other side of the pelvis, which quickly spreads to the whole of the lower abdomen. This pain is usually preceded by a profuse leucorrheal discharge or recent gestation, but both may be absent. Pulse may be accelerated, running up to 140 or 160 beats a minute and is bounding in character, while the temperature mounts to 102–104° F.; the respirations usually being increased in rapidity also. There is usually nausea or even vomiting and the patient may have a chill. The pain is aggravated by movement, such as defecation. The lower abdomen is exquisitely tender, especially on the affected side and it is frequently distended and hard or board-like. The vagina is hot and the fornices tender, movement of the uterus causing pain. When the patient's abdomen is thin, it may be possible to feel the distended tube, but this is usually difficult on account of the hardness of the abdomen and tenderness of the tube. Where the condition has advanced to the formation of pus, the general condition of the patient is greatly aggravated, the skin becoming hot and dry, the tongue furred, and the head aching severely. Examination of the blood reveals increased leucocytosis.

In the *chronic* form of the disease, the symptoms, as one would naturally suspect, are much less marked. There is a dull aching pain in one or other lower quadrant of the abdomen, as well as in the back, this pain frequently running down along the inner side of the leg. Dyspareunia, at times, is marked and headache is felt. The digestion may be so greatly interfered with that the woman becomes greatly emaciated. The pain is aggravated by any exertion and relieved by quiet, especially in the recumbent position. Exacerbations may be expected. The patient suffers from dysmenorrhea of a usually characteristic form, the pain beginning several days before the onset of the flow and lasting until the latter has ceased or even longer. The menstrual discharge is usually increased in amount and may become irregular in its appearance. While it is possible for a woman to have a child when one tube only is affected, it is exceedingly dangerous on account of the liability of the tube to rupture followed by peritonitis, owing to increase in size of the growing uterus or during labor, but the patient is usually sterile.

On making a bimanual examination, the uterus will feel enlarged, hard, and, where the disease is unilateral, pushed to one side, these alterations in the condition of the uterus being due to a concomitant chronic inflammation which is present. The mobility of the fundus is impaired. To one or other side, or

Fig. 4217.—Appendix Attached to Ovary and Tube, in a Case of Chronic Salpingitis.

both, where the disease is bilateral, of the fundus masses can be felt. These are sausage-shaped, running out from the uterus to the lateral or posterior pelvic wall. They are somewhat tender and, where pus is present, fluctuation can be felt. Where the tubal wall is thick, however, or the abdominal walls are fat or rigid, the masses feel firm or even hard.

Diagnosis.—Acute inflammation of the tubes is easily mistaken for pelvic cellulitis, ruptured tubal gestation, small ovarian tumor with a twisted pedicle or, when on the right side, appendicitis. In pelvic cellulitis, a chill is more often present and pelvic examination reveals a mass which fades away on the side of the pelvis, whereas with an inflamed tube the outlines of the mass are readily palpated, although an anesthetic may be necessary in order to lessen the sensitiveness of the parts.

A ruptured tubal gestation causes sudden syncope from internal hemorrhage, so that the woman's mucous membranes are much more blanched than in inflammation. Usually some history of menstrual irregularity, as amenorrhea or a constant dribbling of blood from the vagina, may be obtained and on vaginal examination a boggy mass is to be felt.

When a tumor with a twisted pedicle is present, the patient gives a history of previous pelvic pain and dysmenorrhea, but no history of any form of infection. Vaginally, the tumor can be felt to be round or ovoid, not elongated.

An appendicular mass is usually felt higher up in the pelvis than one due to tubal infection, there is more vomiting and a history of chronic constipation can be elicited but none of any pelvic infection.

Treatment.—In the treatment of acute salpingitis,

the two essentials are absolute rest in the recumbent position and the application of cold over the affected area. The woman's diet should be of the lightest and most easily assimilated description, consisting of milk, either alone or diluted with some kind of aerated water, whey, or barley or albumen water. The bowels should be emptied by an initial dose of saline but will require little further attention on account of the nature of the diet. A hypodermic of morphine may be necessary to control pain but this result is best attained by the application of cold. For this purpose, the use of the ice-bag is the most efficacious, it not only relieving the pain but allaying the

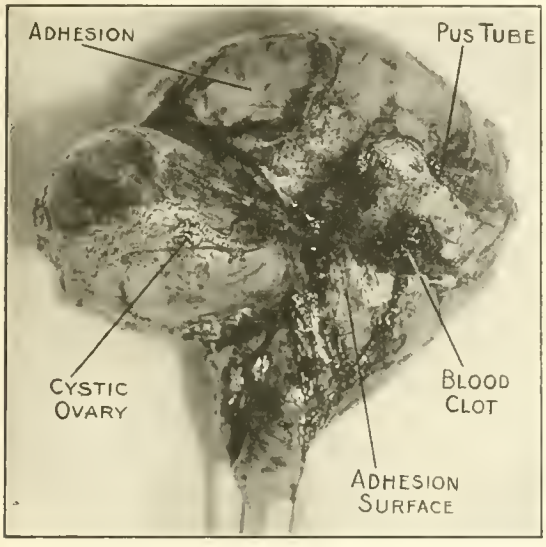


FIG. 4218.—Cystic Ovary with Chronic Pus Tube; adhesions very extensive.

inflammatory process as well. This should be kept in place continuously, but if the tissues of the patient are in a very poor condition it must be carefully watched lest it cause sloughing. Where ice fails to relieve the pain or cannot be borne, it may be replaced by heat in the form of hot turpentine stupes, but cold is to be preferred wherever possible as it is less liable to cause pus formation. If the attack follows a vaginal gonorrhea, hot antiseptic douches, to which one dram of tincture of opium may be added to each quart, may be tried but in the more acute stages they cause too much local pain. The patient's strength may be supported by the administration of strychnine but all alcohol ought to be avoided. As the process subsides, the diet may be gradually increased in amount and quality until the patient is eating all kinds of food.

All signs and symptoms of pelvic inflammation should have been absent for several days before allowing the patient to sit up in bed.

When the process is chronic before being seen, local non-operative treatment should be given a thorough trial. Great patience on the part of both the patient and doctor is necessary here but will frequently be rewarded by complete restoration of the parts to their normal condition. Here again, it is advisable to put the patient to bed and keep her quiet as possible, all sexual intercourse being prohibited. The diet should be light and non-stimulating, all alcohol being forbidden and tea and coffee limited. The bowels must be kept in good condition by laxatives or enemata. Local anti-inflammation treatment must be employed as follows: A bivalve speculum is introduced into the vagina which is then cleansed of all mucus and other discharges by swabs of absorbent cotton. The vaginal fornices and cervix are thoroughly painted with Churchill's tincture of iodine and a tampon is inserted into the vagina. This tampon should not be too large, or it may be forced out before its time, and the inner end saturated with a ten per cent. solution of ichthyol in glycerine. It is left *in situ* for thirty-six hours, when it is removed and a hot douche taken. Presumably the tampon has been removed at night, so a second douche is taken the next morning and the treatment repeated. The patient must be instructed that she must expect a free watery discharge while the tampon is in place and that the douche must be taken while in the recumbent position. This treatment should be continued for at least one month, but it is extremely probable that two or three months will be required more often than one. Of course, it should be discontinued during menstruation. As an adjuvant, dry hot air-baths to the pelvis and lower abdomen may be very highly recommended. These are best applied by means of a cradle of zinc lined with asbestos and fitted to hold several electric light bulbs, which are connected by a cable and plug and are to supply the heat. These baths at times produce marvelous results and may be used even before the temperature has fallen quite to normal. ("Pelvic Inflammation" by F. A. L. Lockhart, *Jour. of Obstet. and Gyn. of the Brit. Emp.*, Sept., 1914.)

When the patient is suffering much pain, the application of fly-blisters over the ovarian region will be indicated.

Galvanism, using the negative pole in the vagina and the positive over the lower abdomen will now and then hasten absorption of the inflammatory products and may be used in conjunction with the local treatment described above. The whole may be given while the patient is up and going about as usual but is more certain and speedy if she is kept at rest.

When all else has been thoroughly tried and failed, final appeal to surgery may be made.

If the woman is too weak to stand a prolonged and serious operation and there is an abscess pressing down into the vagina, it may be evacuated and drained by posterior colpotomy. In doing this, care should be taken to thoroughly break down and evacuate all secondary sacs, which should be then douched out with an antiseptic and packed lightly with gauze. This ought to be removed daily and the cavity douched and repacked until finally closed. In cases where it is decided to remove the tubes, this may be effected through a similar incision. When the abdominal route is selected, the tube may be found not to be very extensively diseased, in which case it will be sufficient to open it up internally and stitch the mucosa to the peritoneum covering the tube, this proceeding being called "salpingotomy." If the disease is still more advanced, "salpingostomy," or resection of a portion of the tube, may suffice. Extensive disease, as is usually found when operation has been called for, will, however, demand the removal of the whole tube and very often the ovary of the same side on account of intimate adhesions between the two structures. This is "salpingectomy."

In this operation, the patient is anesthetized and the abdomen sterilized in the usual manner. She is then placed in the Trendelenburg position and the abdomen opened by an incision in the middle line between the pubes and umbilicus, the length of the incision varying with the experience of the operator, the thickness of the abdominal wall and the extent of the disease. The omentum will frequently be found adherent to the brim of the pelvis and the inflammatory mass. This should be carefully separated and the field of operation walled off by abdominal towels with tapes. If the abscess sac can be isolated and is at all large it may be aspirated of its contents before proceeding further. The various adhesions are then separated with great care, this latter being

especially necessary when working on the left side as there is such danger of wounding the rectum. If so unfortunate as to cause such a laceration, it must be closed at once by a series of Lambert sutures and the surrounding area thoroughly but lightly cleansed by gauzes saturated with a 1–500 hot solution of formaline, a small quantity of which may be left *in situ*. There is no given landmark at which to begin the separation but careful palpation will usually reveal some weak point from which to proceed. These adhesions rarely require ligation as all oozing usually ceases before the operation is completed but if they are very strong it is well to ligate them in two places and cut between. As soon as each tube is freed, it is brought up into the incision, tied off and removed, but occasionally the whole mass is so adherent that both tubes require to be separated before either of them can be thus treated. The stump of each is to be well cauterized. Any pus which may have escaped during operation is carefully wiped up by gauzes as soon as it is observed. All bleeding points must be attended to before the abdomen is closed. If they are simply capillaries or there is slight general oozing, the application of really hot, not warm, gauzes will often check it but if the vessels are of an appreciative size, each ought to be tied separately. In some instances, as where the bleeding comes from the posterior surface of the uterus, the vessels may be closed by the application of the actual cautery at a dull red heat. It may, however, be necessary to pack the field of operation with strips of gauze in order to stop all bleeding. Carefully inspect every part of the operation area before closing, and also make absolutely certain that the gauze nurse has all of her gauzes.

There are many ways of uniting the edges of the abdominal incision but the following has been used by the writer for many years and found to be satisfactory. The peritoneum is closed by a continuous suture of fine catgut, No. I. The edges of the anterior layer of the sheath of the rectus are then united by a similar suture which is then continued through the subcutaneous tissue. The skin incision is closed by either the subcuticular suture of catgut or by spring pins. The wound is then dusted well with boric acid powder and the usual dressings of gauze and absorbent cotton applied. These are held in place by broad strips of adhesive plaster which are carried well around to the back. Where drainage is used a combination of through-and-through sutures and the above is used, the through-and-through sutures being placed near the gauze or tube. Drainage, however, is seldom employed now as compared with some years ago, thanks to our improved knowledge of the ability of the peritoneum to take care of itself. When pus containing active organisms has escaped into the peritoneal cavity or where the separation of dense and numerous adhesions has resulted in the formation of an extensive raw area, from which oozing of a considerable amount of serum may be expected, the employment of a cigarette drain or a soft rubber tube enclosing a gauze wick is advised. Otherwise the incision is completely closed. Where the operation has been incomplete, some of the pus sac being left or where the escaped pus is very virulent, it may be advisable to puncture the pouch of Douglas and carry the drain through into the vagina, some operators preferring this method of drainage to the abdominal.

In all cases of extensive destruction of tissue, and especially where drainage has been practised, it is advisable to place the patient in the Fowler's position when she is removed to the ward. This does not mean simply raising the head of the bed or placing one or two pillows under the patient's shoulders as the writer has seen done, but she must be placed almost in a sitting posture and held there by some sort of framework which can be easily manufactured by any intelligent carpenter if a regular peritonitis bed is not available.

In the postoperative treatment of the patient, she should not be given anything by mouth except sips of very hot water for some hours, or she may be given small pieces of cracked ice. If vomiting is persistent, even these ought to be witheld for a time, but vomiting will be met with much less frequently if the patient be given hyoscine, gr. $\frac{1}{150}$ about one hour before the administration of the anesthesia. Emesis may be checked by placing a mustard plaster over the cardiac region, by the administration of aqua chloroformi, or gastric lavage either by means of the stomach tube or simply allowing the woman to swallow a tumbler of tepid water which will usually come right up again bringing the stomach contents with it. The patient's strength may be supported by strychnine, or, in serious cases, by champagne given in teaspoonful doses on cracked ice every hour or so. In some cases, the administration of saline solution, either by rectum or beneath the breasts will be most beneficial. As the patient's stomach shows signs of settling, she may be given albumen water, milk, milk with some aerated water, ice-cream and then gradually she may be worked up to full diet. Postoperative pain is usually to a large extent due to gas. For this one should never hesitate to give an enema, even as soon as three or four hours after operation, unless there has been some injury to the bowel, in which case they should not be given for at least forty-eight hours. Where the gas continues to be troublesome for some days, sips of dry ginger-ale on ice or even a very small piece of bread, not too fresh, with very little butter on it will often check its formation, as will also any intestinal antiseptic such as salol or minim doses of tinct. of iodine well diluted.

During the first twenty-four hours, small doses of morphine may be given hypodermically for pain and general restlessness, although heroin in doses of gr. $\frac{1}{10}$ hypodermically will usually suffice for the latter.

How long should the patient be kept in bed after an abdominal section for pus tubes? This period varies with the operator and the strength of the patient. The writer must confess to be somewhat old fashioned and to keep her there for about twenty-one days, as the prolonged rest is undoubtedly beneficial.

F. A. L. Lockhart.

Ovulation.—See *Menstruation*.

Ovum.—(Greek ᾠόν, Latin *ovum*, an egg.)—The *ovum*, or egg proper, is a cell capable under certain conditions of giving rise by subsequent cell divisions to a complete multicellular organism. This definition applies to the female germ cells of plants as well as to those of animals. Frequently the terms ovum and egg are used loosely, however, not only to include the envelopes surrounding the egg proper, but even to designate the embryo and its fetal membranes.

Historical.—Although a hen's egg has been probably one of the most familiar of objects since long before man ever thought of domesticating wild animals, it remained for the anatomists of the nineteenth century to discover its true nature; and although investigators of this subject in recent times have carried on their work with a refinement of technique not dreamed of in earlier years, there is still a great deal to be learned.

Modern embryological observations may be said to have begun with William Harvey, who published his results in 1651. The best microscope that he could obtain was a simple lens, and with this he was able to make out the general outline of a chick embryo during the second day of incubation. His view of the ovum was that it consisted of a fluid matrix in which the embryo appeared by a process of spontaneous generation. The female sexual product was supposed at that time to be a fluid secreted by the "testes

muliebres," the term "ovarium" not having been invented by Stensen until 1667.

Regnier de Graaf published in 1677 a description of the follicles, which have since borne his name. He found that they contained a fluid which was capable of being coagulated by heat into a firm, white substance. He discovered also that in the Fallopian tubes of a rabbit killed seventy-two hours after coitus there were to be found a number of eggs which were vesicles and contained a fluid that could be coagulated by heat, like the white of egg, and, moreover, these corresponded in number to the empty follicles found in the ovaries of the same subject. He concluded,

Fig. 4219.—Ovum Surrounded by Follicular Cells from the Ovary of a Rabbit Four Weeks Old. On the left of the egg nucleus is the attraction sphere containing two centrosomes and below is a small yolk nucleus. Highly magnified. (After Winiwarter.)

therefore, that the Graafian follicles were ova. But the chain of evidence was not complete because all trace of the eggs was lost between the time of coitus and the end of the third day, and, moreover, the blastoderms in the Fallopian tubes were not so large as the empty follicles. During the same year, 1677, Leeuwenhoek announced the discovery of spermatozoa, and there followed a long dispute as to whether the spermatozoon is the true germ and the egg a matrix for its nutrition, or whether the germ dwells originally in the egg itself (see article *Evolution*).

It was not until 1827 that Carl Ernst von Baer was able to show that the Graafian follicle is not the ovum; but that the ovum is a minute body embedded in the follicular epithelium. And it was not until 1838 that Schwann was able to declare the egg to be a cell with the same fundamental structure as the other cells of the body.

Morphology.—The ovum is usually a more or less spherical body, but may be flattened or elongated, as is the case with most insect eggs.

The protoplasmic contents of the egg consist of a nucleus and a mass of cytoplasm, as in all cells, and, in addition, the cytoplasm usually contains a greater or less amount of yolk, or *deutoplasm*.

The cytoplasm of the eggs of echinoderms and other invertebrates has been shown to have a distinctly vesicular, or foam-like, structure, and it is probable that all eggs will show a similar structure. It is within the vesicles of the foam that the deutoplasm is deposited, sometimes in the form of clear oil globules, as in some worms and fishes, more often as more or less opaque yolk granules. In the hen's egg there are two principal kinds of yolk granules, the yellow and the white. The white granules are gathered together in the form of a small flask-shaped body, extending from the center of the ovum to the upper pole, and the yellow yolk forms concentric layers surrounding this and alternating with thinner layers of white yolk (Fig. 4220). These may be seen in a carefully made section of a hard-boiled egg. Where the white yolk approaches the surface there is in the unfertilized egg a portion of the cytoplasm comparatively free from yolk and containing the nucleus.

The arrangements of the yolk in the hen's egg has been explained by Riddle (1911) as due to daily variations in the rate of metabolism. The yellow granules in their development pass through a stage represented by the white granules, which are arrested in development because of poor nutrition of the egg. By feeding hens with the dye Sudan III, which stains fat, Riddle was able to determine the rate of growth of eggs. This is slow until the eggs are about six millimeters in diameter, then there is a sudden increase in the rate so that a layer about two millimeters thick is added daily. The interval between the beginning of rapid growth and ovulation was found to be usually six or seven days.

Eggs are classified according to the absence, presence, and position of the yolk, into three groups: (1) *Alecithal* eggs, having very little or no yolk; (2) *telolecithal* eggs, in which there is an accumulation of yolk at one pole; and (3) *centrolecithal* eggs, in which the accumulation of yolk is at the center and is surrounded on all sides by a purely protoplasmic layer. Eggs of this type are especially characteristic of the arthropods.

The size of the egg, the position of the nucleus, and the subsequent course of development, especially in the early stages, depend to a large extent upon the presence or absence of yolk. For example, the eggs of elasmobranch fishes, reptiles, and birds are heavily charged with yolk and are very large, while all mammals, except the Monotremes, have eggs almost free from yolk, and they are very minute. The size of the ovum at ovulation differs in the three great groups of mammals. In the Monotremes the ovum is telolecithal with a relatively large amount of yolk in the form of distinct granules, as in the birds and reptiles. The ova are 3.5 to 4 millimeters in diameter, small as compared to a bird's ovum, but large for a mammal. In Marsupials the ovum is minute, 0.24 millimeters in diameter in one species, Dasyurus, but still contains a perceptable amount of yolk. The ova of the placental mammals, Eutheria, are still more minute, varying from 0.07 millimeters in the mouse to 0.2, or at most 0.25 millimeters in man, and, while not completely alecithal, contain a very small amount of deutoplasmic material. Such eggs in which the yolk is small in amount and pretty evenly distributed are more correctly described as *homolecithal*, or *isolecithal*.

The unequal distribution of material in telolecithal eggs, indicates a condition known as *polarity* of the ovum, in which an axis of symmetry may be recognized. The end of the axis on the side of the egg that is the richer in yolk is called the *vegetal* pole. The nucleus lies nearer the opposite, or *animal* pole, and the purely protoplasmic portion surrounding the nucleus may be confined to a very small area, the *germinal disc*, near the surface, as in the hen's egg.

The nucleus is usually a spherical body surrounded by a delicate nuclear membrane, and is still frequently called by the old name, *germinal vesicle*, although it presents all the ordinary features of a cell nucleus (Fig. 4219), including linin network, chromatin granules, and nucleolus, the latter is called in the older books the *germinal spot* (see article *Cell*).

In many eggs there may be seen near the nucleus an "attraction sphere" of finely granular protoplasm surrounding a very minute, darkly staining spot, the *centrosome*. The eggs of many animals of various groups contain also another body, often somewhat resembling a nucleus and hence called the *yolk nucleus* (Fig. 4219). It is also called, after the author who first described one of these bodies, the corpuscle of Balbiani. It is probable that the bodies classed together under this name are far from all having the same morphological or the same physiological significance. By the use of special methods of staining it has been demonstrated

that ovarian ova, as well as other cells, contain in the cytoplasm minute bodies known as *mitochondria*.

The Envelopes.—The most primitive type of egg to be met with anywhere in the animal kingdom is that characteristic of the sponges and hydroids. In these groups we meet with eggs that are not only wholly naked, but also show the power, at least within the maternal body, of active ameboid movement. Naked eggs are found in representatives of other groups of cœlenterates; and the eggs of some echinoderms, at least, are without envelopes when discharged from the oviduct, although an envelope is formed immediately after the entrance of the spermatozoon.

In all the higher groups of animals the egg is provided with one or more coverings. These are divided into three principal classes. First we have the primary envelope or *vitelline membrane*, which is essentially a cell wall formed by the cytoplasm of the egg. This is found in representatives of all groups of the animal kingdom, except in the mammalia. In this group a vitelline membrane has not been clearly demonstrated.

The secondary envelope is found only in eggs that are surrounded in the ovary by a follicular epithelium, which gives rise to this envelope; and it is especially characteristic of the eggs of insects and mollusks. In these forms it is called a *chorion*, a term used also to designate a very different fetal membrane of mammalia.

After leaving the ovary the egg may receive one or more *tertiary* envelopes, which are secreted by the walls of the oviduct or by glands connected with it. These envelopes may be protective or nutritive in

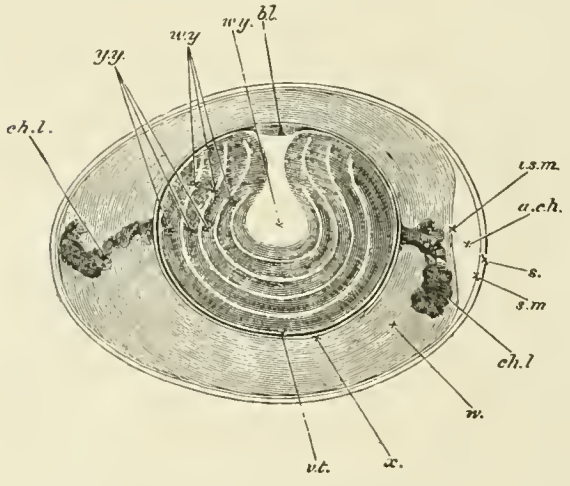


Fig. 4220.—Diagrammatic Section of an Unincubated Hen's Egg. *bl.*, Blastoderm; *w.y.*, white yolk; *y.y.*, yellow yolk; *v.t.*, vitelline membrane; *w*, albumin; *ch.l.*, chalaza; *a.ch.*, air chamber; *i.s.m.*, inner shell membrane; *s.m.*, outer shell membrane; *s*, shell. (From Balfour, modified from Allen Thomson.)

function or both. For example, in the hen's egg (Fig. 4220), the ovum, commonly known as the "yolk," covered by a thin vitelline membrane, lies embedded in a mass of albumen that serves as food for the embryo chick. But at opposite poles of the ovum there are attached much denser strands of albumen, the *chalazæ*, that undoubtedly serve also as a sort of packing to prevent the ovum from coming into too close contact with the ends of the shell. Outside of the albumen are two shell membranes and then the hard calcareous shell. The egg when it emerges from the ovary is provided with only a vitelline membrane. The albumen, shell membranes, and shell are tertiary envelopes and are secreted in succession by the wall of the oviduct as the egg passes outward.

The ripe mammalian ovum is surrounded by a relatively thick covering known as the *zona pellucida*, also frequently called *zona radiata* because it sometimes shows fine vertical striations. This membrane is formed in the ovary; whether it is primary or secondary or both is undetermined. That it is a secondary membrane deposited by the follicular cells is indicated by the observation of Kirkham and Burr (1913). They found in the rat's ovary fine protoplasmic bridges crossing the zona radiata from the follicular cells to the egg. A similar condition is said to occur in man (Keibel and Mall, 1910, p. 6). The surrounding

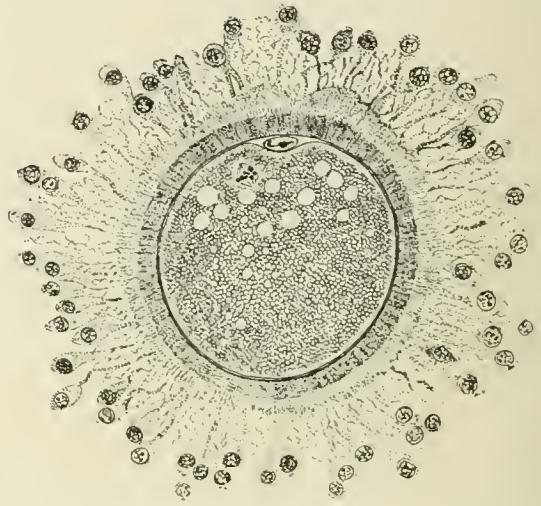


Fig. 4221.—Normal Ovarian Egg of the Cat, just before Ovulation. It is surrounded by a thick zona pellucida and the radiating cells of the corona. The first polar body lies in the perivitelline space, and the second polar spindle is seen within the egg near the animal pole. × 422. (After Longley.)

follicular cells may remain attached to the zona until after ovulation. They then form what is called the *corona radiata* (Fig. 4221). Eggs of placental mammals receive no tertiary envelope, except a thin layer of albumen in some species. But the eggs of the oviparous monotremes are covered by albumen and a distinct shell that has the remarkable property of increasing to several times its original diameter, while in the oviduct. The eggs of marsupials are intermediate in character, having albumin and a shell-membrane, but no shell (Hill, 1910).

The outer coverings of the eggs of the different groups of animals show much diversity of form and structure, and many of them present wonderful adaptive modifications. But to treat of this fascinating branch of the subject would carry one far beyond the possible limits of the present article.

Early Development.—In the sponges, some cœlenterates, and some of the lower worms the development of eggs is apparently not localized, but may occur in various parts of the body. In vertebrates the primordial germ cells first appear at some distance from the ovary, where later the ova collect and undergo the greater part of their development. The development of the ovary is described in the article "*Genital Organs, Female*," and the origin and migration of the primordial germ cells is described in the article "*Germ Cells*." Since the publication of vol. iv. of this Handbook, Swift (1915) has continued his studies and has traced the history of the ovum in the chick step by step from the stage when the wandering germ-cells arrive in the "germinal epithelium" to the stage in the ovary when they assume distinctly the characteristics of oögonia. He finds that the primordial germ cells by division give rise to the oögonia, while from the peritoneal cells of the germinal epithelium are derived the follicular cells (Fig. 4222) which surround the young ova and

form the *membrana granulosa* of the mature ovisacs (Fig. 2711, vol. iv.).

The Ovarian Ova.—At the time when the primordial germ cells make their appearance the sex of the embryo cannot be recognized. But a little later the sexual glands assume the distinctive characteristics of ovaries or testes. From this time until they are discharged from the ovary the germ cells of the female are known as ovarian ova. With the development of the ovary they become very numerous. Many of them never reach maturity, but degenerate and are absorbed while in the ovary. The number present

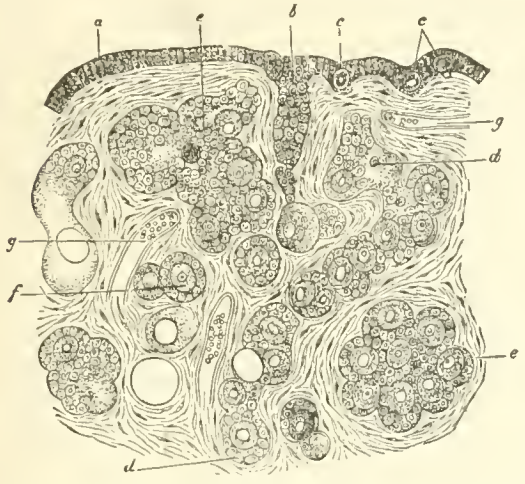


FIG. 4222.—Part of a Sagittal Section of an Ovary of a Newborn Child. *a*, Ovarian epithelium; *b*, commencement of one of Pflüger's cords; *c*, *c*, "primitive ova" in the epithelium; *d*, *d*, and *e*, *e*, germinal involutions with developing ova and young follicles; *f*, young follicle; *g*, *g*, blood-vessels. Magnified. (From Waldeyer.)

at various stages in the human ovary is given in the article on the *Genital Organs* of the Female. The ova that survive undergo a long period of very slow growth, followed by a short period of rapid growth, ending just before ovulation.

The typical ovarian ovum has a large vesicular nucleus, generally with a distinct nucleolus (Fig. 4219). After the end of the period of growth, and before fertilization, the nucleus passes through a period of activity, known as the *maturation of the ovum*, which results in the production of two *polar bodies* at the animal pole of the egg. This process is described in the article *Maturation*. The mammalian egg when discharged from the ovary has given off the first polar body and the nucleus is in a stage preliminary to the production of the second. The formation of the second polar body is not completed, however, until the egg is penetrated by a spermatozoon. This is likewise the first essential event in the *fertilization of the ovum*, described in the article *Impregnation*.

The Promorphology of the Ovum.—In many animals the primary axis of the egg, and the path of entrance of the spermatozoon have definite relations to the axes of symmetry of the embryo. There are also certain substances present that take part in the formation of definite organs. In one invertebrate, at least, these "organ-forming substances" have distinctive colors, and may be traced from their source to their final resting place (Conklin, 1905). Thus the structure of the individual is foreshadowed in the structure of the egg, but this *promorphology* is better to be understood in connection with the early stages of development of the embryo. Therefore discussion of this subject will be deferred to the article *Segmentation of the Ovum*.

R. P. BIGELOW.

BIBLIOGRAPHICAL REFERENCES.

Caldwell, W. H., 1887: The Embryology of Monotremata and Marsupialia, Part 1. Phil. Trans. Roy. Soc., vol. clxxviii., B.

Conklin, E. G., 1905: Organization and Cell-lineage of the Ascidian Egg. Jour. Acad. Nat. Sci., Phila., Ser. 2, vol. xiii., pp. 1–119.

Hill, J. P., 1910: Early development of the Marsupialia. Q. J. Mic. Sci., vol. xlvi., pp. 1–134.

Keibel, F. and Mall, F. P., 1910: Manual of Human Embryology, Phila., pp. 1–7.

Kirkham, W. B. and Burr, H. S., 1913: Breeding Habits, Maturation of Eggs, and Ovulation of the Albino Rat. Amer. Jour. Anat., vol. xvi., pp. 291–318.

Longley, W. H., 1911: Maturation of the Egg and Ovulation in the Domestic Cat. Amer. Jour. Anat., vol. xii., pp. 139–172.

Riddle, O., 1911: On the Formation, Significance, and Chemistry of the White and Yellow Yolk of Ova. Jour. of Morph., vol. xxii., pp. 455–490.

Swift, C. H., 1915: Origin of the Definitive Sex-cells in the Female Chick, and Their Relation to the Primordial Germ-cells. Amer. Jour. Anat., vol. xviii., pp. 441–470.

Waldeyer, W., 1906: Die Geschlechtszellen. In Hertwig's Handbuch der Entwickelungslehre der Wirbeltiere, Bd. i., pp. 221–429.

Winiwarter, H. von, 1900: Recherches sur l'ovogenèse et l'organogenèse de l'ovaire des Mammifères (Lapin et Homme). Archives de Biologie, vol. xvii., pp. 33–199.

Winiwarter, H. von, 1902: Nachtrag zu meiner Arbeit über Oogenese der Säugethiere. Anat. Anz., vol. xxi., pp. 401–407.

Owen, Griffith.—Born in Wales about 1647. He was liberally educated and became a physician and surgeon. In 1684 he arrived in Pennsylvania with his family and established himself in practice in the territory (some 40,000 acres) which Penn had set apart as a Welsh tract. Subsequently he removed to Philadelphia. On Dec. 1, 1699, he performed what is believed to have been the first surgical operation in Pennsylvania—namely, the amputation of a young man's arm which had been injured by the premature firing of a cannon on the occasion of Penn's second visit to the Province. He died at about the age of seventy years.

A. H. B.

Owen Mineral Well.—Washtenaw County, Michigan.

POST-OFFICE.—Ypsilanti.

ACCESS.—Viâ Michigan Central and the Lake Shore and Michigan Southern Railroad.

The following analysis was made by James H. Shepard and Willard F. Pett:

	Grams per Liter.	Grains per Imperial Gallon.
Potassium sulphate	0.52675	36.8725
Calcium sulphate	0.66630	46.6410
Ferrous salts	Traces.	
Sodium chloride	34.45684	2,411.9788
Magnesium chloride	1.91055	133.7385
Phosphates	Traces.	
Magnesium bromide	0.19297	13.5079
Magnesium sulphate	1.32043	92.4301
Barium salts	Traces.	
Lithium salts	Traces.	
Calcium chloride	2.99997	209.9930
Silica	0.01525	1.0675
Borates	Traces.	
Fluorides	Minute traces.	
Calcium carbonate	0.82727	56.9089
Organic matter	Traces.	
Total salts determined	42.91633	3,003.1382
	c.c. per liter.	Cu. in. per gallon.
Hydrogen sulphide (temperature of well)	56.1	15.527
Total solids by evaporation	42.8239	2,997.6730

Temperature of water, 13.7° C. (56.6° F.).
Temperature of air, 21.3° C. (70.3° F.).
Specific gravity, 1.0284.

Baths and treatments are given at the Occidental Hotel. The use of this water has proved beneficial in a variety of disorders—rheumatic affections, neuralgia, nervous debility, constipation, hay fever, catarrh, asthma, alcoholism, mercurial poisoning, Bright's disease, diabetes, skin diseases, and venereal diseases. The water is used commercially.

EMMA E. WALKER.

Oxalic Acid.—Oxalic acid, having no medicinal virtues, is not official in the United States Pharmacopœia. It is an organic acid with the constitution

$$\begin{matrix} COOH \\ | \\ COOH \end{matrix}$$

and exists as an oxalate in many plants. Cerium oxalate is the only official preparation (see vol. ii., p. 754). Its importance depends entirely upon its toxicological relations. R. J. E. S.

Oxford Chalybeate Mineral Spring.—New Haven County, Connecticut.

POST-OFFICE.—Oxford.

Good hotel within one-half mile. This spring, situated about three miles from Seymour, Connecticut, has been well known to residents of the neighborhood for many years, but it has only recently been brought to the attention of the public. Its medicinal properties are supposed to have been known to the Indians, as arrow heads and other evidences of aboriginal life are frequently found near it. The spring yields about one and a half gallons of pure, sparkling water per minute. An analysis by Prof. George F. Barker, of the Sheffield Scientific School, resulted as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.346
Sodium sulphate	0.491
Potassium sulphate	Traces.
Lithium sulphate	Traces.
Magnesium sulphate	0.620
Calcium sulphate	1.160
Iron carbonate	0.909
Silica and insoluble matter	1.326
Organic matter	1.276
Loss in analysis	0.097
Total residue	6.225

The path of the stream can be easily traced by the abundant bright yellow deposit of hydrate of iron. In the short time since this water was brought before the public it has risen high in popular favor as an invigorant and general tonic. It is useful in conditions of debility and anemia, and in stomach, liver, and renal disorders. The water is used commercially.

EMMA E. WALKER.

Ox-gall.—See *Fel Bovis*.

Oxidases.—In different tissues of the body as well as in plant tissues certain enzymes or enzyme-like bodies are found which have the property of bringing about oxidations. They have been called oxidases and may be divided into primary or direct oxidases, called simply oxidases, and the indirect oxidases or peroxidases, which are active only in the presence of a peroxide as they set oxygen free from the latter by decomposition. See *Enzymes*. F. P. U.

Oxidase Reaction.—The oxidase reaction as practically applied in the study of tissues and blood cells depends on the so-called indophenol-blue synthesis of Ehrlich. This is produced by the addition of two atoms of oxygen to a combination of alpha-naphthol + dimethylparaphenylendiamine, resulting in the formation of a deep blue color. Cells containing oxidase ferment can bring about this reaction and consequently are stained blue by a mixture of the two reagents mentioned, while cells devoid of the ferment remain unaffected. Belonging in this group are all cells of myeloid origin, *i.e.* neutrophilic, basophilic, and eosinophilic polymorphonuclear leucocytes, transitionals, large mononuclears, myelocytes, and myeloblasts, while cells of lymphoid origin do not give the reaction. The method, therefore, is of use in differentiating between cases of myeloid and lymphatic leucemia, especially the acute forms, and in recognizing foci of myeloid cells in the tissues.

To apply the reaction to blood films the preparations are exposed to the vapor of formalin in a closed receptacle. Strong formalin may be used and fixation is then secured in a few minutes, but it is preferable to use a four per cent. solution for three to four hours. The nuclei of the cells may be stained by the application of a five per cent. pyronin or methyl green solution or saturated safranin solution for a few minutes, but this is not necessary. The preparation is washed and the following mixture is applied: a knife-point of para-amido-dimethyl-aniline-sulphate is dissolved in 2 c.c. of normal sodium hydrate solution and to this is added an equal amount of one per cent. aqueous solution of alpha-naphthol. A cover-glass is applied and the preparation is examined with a high power dry lens. Myeloid cells will show blue granules in a few minutes, but the color fades within a few hours, so that permanent preparations cannot be made. Tissues must be fixed in formalin or in Bonn solution (Carlsbad salts 5, formalin 12.5, water 100 parts) and embedded in paraffin, or frozen sections may be used. The sections are immersed for two minutes in the above staining mixture, washed, counterstained in the pyronin, methyl green, or safranin solution, and mounted in glycerin.

KARL M. VOGEL.

REFERENCES.

Fursenko, B.: Ueber die Granulafärbung mit alpha-Naphthol-dimethylparaphenylendiamine. Centralbl. für allg. Path. u. path. Anat., 1911, xxii., 97.

Dunn, J. S.: Use of the Oxidase Reaction in the Differentiation of the Acute Leucemias. Quart. Jour. Med., 1912, vi., 293.

Oxycamphor.—(C_8H_{14}.CO.CHOH), a product of the oxidation of camphor—is prepared by reducing camphor orthoquinone with zinc powder and acetic, sulphuric, or hydrochloric acid. It is a white crystalline powder of bitterish, peppery taste, and without odor. It fuses at 204° C. (400° F.), and is soluble in fifty parts of cold water and freely in hot water, alcohol, ether, chloroform, and the oils. Its two-per-cent. solution coagulates albumin, reduces hemoglobin, and is strongly bactericidal.

To this drug is attributed the special power to overcome dyspnea by diminishing the excitability of the respiratory center in the medulla. Physiological experiments with 0.5-per-cent. solutions and clinical usage by Ruttner, Ehrlich, Marlier, and others have demonstrated that oxycamphor tends to lessen the frequency of the respirations, to increase their depth, to slow the pulse, and slightly to increase the blood pressure. It is said to have improved the breathing in cases of tuberculosis, bronchitis, emphysema, Bright's disease, anemia, and heart disease.

Exposed to light and moisture the powder becomes a soft, slimy, sticky, yellowish mass. It keeps fairly well, however, in tablet triturates made with sugar of milk, and is stable in fifty-per-cent. alcoholic solution. This solution, known as *oxaphor*, is given with much water in dose of ♏viij.–xv. (0.5–1.0).

W. A. BASTEDO.
R. J. E. SCOTT.

Oxygen.—Oxygen is not recognized in the United States Pharmacopœia as a drug, but yet is used in medicine to a certain extent, generally by inhalation, either of the pure gas, or of the same mingled with from one to four volumes of atmospheric air or of nitrogen monoxide (nitrous oxide gas). Oxygen is a colorless, odorless, and tasteless gas, and is, when pure, distinctly irritant to sensitive parts. Its main medical interest centers upon the phenomena which follow the inhalation of the gas in greater concentration than is the case in the atmosphere. Continuously inhaled, pure, the irritant effects of oxygen are considerable; mice immersed in an atmosphere of pure oxygen die after three days with congested and inflamed lungs. With inhalations too short to excite local mischief, the question naturally arises whether an atmosphere abnormally rich in oxygen does or does not tend to determine abnormal absorption of the gas into the blood, and so a quickening of the oxidations concerned in vital processes. Opposite opinions have been held on this question. The one view (Regnault and others) is that with healthy lungs the blood normally takes from the ordinary atmosphere all the oxygen that it is physiologically capable of absorbing, so that the presentment to it of an air containing an increased proportion of the gas can have no effect on the absorption rate. But a considerable number of experiments and observations of various kinds seem to oppose this view, and lead to the belief that crowding the lungs with oxygen does also crowd the blood with the gas. Thus, during oxygen inhalations granulation tissue has been observed to grow quickly ruddier in hue (Demarquay), expired carbon dioxide to double in amount (Allen and Pepys, Limousin), and excreted uric acid to lessen in quantity, presumably by undergoing oxidation within the system (Kollman). Whichever answer to the question be the true one, no marked symptom pointing to any serious derangement of physiological processes occurs when a moderate inhalation is practised by one in health. The gas, even when pure, is pleasantly respirable, and from fifteen to thirty liters (from four to eight gallons, about) can be inhaled with little other obvious effect than a feeling of general warmth and nervous exhilaration, with occasionally a little giddiness and quickening of the pulse rate. But while the effects in health are comparatively negative, it is far otherwise when an oxygen inhalation is undertaken by one suffering for want of a sufficiency of oxygen because of some impediment to the full exercise of the respiratory function, such as may be caused by asthma, pneumonia, emphysema, cardiac disease, croup, diphtheria, etc. Oxygen is also administered in poisoning by chloroform, and in threatened death from the inhalation of coal gas. In such case the distress, because of the insufficiency of the air supply, tends to be compensated by the higher oxygenation of the same, and the dyspnea may be greatly abated, or even, for the time, wholly abrogated. And the relief may persist, of course in keeping with the character of the case, for a longer or shorter time after discontinuance of the inhalation. Similar relief by respiration of oxygen is afforded in cases of asphyxia from irrespirable or noxious gases, such as carbon monoxide or the poisoned air of sewers.

The therapeutic applications of oxygen are, first in importance, the administration of the gas by inhalation for the relief of dyspnea or asphyxia in the circumstances above described. Inhalations have also been practised with the view of quickening the processes of physiological chemistry and so determining better nutrition in chronic cachectic states, such as anemia, chlorosis, tuberculosis, etc. The results of this latter therapeusis, however, have not been very striking. Under any circumstances the existence of ulceration or active inflammation within the air passages had better be accepted as contraindicating oxygen inhalation, unless the gas be well diluted. In appropriate cases, from four to sixteen liters (one to four gallons, about) may be inhaled at a sitting, two or three times a day, pure or diluted with air, from one to four volumes, according to the urgency of the case. The gas must be known to be pure, in the chemical sense of the word, and is best administered by means of the bags devised for the giving of nitrous oxide gas. But whether the gas be drawn from a bag or from a gasometer, the inhalation should be by means of a mouthpiece so fitted with valves that the products of expiration shall not pass into the apparatus to mingle with the gases to be respired. In order to obtain dilution with air the simplest expedient is to leave the nostrils open to inhale the atmosphere, while the mouth inhales oxygen. For the use of oxygen in connection with anesthetics, see vol. i., pp. 374 and 383.

Oxygen is supplied for medical use in iron cylinders, generally condensed so that a cylinder holding from 100 to 200 gallons is of a size easily handled and stored. From such reservoirs a bag or gasometer is charged for the individual inhalations.

EDWARD CURTIS.
R. J. E. SCOTT.

Oxyhemoglobin is the red protein coloring matter of the blood and belongs to the group of compound proteins. It is particularly characterized by its ability to act as an oxygen-carrier presumably due to the iron-containing portion, the hematin. It is readily crystallizable and yields a characteristic absorption spectrum. It is the mother substance of all the normal coloring matters of the organism, except perhaps the pigment of the hair. Hemoglobin is readily transformed into a variety of closely related pigments, some of them of special significance in pathology. See *Blood.* FRANK P. UNDERHILL.

Oxymel is a mixture containing honey and a dilute acid (generally acetic acid). The agreeable flavor of the oxymels renders them of use as gargles and as excipients. There are two of these preparations official in the British Pharmacopœia, and one in the National Formulary.

OXYMEL (oxymel).	B. P.	Clarified honey, liquefied, 40 ounces; acetic acid, 5 fl. ounces; distilled water, q.s. Dose, fl. ʒi.–ii. (4.0–8.0).
OXYMEL SCILLÆ (oxymel of squill).	B. P.	Squill, bruised, 2½ ounces; acetic acid, 22 fl. ounces; distilled water, 8 fl. ounces; clarified honey, liquefied, q.s. Dose, fl. ʒss–i. (2.0–4.0).
OXYMEL SCILLÆ (oxymel of squill).	N. F.	Vinegar of squill (U. S. P.), 50 gm.; honey, 100 gm. Dose, fl. ʒi. (4.0).

R. J. E. SCOTT.

Oxyuris.—A genus of nematode worms. The three labial papillæ are not distinct; the esophagus is long with a distinct dilation; ulva near anterior end of body. *O. vermicularis* is the pin worm which occurs in no other animal except man. The eggs escape with the feces and reenter the mouth to infect. The females often wander out through the anus and cause intense itching. A large number of these parasites may set up enterocolitis; in small numbers they cause only irritation. See *Nematoda.* A. S. P.

Ozæna.—See *Rhinitis, Chronic.*

END OF VOLUME VI.

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